320006
Wayne State University
Chemistry Building
Electrical Reliability Upgrades
November 24, 2014 – For Bids

007 - CHEMISTRY BUILDING
WSU PROJECT NO. 007-248857
ELECTRICAL RELIABILITY UPGRADES
BID PACKAGE NO.5

Project Specifications

Prepared for:

Wayne State University

For Bids
11/24/2014

Prepared by

Connect With Confidence
Commonwealth associates, inc.

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Chemistry Building

Building No. 007
5101 Cass Ave.
Detroit, MI 48201

Specifications **Table of Contents**

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Specification Sections – Table of Contents

SECTION 012100 - ALLOWANCES

PART 1 - GENERAL

1.1 SUMMARY

A. Selected labor are shown and specified in the Contract Documents by allowances. Allowances have been established in lieu of additional requirements and to defer selection of actual labor to a later date.

1. Cash Allowances: Base bid shall include an allowance to cover costs associated with premium time associated with overtime work in amount of $5,000.00. The allowance expenditure must be accounted for and approved in advance by WSU during the construction phase of the project, unused allowances will be returned to the University.

B. Type of allowance is "Lump-sum" cash allowance.

1.4 SUBMITTALS

A. Submit in writing to the WSU Rep in advance allocation of expected monies required to perform pre-approved work.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION (NOT APPLICABLE)

3.1 SCHEDULE OF CASH ALLOWANCES

END OF SECTION 012100

SECTION 017823 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:

1. Operation and maintenance documentation directory.
2. Emergency manuals.
3. Operation manuals for systems, subsystems, and equipment.
4. Product maintenance manuals.
5. Systems and equipment maintenance manuals.

1.3 DEFINITIONS

A. System: An organized collection of parts, equipment, or subsystems united by regular interaction.

B. Subsystem: A portion of a system with characteristics similar to a system.

1.4 CLOSEOUT SUBMITTALS

A. Manual Content: Operations and maintenance manual content is specified in individual Specification Sections to be reviewed at the time of Section submittals. Submit reviewed manual content formatted and organized as required by this Section.

1. Architect will comment on whether content of operations and maintenance submittals are acceptable.
2. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.

B. Format: Submit operations and maintenance manuals in the following format:

1. PDF electronic file. Assemble each manual into a composite electronically indexed file. Submit on digital media acceptable to Architect.

a. Name each indexed document file in composite electronic index with applicable item name. Include a complete electronically linked operation and maintenance directory.

b. Enable inserted reviewer comments on draft submittals.

2. **Three** paper copies. Include a complete operation and maintenance directory. Enclose title pages and directories in clear plastic sleeves. Architect**, through Construction Manager,** will return **two** copies.

C. Initial Manual Submittal: Submit draft copy of each manual at least **30** days before commencing demonstration and training. Architect **and Commissioning Authority** will comment on whether general scope and content of manual are acceptable.

D. Final Manual Submittal: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least **15** days before commencing demonstration and training. Architect **and Commissioning Authority** will return copy with comments.

1. Correct or revise each manual to comply with Architect's **and Commissioning Authority's** comments. Submit copies of each corrected manual within **15** days of receipt of Architect's **and Commissioning Authority's** comments and prior to commencing demonstration and training.

PART 2 - PRODUCTS

2.1 OPERATION AND MAINTENANCE DOCUMENTATION DIRECTORY

A. Directory: Prepare a single, comprehensive directory of emergency, operation, and maintenance data and materials, listing items and their location to facilitate ready access to desired information. Include a section in the directory for each of the following:

1. List of documents.
2. List of systems.
3. List of equipment.
4. Table of contents.

B. List of Systems and Subsystems: List systems alphabetically. Include references to operation and maintenance manuals that contain information about each system.

C. List of Equipment: List equipment for each system, organized alphabetically by system. For pieces of equipment not part of system, list alphabetically in separate list.

D. Tables of Contents: Include a table of contents for each emergency, operation, and maintenance manual.

E. Identification: In the documentation directory and in each operation and maintenance manual, identify each system, subsystem, and piece of equipment with same designation used in the Contract Documents. If no designation exists, assign a designation according to ASHRAE Guideline 4, "Preparation of Operating and Maintenance Documentation for Building Systems."

2.2 REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS

A. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:

1. Title page.
2. Table of contents.
3. Manual contents.

B. Title Page: Include the following information:

1. Subject matter included in manual.
2. Name and address of Project.
3. Name and address of Owner.
4. Date of submittal.
5. Name and contact information for Contractor.
6. Name and contact information for Construction Manager.
7. Name and contact information for Architect.
8. Name and contact information for Commissioning Authority.
9. Names and contact information for major consultants to the Architect that designed the systems contained in the manuals.
10. Cross-reference to related systems in other operation and maintenance manuals.

C. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.

1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.

D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.

E. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF file for each manual type required.

1. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.
2. File Names and Bookmarks: Enable bookmarking of individual documents based on file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel on opening file.

F. Manuals, Paper Copy: Submit manuals in the form of hard copy, bound and labeled volumes.

1. Binders: Heavy-duty, three-ring, vinyl-covered, **loose-leaf** binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch (215-by-280-mm) paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

    a. If two or more binders are necessary to accommodate data of a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary to provide essential information for proper operation or maintenance of equipment or system.
    b. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, **and** subject matter of contents. Indicate volume number for multiple-volume sets.

2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment.
4. Supplementary Text: Prepared on 8-1/2-by-11-inch (215-by-280-mm) white bond paper.
5. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.

    a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
    b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

2.3 EMERGENCY MANUALS

A. Content: Organize manual into a separate section for each of the following:

1. Type of emergency.
2. Emergency instructions.
3. Emergency procedures.

B. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:

1. Fire.
2. Flood.
3. Gas leak.
4. Water leak.
5. Power failure.
6. Water outage.
7. System, subsystem, or equipment failure.

8. Chemical release or spill.

C. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of Owner's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.

D. Emergency Procedures: Include the following, as applicable:

1. Instructions on stopping.
2. Shutdown instructions for each type of emergency.
3. Operating instructions for conditions outside normal operating limits.
4. Required sequences for electric or electronic systems.
5. Special operating instructions and procedures.

2.4 OPERATION MANUALS

A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:

1. System, subsystem, and equipment descriptions. Use designations for systems and equipment indicated on Contract Documents.
2. Performance and design criteria if Contractor has delegated design responsibility.
3. Operating standards.
4. Operating procedures.
5. Operating logs.
6. Wiring diagrams.
7. Control diagrams.
8. Piped system diagrams.
9. Precautions against improper use.
10. License requirements including inspection and renewal dates.

B. Descriptions: Include the following:

1. Product name and model number. Use designations for products indicated on Contract Documents.
2. Manufacturer's name.
3. Equipment identification with serial number of each component.
4. Equipment function.
5. Operating characteristics.
6. Limiting conditions.
7. Performance curves.
8. Engineering data and tests.
9. Complete nomenclature and number of replacement parts.

C. Operating Procedures: Include the following, as applicable:

1. Startup procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.

4. Regulation and control procedures.
5. Instructions on stopping.
6. Normal shutdown instructions.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

E. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

2.5 PRODUCT MAINTENANCE MANUALS

A. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual and drawing or schedule designation or identifier where applicable.

C. Product Information: Include the following, as applicable:

1. Product name and model number.
2. Manufacturer's name.
3. Color, pattern, and texture.
4. Material and chemical composition.
5. Reordering information for specially manufactured products.

D. Maintenance Procedures: Include manufacturer's written recommendations and the following:

1. Inspection procedures.
2. Types of cleaning agents to be used and methods of cleaning.
3. List of cleaning agents and methods of cleaning detrimental to product.
4. Schedule for routine cleaning and maintenance.
5. Repair instructions.

E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.

F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

1. Include procedures to follow and required notifications for warranty claims.

2.6 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS

A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.

B. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual and drawing or schedule designation or identifier where applicable.

C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:

1. Standard maintenance instructions and bulletins.
2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
3. Identification and nomenclature of parts and components.
4. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:

1. Test and inspection instructions.
2. Troubleshooting guide.
3. Precautions against improper maintenance.
4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
5. Aligning, adjusting, and checking instructions.
6. Demonstration and training video recording, if available.

E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.

1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual, and annual frequencies.
2. Maintenance and Service Record: Include manufacturers' forms for recording maintenance.

F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.

G. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

1. Include procedures to follow and required notifications for warranty claims.

PART 3 - EXECUTION

3.1 MANUAL PREPARATION

A. Operation and Maintenance Documentation Directory: Prepare a separate manual that provides an organized reference to emergency, operation, and maintenance manuals.

B. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.

C. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.

D. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.

1. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
2. Prepare a separate manual for each system and subsystem, in the form of an instructional manual for use by Owner's operating personnel.

E. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

1. Prepare supplementary text if manufacturers' standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.

F. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in record Drawings to ensure correct illustration of completed installation.

1. Do not use original project record documents as part of operation and maintenance manuals.
2. Comply with requirements of newly prepared record Drawings in Section 017839 "Project Record Documents."

END OF SECTION 017823

SECTION 031000 – CONCRETE FORMWORK

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.

1.2 SUMMARY

A. This Section includes the design, installation and removal of forms for cast-in-place concrete.

B. Related Sections include the following:
   1. Division 3 Section “Concrete Reinforcement.”
   2. Division 3 Section “Concrete Accessories.”
   3. Division 3 Section “Cast-In-Place Concrete.”

C. Division of Work:
   1. In accordance with the General Conditions, Contractor is responsible for dividing the Work among the Subcontractors and Suppliers and for delineating the work to be performed by specific trades. The following are suggestions as to how the Work may be divided. This is not a complete list of all the work:
      a. Mechanical, Electrical and Plumbing Trades: Supply, locate and install premanufactured items including inserts, sleeves, and other embedded items required by those respective trades.
      b. Formwork Subcontractor:
         1) Supply and install Site fabricated box-outs for chases, sleeves and other openings for mechanical, electrical and plumbing trades.
         2) Install other inserts, embedded parts, box-outs for openings, chases, reveals and recesses, except those specifically mentioned above that are by mechanical, electrical or plumbing trades. Special inserts, embedded parts or other special requirements needed by a specific trade shall be supplied by that trade to the formwork Subcontractor for installation.
      c. Contractor: Coordinate location of mechanical, electrical and plumbing inserts, embedded parts, openings and recesses with respective trades.

1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
   1. ACI - American Concrete Institute:
      a. 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
      b. 301 - Standard Specifications for Structural Concrete for Buildings.
      c. 303R - Guide to Cast-In-Place Architectural Concrete Practice.
      d. 347R - Guide to Formwork for Concrete.

1.4 DESIGN AND PERFORMANCE REQUIREMENTS

A. Form Construction:
   1. Provide required forms, shores, bracing, breast timbers, form ties, and accessories in sufficient quantities so as not to delay the Work, and of strength to support vertical and horizontal loads to which they are subjected.
   2. Deflection: Maximum deflection of forms shall be 1/240 of span or 1/4-inch, whichever is less.

1.5 SUBMITTALS

A. Manufacturer's Literature: For form release agent**.**

1.6 QUALITY ASSURANCE

A. Design: The design and engineering of formwork, as well as its construction, shall be the responsibility of Contractor.

B. Notifications: Notify special inspector at least 24 hours in advance of placing concrete.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Formwork Facing Materials:
   1. Smooth Form Finish Areas:
      a. Locations: All locations unless otherwise noted.
      b. The form facing material shall produce a smooth, hard, uniform surface on the concrete.
      c. Form facing materials may be plywood, tempered concrete-form-grade hardboard, metal, plastic, paper; or other approved material capable of producing the desired finish.
      d. Facing materials shall be supported by studs or other backing capable of preventing deflections in excess of those specified herein.
      e. Material with damaged surfaces, worn edges, patches, dents or other defects which will impair the texture of the concrete surface shall not be used.

B. Pan Forms:
   1. Steel or fiberglass, formed to profiles required to produce indicated shapes.
   2. Designed to be strong enough to carry construction live loads and the weight of plastic concrete without deflection detrimental to the structure.
   3. Formed for secure attachment to formwork platforms.
   4. Formed for removal in a manner which will not damage concrete.

C. Cylindrical Forms:
   1. Steel or fiberglass, formed to diameters required to produce indicated shapes.
   2. Strong enough to carry pressure of plastic concrete.
   3. Formed to produce shapes free from abrupt changes in shape, and to produce smooth uniform surface.

D. Void Forms:

1. Degradable paper or cardboard forms, to suit slab and beam applications.
2. Strong enough to carry construction live load and the weight of plastic concrete without significant deformation.
3. Configurations to suit application indicated on the Drawings, as chosen by Contractor.
4. Sure Void Products, Inc.; or equal.

E. Chamfer Strips:
1. Wood, metal, rubber, or PVC.
2. Sizes as indicated, 3/4-inch x 3/4-inch minimum.

F. Form Ties:
1. At Smooth Form Finish Areas:
a. Factory fabricated metal ties.
b. Removable or snap type, with tapered cones as required to leave no tie portion within 1-inch of concrete surface plane.
c. Designed to leave no larger than a 7/8-inch diameter hole at concrete surface.
d. Chosen by Contractor to suit application and to resist pressure of fresh concrete.
e. For concrete tank walls, in addition to the above requirements, provide waterstop type feature on the tie.

G. Form Release Agent:
1. Products for General Use: Magic Kote by Symons, Crete-lease 727 by Cresset Company; or equal.
2. Chemically neutral agent in hydrocarbon solvent that will effectively prevent absorption of moisture and prevent bond with the concrete.

PART 3 - EXECUTION

3.1 FORMWORK CONSTRUCTION

A. General:
1. Install wall form ties in a regular repetitive pattern.
2. Align and secure joints to avoid offsets.
3. Provide chamfered strips in exposed corners of exterior corners, internal corners and for similar conditions throughout the Work.
4. Construct forms to allow for installation of waterstops, bentonite waterproof bead, and waterproofing termination.
5. Tie waterstops up to prevent folding when concrete is placed.
6. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only.
7. The arrangement of facing material shall be orderly and symmetrical with the number of seams kept to the practical minimum.
8. Retighten forms after concrete placement if required to eliminate mortar leaks.
9. Inspection Ports and Cleanouts:
a. Provide temporary openings where interior area of formwork is inaccessible for cleanout and inspection.
b. Securely brace temporary openings and set tightly to forms to prevent loss of concrete mortar.
c. Locate temporary openings on forms at inconspicuous locations.

B. Openings and Embedded Items:
   1. Set and build into the work anchorage devices and other embedded items required for work that is attached to, or supported by, cast-in-place concrete.
   2. Coordinate work of other Sections and cooperate with trade involved in forming and setting openings, slots, recesses, chases, sleeves, bolts, anchor and other inserts.
   3. Use setting drawings, diagrams, instructions and directions provided by Suppliers of the respective items.
   4. Do not perform work unless specifically indicated on Drawings or reviewed prior to installation.

C. Cleaning:
   1. Clean forms as erection proceeds, to remove foreign matter.
   2. Remove cuttings, shavings and debris from within forms.
   3. Flush with water or use compressed air to remove remaining foreign matter.
   4. Ensure that water and debris drain to exterior through clean-out ports.
   5. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints.
   6. Thoroughly clean embedded waterstops and concrete surfaces prior to constructing forms for the next pour.

D. Applying Form Release Agent:
   1. Temperature of release agent and surfaces to which it is applied shall be a minimum of 70 degrees F.
   2. Apply by spray only.
   3. Uniformly coat surfaces with a thin film.
   4. Wipe off excess with clean towels.
   5. Apply in accordance with Manufacturer's recommendations.
   6. Do not allow to stand in puddles in the forms and prevent bonding of concrete at construction joints.

E. Provisions for Form Removal:
   1. Fabricate forms for easy removal without hammering or prying against the concrete surfaces.
   2. Kerf wood inserts for forming keyways, reglets, recesses and the like to prevent swelling and for easy removal.

3.2 FORM AND SUPPORT REMOVAL

A. Forms and supports shall remain in place for not less than the following periods of time:
   1. Tunnel Walls: 12 to 24 hours.
   2. Vault and Tunnel Top Slabs:
      a. Under 10 Feet Clear Span Between Supports: 96 hours (4 days).
      b. 10 to 20 Feet Clear Span Between Supports: 168 hours (7 days).
      c. Over 20 Feet Clear Span Between Supports: 240 hours (10 days).

B. In any event, do not remove forms and supports until concrete in walls has reached 30% of design strength, and in structural members and slabs has reached 75% of design strength.

C. Special precautions shall be taken when concrete is placed in average temperatures of 50 degrees F or below to ensure that forms are not removed before design strengths specified above are met.

D. If Contractor elects to use high-early-strength cement, the specified periods of time may be reduced as allowed by Engineer. This does not relieve Contractor of Contractor's liability.

E. Remove forms in such a manner and at such times as required to ensure safety of persons involved and so as to protect and maintain structural integrity of members.

F. Particular care shall be taken in removing forms to minimize damage to concrete surfaces; use crush or wrecking plates as necessary.

G. Whenever the formwork is removed, cure the exposed concrete as specified under Division 3 Section “Cast-in-Place Concrete.”

3.3 FIELD QUALITY CONTROL

A. Inspect and check completed formwork, shoring and bracing to ensure that work is in accordance with formwork design, and that supports, fastenings, wedges, ties and parts are secure.

B. Form Surface Repairs:
   1. Repair surfaces of forms to be reused in the work.
   2. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable.
   3. Apply new form release agent to new concrete contact form surfaces.
   4. Do not use patched forms for exposed concrete surfaces.

C. Special Inspections:
   1. Inform Engineer when formwork is complete and has been cleaned, to allow for inspection.
   2. Allow inspection of each section of plywood type of formwork prior to reuse.
   3. Obtain inspections prior to placing concrete.

END OF SECTION 031000

CONCRETE REINFORCING

SECTION 032000 – CONCRETE REINFORCEMENT

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.

1.2 SUMMARY

A. This Section includes the furnishing and placement of concrete reinforcement.

B. Related Sections include the following:
   1. Division 3 Section “Concrete Formwork.”
   2. Division 3 Section “Concrete Accessories.”
   3. Division 3 Section “Cast-In-Place Concrete.”

1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
   1. ACI:
      a. 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
      b. 315 - Details and Detailing of Concrete Reinforcement.
      c. 315R - Manual of Engineering and Placing Drawings for Reinforced Concrete Structures.
      d. 318 - Building Code Requirements for Reinforced Concrete.
   2. ASTM Specifications:
      a. A615 - Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   3. AWS:
      a. D1.4: Structural Welding Code - Reinforcing Steel.
   4. CRSI:
      a. Manual of Standard Practice.
      b. Reinforcing Bar Detailing.
      c. Placing Reinforcing Bars.

1.4 SUBMITTALS

A. Prepare Shop Drawings in accordance with ACI 315 and 315R and the CRSI Manual of Standard Practice and Reinforcing Bar Detailing. Include the following:
   1. Number, size, length, mark, and location of concrete reinforcement.
   2. Bending diagrams.

B. Certified Mill Test Reports:
   1. Submit upon request by Engineer.
   2. Showing physical and chemical analysis for each heat of reinforcement used on Project.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver reinforcement free of loose rust, scale, paint, oil and structural defects, and store on the site so as to maintain that condition.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
   1. All concrete reinforcement and accessories shall be new, free from rust, scale, paint, oil and structural defects.
   2. Reinforcement shall be the sizes indicated on the Drawings.

B. Reinforcing Bars:
   1. ASTM A615.
   2. Yield stress: Fy = 60,000 psi.
   3. Deformed unless otherwise noted; smooth where specifically indicated on the Drawings.

C. Accessories:
   1. Chairs, bolsters, anchors, spacers, stirrups, ties and other devices as required for spacing and fastening reinforcement in place shall conform to CRSI Manual of Standard Practice.
   2. At exposed underside of concrete, use plastic-tipped chairs and bolsters.

2.2 FABRICATION

A. General:
   1. Fabricate reinforcement to the dimensions indicated on the Drawings and the reviewed Shop Drawings in accordance with the CRSI Manual of Standard Practice.
   2. Tolerances: As indicated in ACI 117.
   3. Bundle and tag reinforcement with suitable identification to permit checking, sorting and placing.
   4. Welding:
      a. Not permitted, unless specifically indicated on the Drawings.
      b. When permitted, comply with AWS D1.4.
      c. No tack welding permitted.

B. Hooks:
   1. Bend hooks in accordance with ACI 318.
   2. Extension on 90 degree hook shall satisfy the requirements of a standard hook unless indicated longer on the Drawings.
   3. Cold bend bars in such a way that will not damage the reinforcement.

C. Reinforcement with any of the following defects will not be permitted in the Work:
   1. Bar lengths, depths and bends exceeding specified fabrication tolerances.
   2. Bends or kinks not indicated on Drawings or reviewed Shop Drawings.
   3. Bars with reduced cross-section due to excessive rusting or other cause.

PART 3 - EXECUTION

3.1 PLACEMENT

CONCRETE REINFORCING

A. Place concrete reinforcement in accordance with:
   1. Shop Drawings reviewed by Engineer.
   2. CRSI Placing Reinforcing Bars and Manual of Standard Practice.
   3. Tolerances indicated in ACI 117.

B. Clearance:
   1. Preserve clear space between bars of not less than 1 times the normal diameter of round bars.
   2. In no case let the clear distance be less than 1-inch or less than 1-1/3 times the maximum size of aggregate.
   3. In the absence of specific cover requirements on the Drawings, provide the following minimum concrete cover for reinforcement:
      a. Cast Against and Permanently Exposed to Earth: 3 inches.
      b. Exposed to Earth, Weather or Water:
         1) No. 6 Through No. 18 Bars: 2 inches.
         2) No. 5 Bars, 5/8-Inch Wire and Smaller: 1-1/2 inches.
      c. Not Exposed to Weather or in Contact with the Ground:
         1) Slabs, Walls, and Joists:
            a) No. 14 and No. 18 Bars: 1-1/2 inches.
            b) No. 11 Bars and Smaller: 3/4-inch.
         2) Beams, Girders, and Columns: 1-1/2 inches.
         3) Shells and Folded Plate Members:
            a) No. 6 Bars and Larger: 3/4-inch.
            b) No. 5 Bars, 5/8-Inch Wire and Smaller: 1/2-inch.

C. Splices:
   1. Comply with ACI 318 and this Section.
   2. In the absence of specific lap requirements on the Drawings, lap in accordance with ACI 318, Class B.
   3. Laps of Circular Ring Tension Steel: Not less than 40 bar diameters.

D. Corner Bars:
   1. Provide corner bars for all horizontal wall steel.
   2. In the absence of specific lap requirements on the Drawings, lap in accordance with ACI 318, Class B.

E. Field Cutting and Bending: Field cutting or bending of bars will be permitted only under special conditions approved by Engineer.

F. Field Welding:
   1. In accordance with AWS D1.4.
   2. Only when specifically indicated on the Drawings.
   3. No tack welding permitted.

G. Slabs On Grade:
   1. Do not hook up welded wire fabric; either tie on supports at correct elevation, or lay on partial slab thickness of fresh concrete just prior to placing remainder of slab.
   2. For Chairs or Bolsters Resting on Soil, Place on Either:
      a. Sand plates.
      b. Concrete bricks set flush with soil to provide bearing surface for chairs or bolsters.

3.2 FIELD QUALITY CONTROL

A. Notification:
   1. Notify Engineer when reinforcing is in place so Engineer may review the reinforcement placement.
   2. Provide a minimum of 24 hours notice prior to placement of concrete.

END OF SECTION 032000

CAST IN PLACE CONCRETE

SECTION 033000 – CAST IN PLACE CONCRETE

PART 1 – GENERAL

1.1 SUMMARY

A. Work Included: Cast in place concrete.
   1. Spread footing foundation pads.
   2. Continuous wall footings and grade beams.
   3. Slab on grade.
   4. Elevated structural reinforced slabs.

1.2 QUALITY ASSURANCE

REFERENCE STANDARDS

A. Comply with the latest editions of the following design guides and standards:
   1. ACI 301 "Specifications for Structural Concrete for Buildings"
   2. ACI 302 "Guide for Concrete Floor and Slab Construction"
   3. ACI 304 "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete:"
   4. ACI 305 "Hot Weather Concreting"
   5. ACI 306 "Cold Weather Concreting"
   6. ACI 311 "Recommended Practice for Concrete Inspection"
   7. ACI 315 "Details and Detailing of concrete Reinforcement"
   8. ACI 318 "Building Code Requirements for Structural Concrete"
   9. ACI 347 "Recommended Practice for Concrete Formwork"
   10. ACI SP-15 Field Reference Manual
   11. CRSI "Manual of Standard Practice"

1.3 SUBMITTALS

A. Shop Drawings: Submit Shop Drawings for fabrication, bending, and placement of concrete reinforcement. Show bar bending schedules, stirrup spacing, diagrams of bent bars, and arrangements of concrete reinforcement. Include special reinforcement required for openings through concrete. Show elevation of reinforcement for all members at a minimum of ¼ inch – 1'-0" scale. Show locations of all construction and control joints.

B. Mix Designs: Submit proposed mix designs for concrete at least 15 days before start of concreting. Submittal shall include: cement content and type, admixture content and type, aggregate source and gradation, water content, air content, slump, yield, and documentation of average strength by field experience method or laboratory prepared trial mixtures in accordance with ACI 318 Article 4.3.

C. Product Data: Submit data and installation instructions for proprietary materials.

D. Material Certificates: Submit materials certificates certifying that each material complies with Specifications.

1.4 TESTING SERVICES

A. Owner will engage a testing laboratory acceptable to the Architect-Engineer to perform material evaluation tests and for quality control during placement.

B. Sample and test concrete for quality control during placement as follows:
   1. Sampling Fresh Concrete: ASTM C172 except modified for slump to comply with ASTM C94.
   2. Slump: ASTM C143 – one for each concrete truck, measured at point of discharge.
   3. Air Content: ASTM C231 pressure method – one for each truck load of ready-mixed air-entrained concrete.
   4. Temperature: Test concrete temperature hourly when ambient temperature is 40°F and below, and when 80°F and above.
   5. Compressive Strength Test: ASTM C39, one set of six cylinders for each 50 cubic yards or fraction thereof, of each concrete class placed in any one day, two lab specimens tested at 7 days, two lab specimens tested at 28 days and two specimens retained in reserve for later testing if required.

C. Test Reports
   1. Forward results to Architect-Engineer and Contractor on same day that tests are made.
   2. Reports of compressive strength tests shall contain the general information of project identification name and number, date of concrete placement, name of Contractor, name of concrete supplier, truck number and delivery ticket number, name of concrete testing agency, concrete type and class, name of individual making specimen, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials; and the specific information of slump, air content, temperature, compressive strength and type of break for both 7-day and 28-day tests.
   3. Field reports of concrete inspection shall contain general information noted above, plus ambient temperature, concrete temperature, weather, slump, air content, and cylinder numbers.

D. Additional Testing

   1. Testing agency shall make additional test of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure.
   2. Testing agency shall conduct tests to determine adequacy of concrete cored cylinders complying with ASTM C42 or by other methods acceptable to Architect-Engineer.

3. Contractor shall pay for such tests conducted, and any other additional testing required, if concrete testing confirms specified strengths have not been met.

1.5 JOB CONDITIONS

A. Store materials so as to ensure preservation of their quality and fitness for the Work. Store reinforcement and formwork in a manner to prevent damage and accumulation of dirt.

B. Contractor shall be responsible for correction of concrete work which does not conform to specified requirements, including strength, tolerances and finishes. Correct deficient concrete as directed by Architect-Engineer.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Formwork

1. Exposed Concrete: Unless otherwise shown or specified, construct formwork for concrete surfaces, which will be exposed to view in the completed project, with form plywood, metal or other acceptable panel-type material, to provide continuous, straight, smooth exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system show on Drawings. Provide form material with sufficient thickness to withstand pressure of newly-placed concrete without bow or deflection.

2. Unexposed Concrete: Form concrete surfaces which will be unexposed to view in the completed Project with plywood, lumber, metal or other acceptable material. Provide lumber dressed on at least 2 edges and 1 side for tight fit.

B. Form Ties

1. Exposed Concrete: Plastic cone snap tie, Type 3M by Superior or accepted equal.

2. Unexposed Concrete: Snap-off metal ties, designed to prevent form deflection and prevent spalling surfaces upon removal. Portion remaining after removal shall be at least 1” from concrete surface.

C. Form Coatings: Commercial formulation form-coating compounds shall not bond with, stain, nor adversely affect concrete surfaces, and shall not impair subsequent treatments of concrete surfaces requiring bond or adhesion, nor impede wetting of surfaces to be cured with water or curing compound.

D. Reinforcement
   1. Deformed bars: ASTM A615, Grade 60.
   2. Welded Wire Fabric: ASTM A185. Furnish in flat sheets only.
   3. All chairs, spacers, clips, wire anchors and related items necessary to accurately space and secure reinforcement.
   4. Additional bars, if required, to anchor or space reinforcement.
   5. Chairs shall be plastic booted at points of bearing on forms for exposed concrete.
   6. Minimum 16-gauge annealed tie wire, ASTM A82.

E. Cement: ASTM C150, Type I or Type II.

F. Aggregates: ASTM C33 and as herein specified.
   1. Fine Aggregate: Clean, sharp, natural sand free from loam, clay, lumps or other deleterious substances with less that 10% passing the #100 sieve and less than 3% passing the #200 sieve.
   2. Coarse Aggregate: Clean, uncoated, processed aggregate containing no clay, mud, loam or foreign matter, as follows:
      a. Crushed stone: Processed from natural rock or stone for concrete slabs meeting MDOT 6AA, with a ¾ inch maximum aggregate size.
      b. Clean, sharp, natural or processed gravel, or, crushed stone, free from loam, clay, lumps, or other deleterious substances for footings and miscellaneous concrete.
      c. Maximum aggregate Size: Footings and Walls – 1 ½ “, Slabs – ¾”.

G. Water: Clean, fresh, and potable.

H. Air Entraining: ASTM C260.

I. Water Reducing Admixture: ASTM C494, Type A.

J. Non Corrosive, Non Chloride Accelerator: ASTM C494, Type C or E.

K. Prohibited Admixtures: Calcium chloride, thiocyanates. Admixtures containing more than 0.05% chloride ions are not permitted.

L. Evaporation Retarder: Confilm by Master Builders, or accepted equal.

M. Curing Sheet Materials: ASTM C171, including waterproof paper, polyethylene film or polyethylene coated burlap.

N. Liquid Membrane Curing/Sealing Compound: Masterkure by Master Builders or accepted equal.

O. Exterior Anti-Spalling Sealer: Penetrating Sealer 40 by Sonneborn or approved equal.

P. Hardener: Lapidolith by Sonneborn or approved equal.

Q. Mineral Aggregate Floor Surface Hardener: Colorcron by Master Builders or approved equal. French gray color. Apply at rate of 1.00 pounds per square foot.

R. Joint Filler: ½" thick ASTM D994 premolded expansion joint filler strips; vinyl removable filler cap strip, 940 Series by Green Streak or approved equal.

S. Sleeves: ASTM A120, Hot-dipped galvanized.

T. Anchor Bolts: Furnished in Section 05100 ande installed under this Section.

U. Dowel Bars: 1-inch square steel bars with ¼-inch compressible foam on vertical faces; or 1-inch diameter steel bars, greased.

V. Non-shrink Grout: Sonogrout 14 by Sonneborn, or approved equal.

W. Water Stop: Volclay Waterstop RX, 1' x 3/4"' by American Colloid Co. or approved equal.

X. Dovetail Slot: Standard Dovetail Slot #180, 26 gauge galvanized steel with foam filler by Heckmann Building Products or approved equal.

2.2 PROPORTIONING AND MIX DESIGN

A. Prepare design mixes for concrete. Use independent testing facility acceptable to Architect-Engineer for preparing and reporting proposed mix designs.

B. Where the concrete production facility can establish the uniformity of its production for concrete of similar strength and materials based on recent test data, the average strength used as a basis for determining mix design proportions shall exceed the specified design strength by the requirements of ACI 318, section 4.3.2 or ACI 301, Section 3.9.

C. Concrete Quality

Location	**Required 28 day Compressive Strength**	**Maximum Water/Cement Ratio**	**Air-Content**	**Unit Weight**
Footings, foundation walls and all other below grade concrete, miscellaneous concrete	3,000 psi	0.55	4% - 6%	147 – 153 pcf

Location	Required 28 day Compressive Strength	Maximum Water/Cement Ratio	Air-Content	Unit Weight
Interior slab on grade	4,000 psi	0.45	0%	147 – 153 pcf
Elevated structural slabs	4,000 psi	0.45	0%	147 – 153 pcf
Exterior concrete subject to freezing and thawing, exterior slab on grade	4,000 psi	0.45	5% - 7%	147 – 153 pcf
Interior elevated structural lightweight slab	4,000 psi	0.45	4% - 6%	114 – 120 pcf

D. Slump

1. Footings and Foundation Walls: 3” to 5”.
2. Slabs: 4” maximum.

E. Ready Mix Concrete: ASTM C94.

F. The quantity of coarse aggregate in pounds must be in the range of 1.25 to 1.5 times the quantity of fine aggregate in pounds.

G. Fly ash may be substituted for cement for interior slabs only, at a maximum rate of 15 percent by weight. Submittals shall include actual mix design, including percentage of fly ash and test results showing that mix meets specified compressive strength, and air content. Fly ash is not permitted in cold weather concreting unless extended protection is provided. Protection and heat shall be maintained until 70 percent of specified design strength is achieved.

H. Pumping of concrete is permitted only if mix designs specifically prepared and used previously for pumping are submitted. Pumpline shall have a 5-inch minimum inside diameter and shall be used with 5-inch pumps.

2.3 REINFORCING FABRICATION

A. Fabricate bars to required lengths, shapes and bends. Do not rebend or straighten reinforcement in a manner that shall weaken the material

2.4 FORMWORK

A. Design formwork to support vertical and lateral loads that might be applied until such loads can be supported by concrete structure.

PART 3 – EXECUTION

3.1 INSPECTION

A. Examine conditions under which concrete shall be placed. Do not proceed with work until all unsatisfactory conditions are corrected..

3.2 NOTIFICATION

A. Notify Architect-Engineer 24 hours before anticipated time of completion of reinforcement in any section.

B. Do not place concrete until reinforcement has been observed and corrections, if any, made.

3.3 FORMWORK INSTALLATION

A. Erect, brace, and maintain formwork to support vertical and lateral loads.

B. Construct forms to sizes, lines and dimensions shown to obtain accurate alignment, location, grades, level and plumb work in finished structure.

C. Provide for openings, offsets, keys and other features required in work. Accurately position and support items.

D. Solidly butt joints and provide backup at joints to prevent leakage of cement paste.

E. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces.

F. Kerf wood inserts for forming keys and the like to prevent swelling and for easy removal.

G. Provide openings in concrete form to accommodate work of other trades. Determine size and location of openings, recesses and chases from trades providing such.

H. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete is placed. Retighten forms after concrete placement if required to eliminate concrete leaks.

I. Reuse of Forms: Clean and repair surfaces of forms to e reused in the work. Split, frayed, delaminated, or otherwise damaged form facing material is not acceptable. Apply new form coating compound material. When forms are reused for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close all joints. Align and secure joints to avoid offsets.

3.4 REINFORCEMENT PLACING

A. Clean reinforcement of loose rust, mill scale, earth, ice and other materials which reduce or destroy bond with concrete.

B. Accurately position, support and secure reinforcement against displacement by formwork, construction or concrete placement operations. Locate and support reinforcement by metal chairs, runners, bolsters, spacers and hangers as required. Do not use brick.

C. Place reinforcement to obtain at least the minimum coverage's for concrete protection.

D. Arrange, space and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

E. Lap bar splices as indicated. Stagger splices in adjacent bars. Wire tie all splices.

3.5 WELDED WIRE FABRIC REINFORCEMENT PLACEMENT

A. Place welded wire fabric one-third of the slab thickness below top surface of slab.

B. Place flat sheets in as long lengths as practical. Lap adjoining sheets at least one full mesh. Offset laps to prevent continuous laps in either direction.

C. Do not continue welded wire fabric through any control joints or construction joints for slabs on grade.

3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, reinforcing steel and items to be embedded or cast in the concrete.

B. Notify other trades to permit installation of their work. Cooperate with other trades in setting such work as required.

C. Install anchor bolts and sleeves.

D. Deposit concrete continuously or in layers of such thickness that no concrete shall be placed on concrete which has hardened sufficiently to cause formation of seams or planes of weakness within section. Provide construction joints if section cannot be placed continuously.

E. Deposit concrete as nearly as practicable to its final location to avoid segregation caused by rehandling or flowing.

F. Keep excavations free of water. Do not deposit concrete in water, mud, snow or on frozen ground.

G. Maximum drop of concrete shall not exceed 5 feet. Use hopper and trunk for greater drops.

H. Contractor shall be responsible for controlling the proper placing of all embedded pipe, conduit and other embedded items.

I. Contractor shall be responsible for finishing of all concrete slabs to proper elevations to insure that all surface moisture will drain freely to floor drain, and that no puddle areas exist. During finishing operation, Contractor shall pay particular attention to this criterion, and shall make all efforts to obtain this. Any cost of corrections to provide for this positive drainage will be the responsibility of Contractor.

3.7 CONSOLIDATION

A. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand spading, rodding or tamping.

B. Do not use vibrators to transport concrete inside formwork.

C. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of mix.

D. Do not allow vibrator to come in contact with form.

3.8 SURFACE FINISHES

A. Finish of Formed Surfaces:
   1. Rough Form Finish: For formed concrete surfaces not exposed to view in the finished work or concealed by other construction unless otherwise indicated. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective areas repaired and patched and fins and other projections exceeding ¼” in height removed.
   2. Smooth Form Finish: For formed concrete surfaces exposed to view. This is as cast concrete surface obtained with selected form facing material, arranged orderly and

symmetrically with a minimum of seams. Repair and patch defective areas with fins or other projections completely removed and smoothed. Lightly rub all exposed surfaces to achieve a uniform appearance. Or Lightly sandblast to expose fine aggregate with occasional exposure of coarse aggregate and to make the color uniform.

B. Monolithic Slab Finishes
   1. Scratch Finish: Apply scratch finish to monolithic slab surfaces to receive concrete floor topping or mortar setting beds for tile, and other bonded applied cementitious finish flooring material. After placing slabs, roughen surface before final set with stiff brushes, brooms or rakes.
   2. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed to view, and slab surfaces to be covered with carpet, resilient flooring, paint or other thin film finish coating system. After floating, begin first trowel finish operation using a power drive trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand trowel operation, free of trowel marks.
   3. Non-Slip Broom Finish: Apply non-slip broom finish to exterior concrete platforms, steps and ramps, and elsewhere as indicated. Immediately after trowel finishing, slightly roughen concrete surface by brooming with a fiber bristle broom perpendicular to main traffic route.

3.9 APPLICATION OF FLOOR SURFACE HARDENER

A. Bleed water shall not be present before or during the application of this shake.

B. Apply first shake to hand floated concrete adjacent to forms, entryways, columns and walls where moisture will be lost first. Apply two-thirds of the specified total shake immediately following floating of total area. Distribute evenly by hand broadcasting in all areas.

C. Finishing machines with float shoes shall be used as soon as shake has absorbed moisture (indicated by darkening of surface and when surface is firm enough to support a float machine and operator). Float just sufficiently to bring moisture from base slab through the shake. Immediately following floating, apply remaining one-third of total specified shake in the same manner, allow the hardener to darken and machine float as specified.

D. At no time shall water be added to the surface.

E. As surface further stiffens, indicated by loss of sheen, it shall be hand or mechanically trowelled with blades relatively flat. All marks and pin holes shall be removed during the final trowel operation. Finish troweling to produce a light swirl finish to provide skid resistance.

3.10 CURING AND PROTECTION

A. Concrete shall be protected from premature drying, excessively hot or cold temperature, and mechanical injury according to provisions of ACI 301, Chapter 12. During placing, all concrete flatwork exposed to or subject to rapid evaporation of moisture under drying conditions (including hot weather, low humidity, wind and/or sunlight) shall be protected immediately following screeding with evaporation retarder applied in accordance with recommendations of manufacturer. Application shall precede and shall be in addition to curing specified below.

B. Concrete shall be maintained in a continuously moist condition for at least 7 days after placement. Curing shall begin as soon as possible after concrete has been placed and finished. Materials and methods of curing shall be submitted to Architect-Engineer for review and approval.

C. Curing and Protection: Surfaces not in contact with forms and surfaces in contact with forms for less than seven days.
   1. Curing shall be by water curings, application of liquid membrane curing/sealing compound or by application of sheet curing materials. Curing compounds shall be applied in accordance with manufacturer's recommendations. Liquid membrane curing compound used on floor slabs receiving applied finish flooring shall be guaranteed by the manufacturer, in writing, not to impair bonding of adhesive.
   2. For slabs use a curing treatment of water curing, curing sheet materials, or by applying and removing curing/sealing compound. The curing compounds must be applied immediately after final finishing. For curing by water curing or curing sheet materials, the concrete must be continually moist-cured for at least 7 days. Curing shall begin immediately after finishing.
   3. For other surfaces (footing, walls, etc.) curing shall be by one of the accepted curing treatments listed above.
   4. Restore curing protection on all freshly cut joint edges and faces when sawing joints or removing forms.

D. Concrete placed under cold weather conditions shall be cured by completely covering exposed surface of concrete with curing sheet materials with sheets completely sealed around edges. All concrete shall be cured for a minimum of 14 days with temperatures at or above 40°F or for a minimum of 7 days with temperatures at or above 70°F.

3.11 COLD WEATHER CONCRETING

A. Place concrete during cold weather in accordance with ACI 306.

B. For cold weather concreting, (defined as a period when for more than three successive day the mean daily temperature drops below 40°F) concrete temperature shall be maintained in accordance with ACI 306.

3.12 HOT WEATHER CONCRETING

A. Place concrete in accordance with ACI 305.

B. Cool ingredients before mixing to maintain concrete temperature below 90°F at time of placement.

C. Cover reinforcing steel with water-soaked burlap if temperature of reinforcing steel exceeds ambient air temperature.

D. Wet forms thoroughly before placing concrete.

3.13 WALL JOINTS

A. Construction Joints: Locate and install construction joints as shown on Drawings. Where construction joints are not shown, locate joints at masonry control joints. Install joints maximum of 60 feet on center in locations acceptable to Architect-Engineers.

3.14 INTERIOR SLAB JOINTS

A. Construction Joints: Locate and form construction joints as shown on Drawings. Where construction joints are not shown, place in locations acceptable to Architect-Engineer.

B. Contraction Joints: Saw cut joints as soon as possible after finishing generally within 4 to 16 hours. Make sample cut to determine if concrete surface is firm enough so that it is not torn or damaged by the blade.

C. Isolation Joints: Construction isolation in slabs on grade at all points of contact with vertical surfaces and elsewhere as indicated.

3.15 EXTERIOR SLAB JOINTS

A. Expansion Joints: Locate and install expansion joints as shown on Drawings. Where expansion joints are not shown, locate and install joints a maximum of 20 feet on center in either direction.

B. Contraction Joints: Tool joints during final finishing with edging tool.

C. Isolation Joints: Construct isolation joints in slabs on grade at all points of contact with vertical surfaces and elsewhere as indicated.

3.16 TOLERANCES

A. Footings
   1. Variation of dimensions in plan: plus 2” or minus ½”.
   2. Variation of center from specified center in plan: 2 percent of footing width in direction of variation, plus or minus 2” maximum variation.
   3. Variation of bearing surface from specified elevation: plus or minus ½”.

B. Anchor Bolts and Sleeves
   1. Variation from specified location in plan: plus or minus ¼”.
   2. Variation from specified elevation: plus or minus ½”.

C. Slab on Grade
   1. Surface Flatness: F_F = 20 or greater.
   2. Surface Levelness: F_L = 17 or greater.
   3. Variation from specified elevation: plus or minus ¼”.

D. Stairs
   1. Variation in riser: 1/8”.
   2. Variation in tread: 1/8:

3.17 SLAB SEALERS

A. Interior Exposed Slabs: Apply two coats of hardener after slabs have cured a minimum of 28 days at a rate of 100 square feet/gallon; in accordance with manufacturer's recommendations.

B. Exterior Exposed Slabs: Apply two coats of Penetrating Exterior Anti-Spalling Sealer after slabs have cured a minimum of 28 days in accordance with manufacturer's recommendations.

3.18 REPAIR OF SURFACES

A. Contractor shall be responsible for cost of repairing defects.

B. Repair defective wall areas with cement mortar or proprietary patching compound, when acceptable to Architect-Engineer. Cut out honeycomb, rock pockets and voids over 1/2" inch diameter back to solid concrete but in no case to a depth of less than 1 inch. Make edges of cuts perpendicular to concrete surface.

C. Repair defective interior slab areas as follows:
   1. Correct flatness and levelness defects by grinding or removal and replacement of slab. Patching of low spots will not be permitted.
   2. For cracks less than 1/32 inch, no repairs are required. For cracks greater than 1/32 inch, use crack repair material. For cracks over 1/8 inch, fill crack with oven-dried sand prior to application of crack repair material, as recommended by manufacturer. Contractor also has option to remove and rebuild areas of cracking. Mask cracks to limit crack repair material to crack only.
   3. Curling at slab edges which exceeds ¼ inch when measured with a 10-foot straight edge shall be made level by grinding or planning. Straightedge shall be located with it's end at the slab edge, and the space between the straightedge and the slab be measured. If curling exceeds ¼ inch, core drill slab at 3-foot intervals and inject non-shrink grout to fill void beneath slab.
   4. Repair edge spalls which occur from shrinkage cracking or from contractor's operations.

D. Remove and replace all exterior slabs which are cracked or do not drain properly.

END OF SECTION 033000

SECTION 050940 – POST-INSTALLED ANCHORS

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.

1.2 SUMMARY

A. This Section includes the furnishing and installation of post-installed anchors.

1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following pertinent provisions:
   1. ASTM:
      a. A36 - Carbon Structural Steel.
      b. A198 - Steel Bolting Materials for High-Temperature Service.
      c. A240 - Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
      d. A307 - Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
      e. A510 - General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel.
      f. A563 - Carbon and Alloy Steel Nuts.
      g. B633 - Electrodeposited Coatings of Zinc on Iron and Steel.
      h. E488 - Strength of Anchors in Concrete and Masonry Elements.
      i. E1512 - Testing Bond Performance of Bonded Anchors.
      j. F436 - Hardened Steel Washers.
      k. F844 - Washers, Steel, Plain (Flat), Unhardened for General Use.
   2. ACI 318-02, Appendix D - Anchoring to Concrete.
   3. Michigan Building Code.

1.4 SUBMITTALS

A. Product Data: For All Members to be Furnished:
   1. Base material being fastened to.
   2. Anchor embedment depth in base material.

1.5 QUALITY ASSURANCE

A. Installation Personnel Qualifications:
   1. Trained and experienced in the type of work being performed.
   2. Knowledgeable of the specific manufacturer’s requirements for quality installation of post-installed anchors.

B. Inspection of Post-Installed Anchor Installation: Field instruction and inspection during the installation process by Manufacturer’s authorized field representative shall take place at the discretion of Engineer. The General Contractor may utilize such instruction and inspection at any

time without the authorization of Engineer. Any costs which may be associated with such services shall be paid for by the General Contractor.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Post-Installed Anchor Material:
   1. Anchors that resist loads through mechanical friction or keying forces:
      a. Expansion Anchors:
         1) Wedge style anchor.
         2) Capable of sustaining an ultimate load of 6 times the imposed load capacity in unit masonry and 4 times the imposed load capacity in concrete when tested in accordance with ASTM E488.
         3) Hilti Kwik Bolt III; Powers Power-Stud; or equal.
         4) Stainless steel in accordance with ASTM F593.
      b. Sleeve Anchors:
         1) Expanding sleeve style anchor.
         2) Hilti LLC or LSL heavy duty sleeve anchors; Powers Lok/Bolt sleeve anchor; or equal.
         3) Hex, acorn, round or flat head anchor or threaded anchor with hex nut as situation requires or as indicated on the Drawings.
         4) Submerged or Subject to Becoming Wet: Stainless steel in accordance with ASTM F593.
         5) Dry Areas: Mild steel, galvanized in accordance with ASTM B633.
      c. Undercut Anchors:
         1) Expanding sleeve, self-undercutting wedge style anchor.
         2) Hilti HDA Undercut Anchors; Powers Power-Bolt Anchors; or equal.
         3) Hex or flat head anchor or threaded anchor with hex nut as situation requires or as indicated on the Drawings.
         4) Submerged or Subject to Becoming Wet: Stainless steel in accordance with ASTM F593.
   2. Anchors that resist loads through an injectable chemical adhesive:
      a. In Concrete: Hilti HIT HY-150, HIT-ICE, HIT-T2, HIT RE 500 and HSE 2421; Powers Power-Fast; or equal.
      b. Anchored Material: Deformed reinforcing bars as indicated on the Drawings.
      c. Bonding Strength: Tested in accordance with ASTM E1512.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install Post-Installed Anchors:
   1. In strict accordance with the installation instructions supplied by the Manufacturer.
   2. Under the direction and Site supervision of the Manufacturer's authorized field representative when directed to do so by the Project Engineer.
   3. In drilled out holes of the proper depth and diameter cleaned of dust and debris according to the Manufacturer's specific installation instructions.

B. Post installed anchors anchored to substrate with an injectable adhesive shall have no load applied until adhesive has properly cured and developed specified strength where cure time shall be as called out in the Manufacturer's literature based on prevailing environmental conditions at the time of installation.

END OF SECTION 050940

SECTION 055000 - METAL FABRICATIONS

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. Steel handrail.
2. Steel framing and supports for mechanical and electrical equipment.
3. Steel framing and supports for applications where framing and supports are not specified in other Sections.
4. Shelf angles.
5. Metal ladders.
6. Ladder safety cages.
7. Metal floor plate.
8. Miscellaneous steel trim.
9. Metal bollards.
10. Loose bearing and leveling plates for applications where they are not specified in other Sections.

1.3 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of metal fabrications that are anchored to or that receive other work. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:
1. Metal nosings and treads.
2. Paint products.
3. Grout.

B. Shop Drawings: Show fabrication and installation details. For all assemblies.

1.5 INFORMATIONAL SUBMITTALS

A. Mill Certificates: Signed by stainless-steel manufacturers, certifying that products furnished comply with requirements.

B. Welding certificates.

C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

1.7 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.

B. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

C. Stainless-Steel Sheet, Strip, and Plate: ASTM A 240/A 240M or ASTM A 666.

D. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from plate complying with ASTM A 36/A 36M or ASTM A 283/A 283M, Grade C or D.

E. Steel Tubing: ASTM A 500/A 500M, cold-formed steel tubing.

F. Steel Pipe: ASTM A 53/A 53M, Standard Weight (Schedule 40) unless otherwise indicated.

G. Cast Iron: Either gray iron, ASTM A 48/A 48M, or malleable iron, ASTM A 47/A 47M, unless otherwise indicated.

2.2 FASTENERS

A. General: Unless otherwise indicated, provide **Type 304** stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633, Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.
   1. Provide stainless-steel fasteners for fastening nickel silver.
   2. Provide bronze fasteners for fastening bronze.

B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 307, Grade A with hex nuts, ASTM A 563 flat washers.

C. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A 325, Type 3 with hex nuts, ASTM A 563, Grade C3 flat washers.

D. Stainless-Steel Bolts and Nuts: Regular hexagon-head annealed stainless-steel bolts, ASTM F 593 with hex nuts, ASTM F 594 flat washers.

E. Anchor Bolts: ASTM F 1554, Grade 36, of dimensions indicated; with nuts, ASTM A 563 and, where indicated, flat washers.

   1. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.

F. Anchors, General: Anchors capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488/E 488M, conducted by a qualified independent testing agency.

G. Cast-in-Place Anchors in Concrete: Either threaded type or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A 47/A 47M malleable iron or ASTM A 27/A 27M cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F 2329.

2.3 MISCELLANEOUS MATERIALS

A. Low-Emitting Materials: Paints and coatings shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Department of Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.

1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.

C. Water-Based Primer: Emulsion type, anticorrosive primer for mildly corrosive environments that is resistant to flash rusting when applied to cleaned steel, complying with MPI#107 and compatible with topcoat.

D. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.

E. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish paint systems indicated.

F. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

G. Non-shrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107/C 1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

H. Concrete: Comply with requirements in Section 033000 "Cast-in-Place Concrete" for normal-weight, air-entrained, concrete.

2.4 FABRICATION, GENERAL

A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

D. Form exposed work with accurate angles and surfaces and straight edges.

E. Weld corners and seams continuously to comply with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing.

F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.

G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.

H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.

I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

2.5 MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.

B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.

C. Galvanize miscellaneous framing and supports where indicated.

2.6 MISCELLANEOUS STEEL TRIM

A. Unless otherwise indicated, fabricate units from steel shapes, plates, and bars of profiles shown with continuously welded joints and smooth exposed edges. Miter corners and use concealed field splices where possible.

B. Provide cutouts, fittings, and anchorages as needed to coordinate assembly and installation with other work.

1. Provide with integrally welded steel strap anchors for embedding in concrete or masonry construction.

C. Galvanize miscellaneous steel trim.

2.7 STEEL WELD PLATES AND ANGLES

A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.

2.8 FINISHES, GENERAL

A. Finish metal fabrications after assembly.

B. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

2.9 STEEL AND IRON FINISHES

A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A 153/A 153M for steel and iron hardware and with ASTM A 123/A 123M for other steel and iron products.

1. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.

B. Preparation for Shop Priming Galvanized Items: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with metallic phosphate process.

C. Shop prime iron and steel items **not indicated to be galvanized** unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

C. Field Welding: Comply with the following requirements:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.

E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

3.2 INSTALLING MISCELLANEOUS FRAMING AND SUPPORTS

A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.

B. Support steel girders on solid grouted masonry, concrete, or steel pipe columns. Secure girders with anchor bolts embedded in grouted masonry or concrete or with bolts through top plates of pipe columns.

1. Where grout space under bearing plates is indicated for girders supported on concrete or masonry, install as specified in "Installing Bearing and Leveling Plates" Article.

C. Install pipe columns on concrete footings with grouted baseplates. Position and grout column baseplates as specified in "Installing Bearing and Leveling Plates" Article.

1. Grout baseplates of columns supporting steel girders after girders are installed and leveled.

3.3 INSTALLING PREFABRICATED BUILDING COLUMNS

A. Install prefabricated building columns to comply with AISC 360, "Specifications for Structural Steel Buildings," and with requirements applicable to listing and labeling for fire-resistance rating indicated.

3.4 INSTALLING METAL BOLLARDS

A. Fill metal-capped bollards solidly with concrete and allow concrete to cure seven days before installing.

B. Anchor bollards in concrete. Fill annular space around bollard solidly with non-shrink grout; mixed and placed to comply with grout manufacturer's written instructions. Slope grout up approximately 1/8 inch toward bollard.

C. Fill bollards solidly with concrete, mounding top surface to shed water.

3.5 ADJUSTING AND CLEANING

A. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.

B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780/A 780M.

END OF SECTION 055000

SECTION 081100 - METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Prefinished steel frames for interior doors.

B. Related Sections: Section(s) related to this section include:

1.2 REFERENCES

A. ASTM International:

1. ASTM A366 Standard Specification for Commercial Steel (CS) Sheet, Carbon (0.15 Maximum Percent) Cold-Rolled.
2. ASTM A653 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
3. ASTM B117 Standard Practice for Operating Salt Spray (Fog) Apparatus.
4. ASTM D1735 Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus.
5. ASTM D3363 Standard Test Method for Film Hardness by Pencil Test.

B. American National Standards Institute (ANSI):

1. ANSI 115.1 Specifications for Steel Door and Frame Preparation for Hardware.

C. National Fire Protection Association (NFPA):

1. NFPA 80 Fire Doors and Windows.

D. Underwriters Laboratories, Inc. (UL):

1. UL 10B Fire Tests of Door Assemblies.
2. UL 10C Positive Pressure Fire Tests of Door Assemblies.

1.3 PERFORMANCE REQUIREMENTS

A. 1 1/2 hour fire rating in accordance with UL 10B.

B. Passes positive pressure test in accordance with UL 10C.

1.4 SUBMITTALS

A. General: Submit listed submittals in accordance with Conditions of the Contract and Division 01 Submittal Procedures Section.

B. Product Data: Submit product data, including manufacturer's SPEC-DATA product sheet, for specified products. Include details of design and construction and printed instructions covering installation.

C. Shop Drawings: Submit shop drawings showing layout, profiles and product components, including anchorage, accessories, finish colors and textures. Indicate installation requirements of finish hardware and reinforcements.

1. Warranty: Submit the warranty documents specified.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Installer experienced in performing work of this section who has specialized in the installation of work similar to that required for this project.

B. Regulatory Requirements: Fire-rated steel frames shall be of types tested and approved by Intertek Testing Services, Warnock Hersey and shall bear labels of same.

1. Three-sided frames shall receive a permanent embossed 90 minute label. Sidelite and borrowed lite frames shall receive a Mylar Warnock Hersey label when specified.

1.6 DELIVERY, STORAGE & HANDLING

A. Delivery: Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.

1. Factory package components in protective cartons to prevent damage during shipping.

B. Storage and Protection: Store materials protected from exposure to harmful weather and at temperature conditions recommended by manufacturer.

1. Store material on wooden skids under cover in a protected area and keep vented to avoid condensation until ready for installation.

1.7 PROJECT CONDITIONS

A. Field Measurements: Verify actual measurements/openings by field measurements before fabrication. Show recorded measurements on shop drawings. Coordinate field measurements and fabrication schedule with construction progress schedule to avoid construction delays.

1.8 WARRANTY

A. Project Warranty: Refer to Conditions of the Contract for project warranty provisions.

B. Manufacturer's Warranty: Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under the Contract Documents.

1. Warranty Period: 1 year.

PART 2 - PRODUCTS

2.1 PREFINISHED STEEL DOOR FRAMES

1. Refer to drawings, door schedule and details for required types and sizes of frames.

2.2 MATERIALS

A. Header and Jamb Members: Form interior door frames of ASTM A366 commercial quality cold rolled steel. Form exterior door frames of galvanized steel (A40) per ASTM A653. Provide frames in the following gages:

1. Fire Rated Standard Frames for 1 3/4 Inch (44 mm) Doors: [**18**] [**20**] gage.
2. 1 3/8 Inch (35 mm) or 1 3/4 Inch (44 mm) Door Frames: [**18**] [**20**] gage.
3. 1 3/4 Inch (44 mm) Door Sidelite Frames: [**18**] [**20**] gage.
4. Borrowed Lite Frames: [**18**] [**20**] gage.

B. Casings:

1. Steel: 22 gage cold rolled steel to ASTM A366.
2. Aluminum: 0.050 inch (1.3 mm) aluminum extrusion 6063-T5 alloy.
3. S56 Steel Colonial: 24 gage galvanized (A40) steel to ASTM A653.

C. Hinge Reinforcements: 14 gage hot dipped galvanized (G60) steel to ASTM A653 (10 gage equivalent number of threads, SDI-107).

D. Strikes and Deadbolt Covers and Dust Box: 18 gage commercial quality cold rolled steel to ASTM A366.

E. Door Closer Reinforcement: Steel or aluminum in accordance with manufacturer's standard.

1. Standard Arm Mounting: Aluminum extrusion 6063-T5 alloy in accordance with manufacturer's standard.

a. Door Guard: Aluminum extrusion 6063-T5 alloy in accordance with manufacturer's standard.

2. Parallel Arm Mounting: 16 gage galvanized (A40) steel per ASTM A653.

F. Casing Corner Alignment Clips: Pre-painted 22 gage ASTM A366 commercial quality cold rolled steel.

G. Felt Silencers, Weather stripping and Smoke Gasketing (Standard Profile): In accordance with manufacturer's standard.

1. Interior Frames: Install felt silencers on the header and strike jamb. Single door opening, 3 per strike jamb. Pair door opening, 2 per header.

H. Weather stripping and Smoke Gasketing (Kerf Profile):

1. Interior and Exterior Frames: Kerf weather strip to seal opening. Schlegel QDS500 is acceptable.

I. Fasteners: In accordance with manufacturer's standards, to comply with labeling agency for fire-rated frames.

J. Paint: Frame manufacturer's standard baked-on synthetic enamel, applied over a cleaned and phosphate coated surface.

1. Application shall be by electrostatic method.
2. Finish paint dry film thickness on doors panels shall be approximately 1 mil (0.03 mm) for finished paint.
3. Factory finish paint shall pass 200 hour salt spray test in accordance with ASTM B117 and 700 hour humidity test in accordance with ASTM D1735 with no blistering.
4. Paint hardness shall meet calibrated pencil lead test to ASTM D3363.
5. Prime painted frames shall be field painted within 30 days of installation with a good quality oil based enamel as recommended, or a high quality water base latex. A flash rust inhibitor shall be used with water base latex method.

2.3 MANUFACTURED UNITS

A. General: Frames shall be prefinished type designed for installation at rough wall openings over prefinished walls.

1. Provide steel frames to receive metal casings to conceal fasteners.
2. Prepare steel frames to receive decorative wood moldings to conceal fasteners.
3. Provide accessories and fasteners necessary for field assembly and installation in accordance with frame manufacturer's standards.
4. Prepare for and provide reinforcements in accordance with manufacturer's standards as required to receive finished hardware.

B. Door Frames:

1. Construct jamb member to interlock and align with header members to form a strong joint.
2. Provide die cut mitered metal casings held tight together and in alignment with concealed corner backing pieces. Casings shall conceal all frame fasteners. Provide concealed clips to receive snap on casings.

C. Hardware Preparations:

1. In accordance with an approved Hardware Schedule, ANSI A115 and manufacturer's recommendations:

    a. Mortise frames for hinges and strikes.
    b. Drill and tap or reinforce frames for mortised or surface mounted hardware.

2.4 FINISHES

A. Frames and Door Finish:

1. Standard Color selection by owner.

2.5 SOURCE QUALITY CONTROL

A. Obtain steel door frame products from a single manufacturer.

PART 3 - EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

A. Compliance: Comply with manufacturer's product data, including product technical bulletins, product catalog installation instructions and product carton instructions for installation.

3.2 EXAMINATION

A. Site Verification of Conditions: Verify that conditions of substrates previously installed under other sections are acceptable for product installation in accordance with manufacturer's instructions.

3.3 INSTALLATION

A. Prefinished Steel Door Frames:

1. Install frames plumb and square, in accordance with shop drawings and manufacturer's instructions. Verify opening and dimensions with shop drawings. Use door as a template to ensure proper alignment and clearances.
2. Attach hinges and hang door in frame. Adjust frame to door for equal and uniform clearance between top and sides of door and frame.
3. Secure frame to wall with the appropriate type fasteners. Install casing on frame.
4. Install silencers on interior door frames. Install weather stripping on exterior door frames. Install smoke gaskets as required.
5. Adjust strike plate to hold door tight to stops when closed.
6. Install fire-rated door frames in accordance with NFPA 80.

3.4 CLEANING

A. Cleaning: Remove temporary coverings and protection of adjacent work areas. Repair or replace damaged installed products. Clean installed products in accordance with manufacturer's instructions prior to Owner's acceptance. Remove construction debris from project site and legally dispose of debris.

3.5 PROTECTION

A. Protection: Protect installed product and finish surfaces from damage during construction.

1. Repair or replace damaged or defective frames.
2. Touch up damaged areas of factory-applied finishes with aerosol spray cans of same paint as used in factory.

END OF SECTION

DOOR HARDWARE AND ACCESSORIES

SECTION 087100 - METAL DOORS AND FRAMES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Hinges and Pivots.

B. Stops.

C. Pulls and Plates.

D. Flush Bolts and Coordinators.

1.2 REFERENCES

A. ANSI A117.1 - Accessible and Useable Buildings and Facilities.

B. ANSI A156.1

C. ANSI A156.26

D. BHMA - Builder Hardware Manufacturers Association

E. Underwriters Laboratories (UL). - Fire Resistance Directory.
1. UL 10C
2. UL 634

1.3 SUBMITTALS

A. Product Data: Manufacturer's data sheets on each product to be used, including:
1. Preparation instructions and recommendations.
2. Storage and handling requirements and recommendations.
3. Installation methods.

B. Shop Drawings: Manufacturer's approved shop drawings are required detailing the application of each product specified.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: All equipment specified in this section will be provided by a single manufacturer with a minimum of ten (10) years experience manufacturing door hardware.

B. Installer Qualifications: All products listed in this section are to be installed by a single installer with a minimum of five (5) years demonstrated experience in installing products of the same type and scope as specified.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store products in manufacturer's unopened packaging until ready for installation.

1.6 WARRANTY

A. At project closeout, provide to the Owner or Owner's Representative an executed copy if the manufacturer's Limited Warranty against Manufacturing Defects.

PART 2 PRODUCTS

2.1 Flush Bolts and Coordinators

A. Manual Flush Bolts:
   a. Conformance: Meets ANSI A156.16.
   b. Throw: 3/4 inch (19mm).
   c. Backset: 15/32 inch (12mm).

2.2 Lock - Provide stainless steel mortise lock with ANSI 497 strike

2.3 Full mortise stainless steel ball bearing hinges

2.4 Parallel arm door closer with sweep and latch speed adjustment.

2.5 Door Panic Device – provide rim device on active door.

2.6 5 inch Saddle type threshold

PART 3 EXECUTION

3.1 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.3 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION

SECTION 09900 PAINTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes surface preparation and field painting of the following:
   1. Exposed conduits and conduit support stanchions and plates.
   2. Wall painting to match existing where restoration is required.
   3. Surface preparation, priming, and finish coats specified in this Section are in addition to shop priming and surface treatments.
B. Paint exposed surfaces of exposed conduits where approved by the Owner and walls that were disrupted to accommodate new electrical. Colors to match existing and/or adjacent utilities and/or walls. The entire wall section disrupted by new conduit penetrations shall be painted.
C. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels.

1.3 SUBMITTALS

A. Product Data: For each paint system specified. Include block fillers and primers.
   1. Material List: Provide an inclusive list of required coating materials. Indicate each material and cross reference specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.
   2. Manufacturer's Information: Provide manufacturer's technical information, including label analysis and instructions for handling, storing, and applying each coating material proposed for use.

B. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for each type of finish coat material indicated.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain block fillers, primers, and undercoat materials for each coating system from the same manufacturer as the finish coats.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Project Site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label.
B. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45 deg F. Maintain containers used in storage in a clean condition, free of foreign materials and residue.
   1. Protect from freezing. Keep storage area neat and orderly. Remove oily rags and waste daily. Take necessary measures to ensure that workers and work areas are protected from fire and health hazards resulting from handling, mixing, and application.

1.6 PROJECT CONDITIONS

A. Do not apply paint in when the relative humidity exceeds 85 percent; or at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products in the paint schedules.
B. Acceptable Manufacturers: Subject to compliance with requirements, provide products of one of the following:

Benjamin Moore & Co.
O'Leary Paint Co.
PPG Industries, Inc.
Pratt & Lambert, Inc.
Standard Detroit Paint Co.
Sherwin Williams Co.

2.2 PAINT MATERIALS, GENERAL

A. Material Compatibility: Provide block fillers, primers, undercoats, and finish coat materials that are compatible with one another and the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.
B. Material Quality: Provide manufacturer's best quality paint material of the various coating types specified. Paint material containers not displaying manufacturer's product identification will not be acceptable.
C. Colors: Provide colors selected by the Owner to match existing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with the Applicator present, under which painting will be performed for compliance with paint application requirements.
   1. Do not begin to apply paint until unsatisfactory conditions have been corrected and surfaces receiving paint are thoroughly dry.
   2. Start of painting will be construed as the Applicator's acceptance of surfaces and conditions within a particular area.
B. Provide seven days' notice to the Owner's Representative prior to the application of epoxy paints.
C. Coordination of Work: Ensure compatibility of the total system for various substrates. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.
   1. Notify the Owner about anticipated problems using the materials specified over substrates primed by others.

3.2 PREPARATION

A. Cleaning, General: Before applying paint or other surface treatments, clean the substrates of substances that could impair the bond of the various coatings. Remove oil and grease before cleaning.
   1. Schedule cleaning and painting so dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces.

B. Surface Preparation: Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition and as specified.
   1. Provide barrier coats over incompatible primers or remove and reprime.
   2. For coatings applied over previously painted surfaces, test application to check for lifting and other adhesion problems. Perform test in an isolated area where practicable.
   3. Ferrous Metals: Clean ungalvanized ferrous metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with the Steel Structures Painting Council's (SSPC) recommendations.
      a. Treat bare and sandblasted or pickled clean metal with a metal treatment wash coat before priming.
      b. Touch up bare areas and shop applied prime coats that have been damaged. Wire brush, clean with solvents recommended by paint manufacturer, and touch up with the same primer as the shop coat.
C. Materials Preparation: Mix and prepare paint materials according to manufacturer's written instructions.
   1. Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.
   2. Stir material before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.
   3. Use only thinners approved by paint manufacturer and only within recommended limits.

3.3 APPLICATION

A. General: Apply paint according to manufacturer's written instructions. Use applicators and techniques best suited for substrate and type of material being applied.
   1. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.
   2. Provide finish coats that are compatible with primers used.
B. Scheduling Painting: Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.
   1. The number of coats and the film thickness required are the same regardless of application method. Do not apply succeeding coats until the previous coat has cured as recommended by the manufacturer. If sanding is required to produce a smooth, even surface according to manufacturer's written instructions, sand between applications.
   2. Omit primer on metal surfaces that have been shop primed and touchup painted.
   3. If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance. Give special attention to ensure edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.
   4. Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and where application of another coat of paint does not cause the undercoat to lift or lose adhesion.
C. Application Procedures: Apply paints and coatings by brush, roller, spray, or other applicators according to manufacturer's written instructions.
   1. Brushes: Use brushes best suited for the type of material applied. Use brush of appropriate size for the surface or item being painted.

2. Rollers: Use rollers of carpet, velvet back, or high pile sheep's wool as recommended by the manufacturer for the material and texture required.
3. Spray Equipment: Use airless spray equipment with orifice size as recommended by the manufacturer for the material and texture required.

D. Minimum Coating Thickness: Apply paint materials no thinner than manufacturers recommended spreading rate. Provide the total dry film thickness of the entire system as recommended by the manufacturer.
E. Prime Coats: Before applying finish coats, apply a prime coat of material, as recommended by the manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn through or other defects due to insufficient sealing.
F. Pigmented (Opaque) Finishes: Completely cover surfaces as necessary to provide a smooth, opaque surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, repines, or other surface imperfections will not be acceptable.
G. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or repaint work not complying with requirements.

3.4 CLEANING

A. Cleanup: At the end of each workday, remove empty cans, rags, rubbish, and other discarded paint materials from the site.
1. After completing painting, clean glass and paint spattered surfaces. Remove spattered paint by washing and scraping. Be careful not to scratch or damage adjacent finished surfaces.
2. Dispose wash water from latex paint to the sanitary sewer. Excess latex paint shall be salvaged for reuse or solidified for disposal with other construction materials. Dry empty latex paint cans and dispose with other construction materials. Coordinate disposal of alkyd paints and solvents with University project manager.

3.5 PROTECTION

A. Protect work of other trades, whether being painted or not, against damage by painting. Correct damage by cleaning, repairing or replacing, and repainting, as approved by Architect.
B. Provide "Wet Paint" signs to protect newly painted finishes. Remove temporary protective wrappings provided by others to protect their work after completing painting operations.
1. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces. Comply with procedures specified in PDCA P1.

END OF SECTION 09900

SECTION 260510 – ELECTRICAL DESIGN AND EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE OF SUPPLY

This section includes design, performance, and technical requirements for Supplier-furnished electrical equipment. The scope of supply shall include the following items:

Medium voltage switchgear equipment.

Medium voltage controller equipment.

Low voltage motor control assemblies.

Low voltage power distribution equipment, including the following:

Low voltage switchboards.

Low voltage panelboards.

Dry type transformers.

1.2 ITEMS FURNISHED BY OTHERS AND INTERFACES

Items furnished by others and not in this scope of supply are identified as follows:

(Later)

1.3 PERFORMANCE AND DESIGN REQUIREMENTS

Performance and design requirements for the Supplier-furnished electrical equipment are as required by Supplier's design, as indicated in Article 16051.2, on the Electrical Design and Equipment Data Sheets included at the end of this section, and as follows:

Design ambient temperature	104° F (40° C)
Site elevation	Less than 3,300 ft (1,000 m)

1.4 CODES AND STANDARDS

Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply. These references shall govern the work except where they conflict with the Purchaser's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Work	In Accordance With
All	The latest revisions of the applicable ANSI C37, NEMA ICS2, IEC, and UL standards

1.5 MATERIALS

The following materials shall be used:

Component	Material

1.6 APPROVED MANUFACTURERS OF COMPONENTS

For the following components, only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications. If the Supplier wants to propose a non-listed manufacturer that is considered to provide an equivalent level of quality, this manufacturer must be identified and supporting testimony provided. Acceptance of the manufacturer as a substitute is at the discretion of the Purchaser:

Component	Manufacturer
Medium voltage switchgear equipment	Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc., Powell Electrical Manufacturing Company
Medium voltage controller equipment	Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc, Powell Electrical Manufacturing Company
Protective relays	ABB Power T&D, Basler Electric, Beckwith Electric, GE, GE - Multilin, Siemens Energy & Automation

Component	Manufacturer
Low voltage switchgear (metal-enclosed circuit breakers)	Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc., Powell Electrical Manufacturing Company
Low voltage motor control centers (motor control center assemblies)	Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc., Powell Electrical Manufacturing Company
UL/NEMA low voltage switchboards	North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer

1.7 TEST REQUIREMENTS

The following testing shall be conducted in accordance with the specified source. This testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Supplier unless specifically identified as a Bid Option or Purchaser-conducted. Tests identified as an option are to be priced separately. If identified as Purchaser-conducted, costs for the initial test will be the responsibility of the Purchaser. However, the Supplier is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Tests	In Accordance With	Conducted By

1.8 TECHNICAL ATTACHMENTS

The following attachments accompany these specifications in either paper or electronic format. The information contained in these documents constitutes requirements under the defined Scope of Work:

Document Number/Description	Title	Revision

PART 2 – PRODUCTS

2.1 MEDIUM VOLTAGE SWITCHGEAR EQUIPMENT

When specified to be in the Supplier's scope of supply, the Supplier shall supply medium voltage metal-clad switchgear in accordance with the articles below and as required by the Supplier's design. The design shall be in accordance with accepted industry practices and standards for electrical power generation.

2.1.1 Switchgear Enclosures

The switchgear shall be furnished with enclosures of the types specified below:

Location	**Description of Enclosure Type**
Indoors	Indoor with gasketed doors, ventilated
Outdoors	Walk-in protected aisle

Switchgear equipment shall be mounted in vertical sections fabricated of steel and assembled to provide rigid self-supporting structures.

The breakers shall be removable from the front. Grounded removable steel barriers shall be provided between the instrument panels and the power cable and current transformer compartments.

Each switchgear unit shall be furnished with hinged front door(s) to allow removal of the circuit breaker(s).

Doors shall be designed and adequately constructed for the mounting of instruments, meters, relays, switches, indicating lights, and other devices. Stops and latches shall be provided for control of each door in the open and closed positions. Each unit of switchgear section shall have a removable rear panel.

2.1.1.1 Outdoor weatherproof

Each unit of switchgear located outdoors shall be furnished with an outdoor weatherproof enclosure furnished with interior hinged front doors as previously specified and an enclosed operating and maintenance aisle. The rear of each such unit shall be furnished with a removable gasketed panel or a hinged and gasketed door.

Each operating and maintenance aisle shall be of sufficient width to allow the removal of breakers from the front of the units and shall be furnished with a door at each end of the switchgear assembly. The doors shall be equipped with panic hardware.

Ventilation openings shall be furnished with filters. The underside of the switchgear shall be coated with a protective sealing compound.

The manufacturer's standard indoor and outdoor lighting (including switching) shall be furnished. One convenience outlet shall be furnished at each end of the operating and maintenance aisle.

2.1.1.2 Switchgear space heaters

Each unit of switchgear shall be furnished with space heaters to prevent condensation of moisture within the switchgear. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored.

Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage specified. Space heaters shall be controlled by an adjustable thermostat or fixed humidistat.

Space heater voltage rating shall be approximately twice the applied voltage to increase the operating life.

2.1.1.3 Motor space heaters

When medium voltage motors are controlled by the lineup of switchgear, the Supplier shall furnish space heater power buses throughout the switchgear, and all space heater wiring shall be integral to the switchgear with suitable branch circuit protection. Motor space heater circuits shall also include connection to switchgear breaker auxiliary contacts and connections to terminal blocks for external connections.

2.1.1.4 Nameplates

Engraved nameplates shall be furnished for the front and rear of each switchgear unit and for equipment and devices within each unit.

2.1.2 Power Circuit Breakers

The switchgear shall be furnished with high voltage power circuit breakers of standard drawout design with the following design features:

Shall not be forced cooled.

All secondary device contact surfaces and main contact surfaces shall be silver-to-silver, designed and fabricated to be self-aligning and to resist burning and deterioration.

Removable breaker units of the same type and ampere capacity shall be wired alike and shall be mechanically and electrically interchangeable.

Shall be a 3-pole single-throw unit, complete with operating mechanism and other required devices, mounted on a drawout type carriage. Each operating

mechanism shall be of the stored energy type with a closing coil and single shunt trip coils. The closing devices, tripping devices, and charging motor shall be designed and rated for operation on the nominal control voltage specified.

Operating mechanisms shall be trip-free in any position and shall be antipump. The breaker main contacts shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.

Each breaker shall be furnished with a manual trip push button which mechanically trips the breaker. The manual trip push button and its associated breaker trip linkage shall have no common components with the electrical trip mechanism, except the final breaker release device.

Each breaker shall be furnished with an operations counter which shall be readable from the front of the switchgear unit with the breaker in the connected position.

2.1.2.1 Rating

Power circuit breakers furnished under these specifications shall be provided with the ratings as required by the Supplier's design. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

2.1.2.2 Auxiliary contacts

Each breaker shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for operation of the breaker. In addition, two normally open and two normally closed sets of spare contacts shall be provided and wired out to terminal blocks for use by the Purchaser.

Breaker mechanism operated auxiliary switches shall operate only when the breaker is in the connected position.

2.1.2.3 Breaker control devices

Each remotely controlled breaker shall be furnished with a local control switch and breaker position switch arranged to provide the following control of breaker operation:

Breaker Drawout Position	**Breaker Operation**			
	Remote Control		**Local Control Switch**	
	Close	**Trip**	**Close**	**Trip**
Connected	X	X	--	--
Test	--	--	X	X

Disconnected	--	--	--	--

Each circuit breaker local control switch shall have a trip/close escutcheon, shall have a center normal position, shall be spring return to normal from close and trip, shall have red and green targets to indicate the latest operation of the switch, and shall be furnished with indicating lights. One set of these contacts shall be wired out to terminal blocks for use by the Purchaser.

The breaker position switch shall be furnished with four stages. Two breaker position switch contacts shall close only when the breaker is in the connected position; the remaining two contacts shall close only when the breaker is in the test position.

2.1.3 Power and Control Conductors

Switchgear power and control conductors shall be furnished in accordance with the requirements of the articles which follow. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through a full ambient temperature range from -13° F (-25° C) to +104° F (+40° C). Expansion joints shall be furnished where required.

2.1.3.1 Main bus

The switchgear main bus shall be copper bar, designed to continuously carry the current required by the Supplier's design plus a 25 percent margin without exceeding temperature rise requirements specified in the applicable standards.

The bus shall be installed with rigid, nontracking, fire-resistant, and nonhygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the close and latch and short-time current ratings of the circuit breakers as specified.

The ungrounded busbars shall be insulated with epoxy, applied using a fluidized bed system or shall be insulated in a manner approved by the Purchaser. Details of the insulation system shall be supplied with the technical data.

All power current carrying connections shall be bolted together. All joints shall have silver-to-silver contact surfaces with minimum contact resistance.

Instrument transformer primary connections shall be designed to permit removal and replacement of the transformers without damage to the connections.

When incoming and outgoing cable and bus connections are accessed from the rear of the equipment, removable insulating boots shall be used to insulate the bolted connections. The insulation rating of the boot shall not be less than the voltage rating of the equipment.

2.1.3.2 Ground (earthing) bus

An uninsulated copper ground bus with a momentary rating at least equal to the momentary rating of the circuit breakers shall be furnished through the entire length of the switchgear. All switchgear equipment requiring grounding shall be connected to this ground bus.

Each compartment containing terminals for connection of external power circuit conductors shall also contain provisions for attaching feeder cable shield ground conductors directly to the ground bus. The compartment ground buses shall also be furnished with clamp type connectors for attachment of the power circuit ground cables.

2.1.4 External Connections

Facilities for the entrance, support, termination, and connection of power and control conductors shall be furnished in accordance with the requirements of the following articles.

2.1.4.1 Entrance

Adequate openings shall be furnished for all conductors (metal-enclosed bus duct, power cables, and control cables, as required) entering the switchgear.

2.1.4.2 Terminal connectors

Terminal connectors for power cable and ground (earthing) cable entering the switchgear shall be long-barrel, 2 hole, bolted clamp or compression type. Solder type terminals are not acceptable.

2.1.4.3 Stress cones

Where power conductors entering a switchgear unit will be cable, adequate space and supporting facilities shall be furnished for flaring of power cables, for field installation of stress cones, and for support of the cable. Hot or cold shrink type termination kits shall be utilized.

2.1.4.4 Bus duct

Where bus duct is entering the switchgear, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.1.4.5 Ground (earthing) bus

Connectors shall be furnished at each end of the switchgear assembly ground bus. Each switchgear unit containing terminals for connection of external power cable shall be furnished with connectors for attaching power cable shields directly to the ground bus.

Each switchgear unit containing terminals for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground bus to the switchgear ground bus and/or bonding the bus duct enclosure to the ground system.

2.1.5 Control Power

Control power for each continuous bus switchgear assembly shall be as specified on the Electrical Design and Equipment Data Sheets included at the end of this section. Control power monitoring shall be provided. When ac control derived from control power transformers within the switchgear is specified, a capacitive charged tripping system shall be provided to permit tripping all of the circuit breakers for a period of at least 24 hours after medium voltage power has been lost.

The Supplier shall furnish all internal switchgear wiring required to distribute control power to each switchgear unit. Each breaker shall be furnished with a 2-pole control power disconnecting and protective device in the closing circuit, and shall be furnished with a 2-pole control power disconnecting and protective device in each tripping circuit. The disconnecting and protective devices shall be molded case circuit breakers or enclosed fused pullouts.

2.1.6 Instrument Transformers, Instruments, and Associated Devices.

Instrument transformers, instruments, and associated devices shall be furnished as required by the Supplier's design. All instrument transformer secondary leads shall be wired out to terminal blocks.

2.1.6.1 Current transformers

Current transformer mechanical and thermal limits shall be coordinated with the momentary and short-time ratings of the circuit breakers with which they are used.

Window type current transformers shall have a 5.25 inch (133 mm) diameter circular window or the oval equivalent. Window current transformers shall be mechanically braced to withstand the same momentary current as the circuit breakers with which they are used. Where a window current transformer braced for the same momentary current as the circuit breaker is unavailable with the ratio specified, the Supplier shall furnish a combination of a window current transformer braced for the momentary current of the circuit breaker and an associated auxiliary current transformer. The product of the ratios of the window current transformer and the auxiliary current transformer shall be equal to the ratio specified.

2.1.6.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second; shall be mounted and have secondary voltage, capacity, accuracy,

and other ratings as required by the Supplier's design; and shall be compatible with the Purchaser's equipment.

Each transformer shall be provided with current limiting primary fuses and secondary fuses, and shall be mounted with primary fuses on a drawout type removable unit designed to isolate and ground (earth) the potential circuits when the unit is in the fully withdrawn position.

2.1.6.3 Protective relays

Each breaker unit shall be provided with at least one solid-state or microprocessor type protective relay and, as a minimum, shall have the following protective functions:

	ANSI C37 Device Function Number							
	25	**27**	**46**	**49**	**50**	**50G**	**51**	**51N/G**
Incoming main breaker	X					X	X	
Tie breaker	X						X	X
Bus feeder breaker							X	X
Motor feeder breaker		X	X	X	X	X		
SUS transformer feeder				X	X	X		

Relay types to be proposed shall be submitted with the bid documents and shall be subject to approval by the Purchaser.

Auxiliary relays mounted internally shall be surface mounted and front connected.

2.1.7 Wiring and Wiring Diagrams

The Supplier shall furnish internal switchgear wiring, connections, and diagrams in accordance with the requirements of the following articles.

2.1.7.1 Control and instrument wiring

All low voltage control and instrument wiring shall be installed and tested at the factory.

All interior wiring shall be neatly and carefully installed in wiring gutters or conduit and shall be terminated at terminal blocks plainly lettered or marked in accordance with the Supplier's connection diagrams. Extra flexible wire shall be furnished at hinge points.

Switchgear units that are split for shipment shall be furnished with all wiring required to interconnect the switchgear units.

The minimum sizes of wire used in the switchgear for control and instrumentation shall be in accordance with the following table:

Minimum Wire Service	**Size, AWG (mm^2)**
Power supplies	12 (4)
Current transformer circuits	12 (4)
Indicating lights and annunciator circuits	16 (1.5)
All other wiring	14 (2.5)

2.1.7.2 Diagrams

Wiring diagrams shall be in accordance with the requirements specified herein.

The complete connection diagram of each switchgear unit shall be on an individual sheet. Information on each connection diagram sheet shall include point-to-point wiring of the entire unit as it would appear to a person wiring the switchgear unit, including wiring on the breaker itself. Elementary diagrams of control and instrument circuits, contact arrangement of switches, and internal wiring of relays and instruments for each switchgear unit shall be on additional sheets as required. Interconnection diagrams shall be on separate sheets. All sheets shall be the same size.

Each item of switchgear mounted equipment indicated on the diagrams shall be identified by item number and name.

Sufficient space shall be left on the customer's side of outgoing terminal blocks for adding cable color codes and circuit numbers.

At the time the Supplier's connection drawings are submitted for review, the Purchaser will mark thereon all external (interface) circuit and wire designations required, and such designations shall be added to the connection drawings by the Supplier.

2.2 Medium Voltage Controller Equipment Specification

When specified to be in the Supplier's scope of supply, the Supplier shall supply medium voltage metal-clad switchgear in accordance with the articles below and as required by the Supplier's design. The design shall be in accordance with accepted industry practices and standards for electrical power generation.

Design and construction of medium voltage controllers shall be in accordance with the requirements of the articles which follow.

2.2.1 Enclosures

Each assembly shall be furnished with enclosures of the types specified below:

Location	**Description of Enclosure Type**
Indoors	Indoor with gasketed doors, ventilated
Outdoors	Weatherproof, walk-in protected aisle
Outdoors	Weatherproof, without enclosed operating and maintenance aisle

Each controller assembly shall consist of a lineup of free-standing metal-enclosed vertical sections interconnected into an integrally built group.

Main contactors and, when required, main incoming circuit breakers shall be removable from the front. Grounded removable steel barriers shall be provided between the medium voltage and low voltage compartments.

2.2.1.1 Front doors

Each controller unit shall include a hinged front door for the medium voltage compartment and a separate hinged front door for the low voltage compartment.

Doors shall be designed and adequately constructed for the mounting of instruments, meters, relays, switches, indicating lights, and other specified devices. Doors shall be hinged and shall have turned-back edges and additional bracing where required to ensure rigidity.

2.2.1.2 Indoor general purpose enclosures

Each unit of switchgear specified on the Electrical Design and Equipment Data Sheets to be furnished with an indoor general purpose enclosure shall be furnished with a hinged front door, as previously specified, and a removable rear panel.

2.2.1.3 Outdoor weatherproof enclosures without an enclosed operating and maintenance aisle

Each unit of switchgear specified on the Electrical Design and Equipment Data Sheets to be furnished with an outdoor weatherproof enclosure without an enclosed operating and maintenance aisle shall be furnished with an interior hinged front door as previously specified and an exterior hinged and gasketed front door. The rear of each such unit shall be furnished with a removable gasketed panel or hinged and gasketed door.

Exterior doors shall have concealed hinge construction and three-point single handle operated latches. Exterior door handles shall be locking type; the switchgear enclosures shall be tamper resistant.

Ventilation openings shall be furnished with filters.

One convenience outlet shall be furnished in each switchgear unit. The Supplier shall furnish all convenience outlet wiring integral to the switchgear and suitable branch circuit protection.

The underside of the switchgear shall be coated with protective sealing compound.

2.2.1.4 Outdoor weatherproof enclosures with an enclosed operating and maintenance aisle

Each unit of switchgear specified on the Electrical Design and Equipment Data Sheets to be furnished with an outdoor weatherproof enclosure with an enclosed operating and maintenance aisle shall be furnished with an interior hinged front door as previously specified and an enclosed operating and maintenance aisle along the front of the controller assembly. The rear of each such unit shall be furnished with a removable gasketed panel or a hinged and gasketed door.

Each operating and maintenance aisle shall be of sufficient width to allow removal of breakers from the front of the units and shall be furnished with a door at each end of the controller assembly. The doors shall be equipped with panic hardware.

Ventilation openings shall be furnished with filters. The underside of the controller assembly shall be coated with a protective sealing compound.

One 100 watt incandescent lighting fixture shall be furnished in the operating and maintenance aisle for each two controller units, and one 150 watt outdoor incandescent lighting fixture shall be furnished over each exterior aisle door. A weatherproof light switch shall be mounted on the exterior of the controller enclosure adjacent to each exterior aisle door for control of all lights. One convenience outlet shall be furnished at each end of the operating and maintenance aisle.

2.2.1.5 Controller space heaters

Where space heaters are specified, all units and the individual compartments of divided units shall be provided with space heaters to prevent condensation of moisture within the enclosures. The heaters shall be spaced away and thermally insulated from any painted surfaces. Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage stated on the Electrical Design and Equipment Data Sheets.

Unless specified otherwise, the Purchaser will provide a single space heater supply feeder to each continuous assembly having a common bus. The Supplier shall furnish contactors, all required internal wiring, suitable branch circuit protection for each space heater circuit, and space heater power buses throughout the controller assembly.

Controller and auxiliary equipment units shall have space heaters controlled by an adjustable thermostat, factory set to close at 85° F (30° C) and to open at 95° F (35° C).

Where a common enclosure and motor space heater bus is specified on the Electrical Design and Equipment Data Sheets, the Supplier shall make connections to the space heater bus for the purpose of providing motor space heater power.

2.2.1.6 Motor space heaters

Where a separate motor space heater bus is specified on the Electrical Design and Equipment Data Sheets, the Supplier shall furnish wiring through the length of the controller assembly. The Supplier shall make a connection to a terminal block for external connection to each motor space heater from the motor space heater bus or the controller assembly space heater bus, as applicable. Each motor space heater circuit shall be routed through a normally closed auxiliary switch contact or auxiliary contact and shall include suitable branch circuit protection.

2.2.1.7 Nameplates

Engraved nameplates shall be furnished for the front of each unit. Equipment and devices within each unit shall be identified with permanently printed tags or engraved nameplates. Nameplate inscriptions will be provided by the Purchaser at a later date.

2.2.2 Incoming Power Circuit Breakers

When required on the Electrical Design and Equipment Data Sheets, the controller assembly shall be furnished with high voltage power circuit breakers of standard drawout design.

The breakers shall not be forced cooled.

All secondary device contact surfaces and main contact surfaces shall be silver-to-silver, designed and fabricated to be self-aligning and to resist burning and deterioration.

Removable breaker units of the same type and ampere capacity shall be wired alike and shall be mechanically and electrically interchangeable.

Terminal designations shall be as indicated on the typical schematic diagrams furnished by the Supplier.

2.2.2.1 Rating

Power circuit breakers furnished under these specifications shall be provided with the ratings as required by the Supplier's design. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

2.2.2.2 Low current switching capability

In addition to conforming with load current switching capability requirements of the applicable standard, breakers shall be capable of interrupting low current loads and faults as specified herein. Breakers shall be capable of interrupting inductive loads having power factors in the range of 20 percent lagging to 80 percent lagging, with current values in the range of 2 percent to 100 percent of the breaker continuous current rating. These loads shall be interrupted without exceeding the rated interrupting time by more than 2.5 cycles for opening operations and 3.5 cycles for close-open operations.

2.2.2.3 Operating mechanism

Each power circuit breaker shall be a 3-pole single-throw unit, complete with operating mechanism and other required devices, mounted on a drawout type carriage.

The operating mechanism shall be of the stored energy type with a closing coil and single or dual shunt trip coils as specified on the Electrical Design and Equipment Data Sheets. The closing devices, tripping devices, and charging motor shall be designed and rated for operation on the nominal control voltage specified.

The operating mechanism shall be trip-free in any position and shall be antipump. The breaker main contacts shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.

Each breaker shall be furnished with a manual trip push button which mechanically trips the breaker. The manual trip push button and its associated breaker trip linkage shall have no common components with the electrical trip mechanism, except the final breaker release device.

Each breaker shall be furnished with an operations counter which shall be readable from the front of the switchgear unit with the breaker in the connected position.

2.2.2.4 Auxiliary contacts

Each breaker shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for operation of the breaker. In addition, two normally open and two normally closed sets of spare contacts shall be provided and wired out to terminal blocks for use by the Purchaser.

Breaker mechanism operated auxiliary switches shall operate only when the breaker is in the connected position.

All spare auxiliary contacts shall be wired to terminal blocks for external connection.

2.2.2.5 Breaker control devices

Each remotely controlled breaker shall be furnished with a local control switch and breaker position switch arranged to provide the following control of breaker operation:

Breaker Drawout Position	**Breaker Operation**			
	Remote Control		**Local Control Switch**	
	Close	**Trip**	**Close**	**Trip**
Connected	X	X	--	--
Test	--	--	X	X
Disconnected	--	--	--	--

Each circuit breaker local control switch shall have a trip/close escutcheon, shall have a center normal position, shall be spring return to normal from close and trip, shall have red and green targets to indicate the latest operation of the switch, and shall be furnished with indicating lights.

The breaker position switch shall be furnished with four stages. Two breaker position switch contacts shall close only when the breaker is in the connected position; the remaining two contacts shall close only when the breaker is in the test position.

2.2.3 Controllers

Controllers shall consist of an assembly of contactors, primary disconnects, current limiting fuses, transformers, and control and instrument equipment as specified in the articles which follow.

The Supplier shall be responsible for the coordination of the contactors, current transformers, protective relays, and current limiting fuses. In selecting suitable components, the following points must be considered:

1. Protection of the load against sustained overloads and locked-rotor conditions, for motor loads, by opening of the circuit with the contactor by means of the protective relay.

2. Protection of the fuses against sustained currents above their continuous ampere rating but below their melting value by opening of the circuit with the contactor by means of the protective relay.

3. Protection of the feeder circuit within the interrupting limits of the contactor by opening the circuit with the contactor by means of the protective relay and not opening the circuit with the fuses.

4. Protection of the feeder circuit, contactor, current transformers, and protective relay from the damaging effects of maximum fault

currents by opening the circuit with properly sized current limiting fuses.

2.2.3.1 Main contactors

Contactors shall be 3-pole, single-throw, vacuum break units furnished electrically and mechanically complete. Contactors shall be capable of carrying the ampere rating as required by the Supplier's design continuously when mounted in a ventilated indoor enclosure in a 104° F (40° C) ambient. Contactors shall be of the magnetically held-in type. When the coil circuit is interrupted, the contactor shall open the feeder circuit. Controller control voltage shall be as specified on the Electrical Design and Equipment Data Sheets. Where an ac control voltage is specified, the contactor coils shall be ac rated or shall be dc rated and shall be supplied from a silicon full wave bridge rectifier furnished on the controller.

Each contactor shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for proper operation of the equipment. Not less than three spare "a" and three spare "b" auxiliary contacts shall be furnished on each contactor. In addition, mechanically operated auxiliary switches shall provide not less than four spare "a" and four spare "b" contacts. The auxiliary switches shall be stationary and shall be mounted in the controller enclosure. All auxiliary switch contacts shall be wired to terminal blocks for use with control circuits where needed.

The contactors shall be capable of carrying their rated full load current continuously without exceeding the temperature rise as specified in the latest applicable standards. The contactors shall be cooled by natural conduction, convection, and radiation. Contactor insulation shall be coordinated with that of the controller assembly structure.

All contactors of the same unit type shall be wired alike and shall be mechanically and electrically interchangeable.

Where drawout contactors are specified, the contactor drawout assembly shall be furnished complete with wheels to provide easy removal from the enclosure.

2.2.3.2 Disconnecting mechanism

A 3-pole externally operated disconnecting mechanism shall be furnished for disconnecting each controller from the bus. For drawout type contactors, operating the mechanism shall disconnect the contactor from the bus and shall operate an automatic insulated shutter to close the openings to the bus. For fixed mounted contactors, operating the mechanism shall open a disconnect switch which will disconnect power to the contactor, power fuses, and control power transformer (if applicable) from the bus. The medium voltage bus shall be isolated from the rest of the medium voltage compartment by insulated barriers or shutters when the discon-

nect switch is open. The disconnect switch shall have a continuous current rating not less than that of the contactor.

Mechanical interlocking means shall be provided to prevent operating the mechanism with the contactor closed. An electrical interlock shall be provided to trip the contactor before enabling operation of the mechanism. Provisions shall be made to allow padlocking of the disconnecting mechanism handle in both the ON and the OFF positions.

2.2.3.3 Fuses

Current limiting fuses shall be furnished to ensure positive interruption of faults to limit the magnitude of short-circuit current and electromechanical stresses to values within the design limits of the controller assembly components.

In addition, the fuses shall limit the surge voltage produced by short-circuit currents to within allowable limits of the applicable standard.

Power fuses shall be supplied by the Supplier. Easy identification of blown fuses shall be provided by positive action indicators.

Fuses shall be furnished for protection of control power transformers and potential transformers. Control power transformer fuses shall be Buss JCW or equal and shall be E rated.

Fuses shall be designed to prevent discharge of flame or gas when operated and shall not require discharge filters, fire boxes, special vents, or reinforcing.

For drawout design, power fuses shall be mounted on the contactor drawout assembly. Where specified, the power fuses shall be equipped with anti-single-phasing devices to open the contactor on a blown fuse and prevent single-phasing of the load.

2.2.4.1 Main bus

Each controller assembly main bus shall be made of the material specified on the Electrical Design and Equipment Data Sheets and shall be capable of carrying rated current continuously without exceeding temperature rise requirements specified in the latest applicable standards.

The bus shall be installed with rigid, non-tracking, nonflammable, and non-hygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the short-time current rating of the largest contactor.

When bus bar insulation is specified on the Electrical Design and Equipment Data Sheets, all buses which are to be insulated shall be furnished with an insulating sleeve, coated with epoxy type insulating material or acceptable equal molded around and bonded to the bus, or shall be taped, except at bolted terminations and connection

points. All bolted joints; expansion joints; and all bus connections, factory or field, shall be insulated with removable boots. Removable boots shall be designed to overlap bus insulation a minimum of 1 inch (25 mm). Insulation rating of bus, joint, connection, and terminal insulation shall be at least equal to the voltage rating of the equipment.

All joints shall have minimum contact resistance and, when specified, shall have tinned or silver contact surfaces.

The main bus shall be arranged Phase A (1), Phase B (2), and Phase C (3), from left to right, from front to back, and from top to bottom when facing the front (operating side) of the controller assembly.

2.2.4.2 Ground (earthing) bus

An uninsulated copper ground (earthing) bus, with a momentary short-time rating at least equal to the momentary and short-time rating of the largest contactor, shall be furnished through the entire length of each controller assembly. All of the assembly equipment requiring grounding (earthing) shall be connected to this ground (earthing) bus. Each compartment containing terminals for connection of external power circuit conductors shall also contain provisions for attaching feeder cable shield ground (earthing) conductors directly to the ground (earthing) bus. Where specified on the Electrical Design and Equipment Data Sheets, the compartment ground (earthing) bus shall also be furnished with a clamp type connector for attachment of the power circuit ground (earthing) cable. Provisions shall be made for the attachment of 2/0 AWG (70 mm^2) to 4/0 AWG (120 mm^2) stranded copper cable to each end of the ground (earthing) bus in each end section of the assembly for external connection to the station ground (earthing) grid.

2.2.4.3 Bus connections

Connections between the main buses and disconnecting devices, instrument transformers, and contactors shall be furnished and installed with an insulating cover equal to the insulation of the main bus (if so insulated). All main current carrying connections shall be made by bolting together flat bar. Insulated cable connections shall be furnished for the control power transformers (if applicable).

Current transformer primary connections shall be designed to allow easy removal and replacement of the transformers without damage to the connections.

All material required for field connection and insulation of bus and terminals shall be provided if an insulated bus system is furnished.

2.2.5 External Connections

Facilities for the entrance, support, termination, and connection of power supply and feeder conductors shall be provided in accordance with the requirements of the articles which follow.

2.2.5.1 Entrance

Adequate openings shall be furnished for all conductors entering each controller assembly. Cable entrance will be from above or below as indicated on the Electrical Design and Equipment Data Sheets.

2.2.5.2 Terminal connectors

Terminal connectors for all power cable and external ground (earthing) conductors entering each controller assembly shall be provided and shall be the same as, or an acceptable equal to, the following terminals. Solder type terminals are not acceptable:

Copper Conductor Cable Size, AWG (mm^2)	**Burndy Terminal Connectors Compression Type**
8 (10) and smaller	YAV
6 (16) and larger	YA-2N (long barrel)

2.2.5.3 Stress cones

Where the power conductors entering a controller unit will be cable, adequate space and supporting facilities shall be furnished for flaring of power cables, for field installation of stress cones, and for support of the cable.

Cable termination points and current transformers shall be arranged for convenient routing of the power conductors (from the direction specified) to the terminal point. Proper clearances and bending space shall be provided.

2.2.5.4 Bus duct

Where bus duct is utilized for power conductors, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.2.5.5 Ground bus

Ground cable connectors shall be furnished for the attachment of stranded copper cable to the ground (earthing) bus for external connection to the station grounding (earthing) system. Connectors shall be furnished at each end of the controller assembly ground (earthing) bus. Each controller unit containing terminals for connection of external power cable shall be furnished with connectors for attaching power cable shields directly to the ground (earthing) bus.

Each controller unit containing terminals for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground (earthing) bus to the switchgear ground (earthing) bus.

2.2.6 Control Power

Electrical power for control and instrumentation shall be as required by Supplier's design.

Where dc control power is specified on the Electrical Design and Equipment Data Sheets, the Supplier shall provide a common bus throughout the controller assembly requiring a single connection of dc control power from the Purchaser. Suitable branch circuit protection and control power disconnecting means shall be provided for each controller unit.

The paragraphs which follow apply only to ac control power.

Where ac control power is specified on the Electrical Design and Equipment Data Sheets, all control power requirements necessary to operate each controller shall be provided by means of individual control power transformers. Each controller unit shall be provided with an individual transformer for control and instrumentation associated with that controller only.

Control power transformers shall be rated not less than 1 kVA. Each control power transformer shall be provided with primary and secondary fuses. The size of each control power transformer shall be clearly indicated on each section schematic and wiring diagram submitted for review.

Control power interlocking provisions shall be provided to allow testing of the control operation of each controller from an external source of control power with the contactor disconnected and isolated from the main bus.

Control power interlocking provisions shall not allow the control power transformer of the controller to be energized during testing as described above.

The Supplier shall furnish a manually operated switch to transfer the control power from the normal source to the external test circuit source.

2.2.7 Instrument Transformers, Instruments, and Associated Devices

Instrument transformers shall be designed for use with meters, relays, and instruments, in accordance with the latest applicable standards. Instrument transformer secondary leads shall be brought out to terminal blocks grouped for the connection of external circuits.

2.2.7.1 Current transformers

Current transformer thermal and mechanical limits shall be coordinated with the short-time rating of the controller with which they shall be used. All current transformers shall be single ratio unless otherwise specified. All current transformer leads shall be

brought out to shorting type terminal blocks arranged to provide any combination of connections or polarity.

Window type current transformers for zero sequence fault current sensing shall be provided for each controller when ground (earth) fault protection is specified. The transformers shall be installed in accordance with the recommendations of the relay manufacturer. Where bottom entry is specified, the transformers shall be spaced above the enclosure bottom to allow the cable shield ground (earthing) conductor to be brought through and connected to the ground (earthing) bus.

2.2.7.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second and shall be mounted and have secondary voltage, capacity, accuracy, and other ratings as required by the Supplier's design.

Each transformer shall be provided with current limiting primary fuses and secondary fuses. When voltage transformers are supplied in a drawout assembly, the drawout unit shall have the primary fuses mounted on it and shall be designed to isolate and ground (earth) the potential circuits when the unit is in the fully withdrawn position.

2.2.7.3 Protective relays

Protective relays shall be as required by the Supplier's design. In addition, specific relay types and/or functions, if required by the Purchaser, are indicated on the Electrical Design and Equipment Data Sheets. Protective relays shall be flush mounted, induction or static drawout type, or microprocessor type, equipped with built-in test switches and operation counters.

Auxiliary relays mounted internally shall be surface mounted, front connected.

Field application relays and controls shall be provided for all synchronous motors.

2.2.7.4 Control and instrument switches

All controllers shall have, mounted on the front instrument panel, red and green indicating lights and either START and STOP push buttons or a multistage control switch equipped with modern pistol grip handle.

Unless specified otherwise on the Electrical Design and Equipment Data Sheets, each local control switch shall be wired to close its contactor only when the contactor is in the TEST position. When in the OPERATE position, the contactor may be tripped with either the local emergency stop push button, protective relay trip, or the remote input.

2.2.8 Wiring and Wiring Diagrams

The Supplier shall provide internal wiring, connections, and diagrams in accordance with the requirements of the articles which follow.

2.2.8.1 Control and instrument wiring

All low voltage control and instrument wiring used within the controller assemblies.

All internal wiring shall be neatly and carefully installed and shall be terminated on terminal blocks or devices. Conductors and terminals shall be plainly lettered or marked in accordance with the manufacturer's connection diagrams. Any controller assembly that is split for shipment shall have terminal blocks adjacent to the split and shall be provided with wiring required to interconnect the shipping sections.

All leads for external circuit wiring shall be connected to terminal blocks located for convenient connection of external circuits. Splices will not be permitted in control wiring or instrument leads.

The minimum sizes of wire used in the controller assembly for control and instrumentation shall be in accordance with the following table:

Minimum Wire Service	**Size, AWG (mm^2)**
Power supplies	12 (4)
Current transformer circuits	12 (4)
Indicating lights and annunciator circuits	16 (1.5)
All other wiring	14 (2.5)

All spare contacts on relays, control switches, limit switches, or similar devices shall be wired to accessible terminal blocks for the Purchaser's future connections. All wiring leaving an enclosure shall leave from terminal blocks and not from other devices within the enclosure.

Terminal blocks shall not be mounted in compartments containing cable or bus operating at voltages above 600 volts.

Control and potential buses, as required, shall be switchboard wire installed at the rear of the instrument and control compartment.

Each terminal block, conductor, relay, circuit breaker, fuse block, and other auxiliary devices and terminals shall be permanently labeled to coincide with the identification indicated on the drawings. All wiring terminations shall be identified by legible markings on the device terminals.

2.2.8.2 Diagrams

Wiring diagrams shall be in accordance with the requirements specified herein. Controller schematic, connection, and interconnection diagrams furnished by the

Supplier shall be based on schematic (elementary) diagrams and connection diagrams furnished by the Purchaser.

The typical schematic diagram of each type of controller specified shall be submitted with the proposal.

The Supplier shall prepare his schematic (elementary), connection, and interconnection diagrams which shall have terminal designations and terminal arrangement acceptable to the Engineer.

The complete connection diagram of each controller unit shall be on an individual sheet. Information on each connection diagram sheet shall include point-to-point wiring of the entire controller as it will be physically constructed, including wiring on the contactor itself. Elementary diagrams of control and instrument circuits, contact arrangement of switches, and internal wiring of relays and instruments for each section shall be on additional sheets as required. Interconnection diagrams shall be on separate sheets. All sheets shall be the same size.

Information indicated on the Supplier's drawings shall include wiring of the individual units as they will actually appear in the assembly, contact arrangements of switches, and internal wiring of relays and instruments.

Each item of mounted equipment indicated on the diagrams shall be identified by item number and name.

2.2.8.3 Wiring method

If the wiring method is to be an internal programmable logic controller (PLC) as indicated on the Electrical Design and Equipment Data Sheets, then the Supplier shall furnish a Purchaser-approved PLC in each shipping split of each controller assembly. All control wiring from the device contacts and protective relays to the internal PLC shall be installed by the Supplier as indicated on the typical schematics. The Purchaser will program the PLCs as required.

If a remote PLC is to be used as indicated on the Electrical Design and Equipment Data Sheets, the Supplier has no responsibility to provide or connect device contacts and protective relays to the PLC.

2.2.9 Tightening of Connections

The Supplier shall include on his erection and assembly drawings complete information for tightening of all electrical connections secured with bolts or studs. The information furnished shall include torque wrench settings or complete details of other tightening procedures recommended for bus joints, connector attachments, and contact attachments.

2.3 Low Voltage Switchgear and Motor Control Equipment

This technical specification is intended for procurement of low voltage metal-clad switchgear and low voltage motor controllers provided as part of a furnish and erect contract. The Supplier shall provide a standard design for items within the scope of this specification, but not covered in detail by these specifications. The standard design shall be in accordance with accepted industry practices and standards for electrical power generation.

2.3.1 Low Voltage Switchgear

Low voltage switchgear shall be in accordance with the standards specified and the general articles below and shall meet the requirements of the Supplier's design.

2.3.1.1 Switchgear enclosures

The switchgear shall be furnished with enclosures of the types specified below:

Location	**Description of Enclosure Type**
Indoors	Indoor with gasketed doors, ventilated
Outdoors	Walk-in protected aisle

Switchgear equipment shall be mounted in vertical sections fabricated of steel and assembled to provide rigid self-supporting structures.

The breakers shall be removable from the front and shall be furnished with hinged front door(s) to allow removal of the circuit breaker(s).

Each unit of switchgear section shall have a removable rear panel.

2.3.1.2 Switchgear space heaters

Each vertical section of switchgear shall be furnished with space heaters to prevent condensation of moisture within the switchgear. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored.

Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage specified. Space heaters shall be controlled by an adjustable thermostat or fixed humidistat.

2.3.1.3 Motor space heaters

When motors are controlled by the lineup of switchgear, the Supplier shall furnish space heater power buses to the required sections. All space heater wiring shall be integral to the switchgear and have suitable branch circuit protection. Motor space heater circuits shall also include connection to switchgear breaker auxiliary contacts and connections to terminal blocks for external connections.

2.3.1.4 Nameplates

Engraved nameplates shall be furnished for the front and rear of each switchgear unit and for equipment and devices within each unit.

2.3.1.5 Power circuit breakers

The switchgear shall be furnished with low voltage power circuit breakers of standard drawout design with the following design features:

Shall not be forced cooled.

All secondary device contact surfaces and main contact surfaces shall be silver- or tin-plated, designed and fabricated to be self-aligning and to resist burning and deterioration.

Removable breaker units of the same type and ampere capacity shall be wired alike and shall be mechanically and electrically interchangeable.

Shall be a 3-pole single-throw unit, complete with operating mechanism and other required devices, mounted on a drawout type carriage. Each operating mechanism shall be of the stored energy type with a closing coil and single shunt trip coils. The closing devices, tripping devices, and charging motor shall be designed and rated for operation on the nominal control voltage specified.

Operating mechanisms shall be trip-free in any position and shall be anti-pump. The breaker main contacts shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.

Motor-operated breakers shall be provided with means to manually trip the breaker in an emergency.

Each breaker shall be furnished with an operations counter which shall be readable from the front of the switchgear unit with the breaker in the connected position.

2.3.1.5.1 Rating

Power circuit breakers furnished under these specifications shall be provided with the ratings as required by the Supplier's design. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

2.3.1.5.2 Auxiliary contacts

Each breaker shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for operation of the breaker. In addition, two normally open and two normally closed sets of spare contacts shall be provided and wired out to terminal blocks for use by the Purchaser.

Breaker mechanism operated auxiliary switches shall operate only when the breaker is in the connected position.

2.3.1.5.3 Breaker control devices

Each remotely controlled breaker shall be furnished with a local control switch and breaker position switch arranged to provide the following control of breaker operation:

Breaker Drawout Position	**Breaker Operation**			
	Remote Control		**Local Control Switch**	
	Close	**Trip**	**Close**	**Trip**
Connected	X	X	--	--
Test	--	--	X	X
Disconnected	--	--	--	--

Each circuit breaker local control switch shall have a trip/close escutcheon, shall have a center normal position, shall be spring return to normal from close and trip, shall have red and green targets to indicate the latest operation of the switch, and shall be furnished with indicating lights. One set of these contacts shall be wired out to terminal blocks for use by the Purchaser.

2.3.1.6 Power and control conductors

Switchgear power and control conductors shall be furnished in accordance with the requirements of the articles which follow. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through a full ambient temperature range from -13° F (-25° C) to 104° F (+40° C). Expansion joints shall be furnished where required.

2.3.1.7 Main bus

The switchgear main bus shall be copper bar, designed to continuously carry the current required by the Supplier's design plus a 25 percent margin without exceeding temperature rise requirements specified in the applicable standards.

The bus shall be installed with rigid, non-tracking, fire-resistant, and non-hygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-

circuit currents equal to the close and latch and short-time current ratings of the circuit breakers as specified.

All power current carrying connections shall be bolted together. All joints shall have silver- or tin-plated contact surfaces with minimum contact resistance.

Instrument transformer primary connections shall be designed to permit removal and replacement of the transformers without damage to the connections.

2.3.1.8 Ground (earthing) bus

An uninsulated copper ground bus with a momentary rating at least equal to the momentary rating of the circuit breakers shall be furnished through the entire length of the switchgear. All switchgear equipment requiring grounding shall be connected to this ground bus.

2.3.1.9 External connections

Facilities for the entrance, support, termination, and connection of power and control conductors shall be furnished in accordance with the requirements of the following articles.

2.3.1.9.1 Entrance

Adequate openings shall be furnished for all conductors (metal-enclosed bus duct, power cables, and control cables, as required) entering the switchgear.

2.3.1.9.2 Terminal connectors

Terminal connectors for power cable and ground (earthing) cable entering the switchgear shall be long barrel, 2-hole, bolted clamp or compression type. Solder type terminals are not acceptable.

2.3.1.9.3 Bus Duct

Where bus duct is entering the switchgear, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.3.1.9.4 Ground (earthing) bus

Connectors shall be furnished at each end of the switchgear assembly ground (earthing) bus. Each switchgear unit containing terminals for connection of external power cable shall be furnished with connectors for attaching power cable shields directly to the ground (earthing) bus.

Each switchgear unit containing terminals for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground (earthing)

bus to the switchgear ground (earthing) bus and/or bonding the bus duct enclosure to the ground system.

2.3.1.10 Control power

Control power for each continuous bus switchgear assembly shall be as specified on the Electrical Design and Equipment Data Sheets. Control power monitoring shall be provided. When ac control derived from control power transformers within the switchgear is specified, a tripping system shall be provided to permit tripping all of the circuit breakers for a period of at least 24 hours after power has been lost.

The Supplier shall furnish all internal switchgear wiring required to distribute control power to each switchgear unit. Each breaker shall be furnished with a 2-pole control power disconnecting and protective device in the closing circuit, and shall be furnished with a 2-pole control power disconnecting and protective device in each tripping circuit. The disconnecting and protective devices shall be molded case circuit breakers or enclosed fused pullouts.

2.3.1.11 Instrument transformers, instruments, and associated devices

Instrument transformers, instruments, and associated devices shall be furnished as required by the Supplier's design. All instrument transformer secondary leads shall be wired out to terminal blocks.

2.3.1.11.1 Current transformers

Current transformer mechanical and thermal limits shall be coordinated with the momentary and short-time ratings of the circuit breakers with which they are used.

2.3.1.11.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second and shall be mounted and have secondary voltage, capacity, accuracy and other ratings as required by the Supplier's design.

Each transformer shall be provided with current limiting primary fuses and secondary fuses and shall be mounted with primary fuses on a drawout type removable unit designed to isolate and ground (earth) the potential circuits when the unit is in the fully withdrawn position.

2.3.1.12 Protective relaying devices

Each breaker unit shall be provided with a solid-state protective device and, as a minimum, shall have the following protective functions. Long-time and short-time functions shall have field adjustable current and time-delay settings. The current setting for instantaneous phase trip shall have a field adjustable current setting:

	Long-Time Phase Trip	Short-Time Phase Trip	Instantaneous Phase Trip
Incoming main breaker	X	X	
Tie breaker	X	X	
Feeder breaker	X	X	X
Motor controller	X	X	X

Ground fault protection shall also be provided for all breakers for solidly grounded systems and shall be coordinated upstream and downstream as appropriate.

Auxiliary relays mounted internally shall be surface mounted and front connected.

2.3.2 Low Voltage Motor Control Assemblies

Low voltage control assemblies shall be in accordance with the standards specified and the general articles below and shall meet the requirements of the Supplier's design.

2.3.2.1 Enclosures

The motor control assemblies shall be furnished with enclosures of the types specified below:

Location	Description of Enclosure Type
Indoors - clean	Indoor gasketed
Indoors - dusty areas	Indoor dustproof
Outdoors	Non walk-in weatherproof with filters

Each assembly shall consist of motor controllers, main and tie breakers (as required), and feeder breakers mounted in vertical sections fabricated of steel and assembled to provide rigid self-supporting structures. Controllers and feeder breakers shall be mounted as individual units separated by grounded steel barriers for other units and, where possible, shall be withdraw able from the front. Each controller or breaker unit shall be furnished with hinged front door(s). Each vertical section shall have a removable rear panel (except in the case of back-to-back construction).

2.3.2.1.1 Space heaters

When located outdoors, each vertical section shall be furnished with space heaters to prevent condensation of moisture within the section. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored.

Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage specified. Space heaters shall be controlled by an adjustable thermostat or fixed humidistat.

2.3.2.1.2 Motor space heaters

When motors controlled by the lineup have space heaters, the Supplier shall furnish space heater power buses throughout the motor control lineup. All space heater wiring shall be integral to the lineup and have suitable branch circuit protection. Motor space heater circuits shall also include connections to controller auxiliary contacts and connections to terminal blocks for external connections.

2.3.2.1.3 Nameplates

Engraved nameplates shall be furnished for the front and rear of each switchgear unit and for equipment and devices within each unit.

2.3.2.2 Motor controllers

Combination motor controllers shall be of standard drawout design (when possible) with the following features. Except where required by the Supplier's design, single-speed, full voltage, non-reversing starters shall be used:

Molded case circuit protectors (MCCP) for disconnecting power and magnetic-only short-circuit protection for high magnitude faults. The drawout function shall be disabled when the MCCP is closed.

When the manufacturer's design does not permit the starter unit to be drawout type because of size limitations, a fused, load-break, disconnect device shall be provided in lieu of an MCCP. The fuses shall be disconnected from the power source when the switch is open. Single phasing protection shall be provided.

Bimetallic or solid-state, 3-phase, ambient compensated, overload devices provide suitable overload protection for the motors.

Auxiliary relays as required for the Supplier's design.

Interposing relays as required by the Supplier's process controller.

Control power transformers (with primary and secondary fuses, 100 VA minimum).

2.3.2.3 Main and tie breakers

Main and tie circuit breakers, when furnished in motor control centers, shall be fixed mounted, molded case design. Means to coordinate instantaneous (and ground fault for solidly grounded systems) tripping functions of feeder breakers and MCCPs with main and tie breakers shall be provided. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with th e indicated industry standards for the nominal system voltage utilized.

2.3.2.4 Feeder breakers

Feeder circuit breakers, when furnished in motor control centers, shall be molded case design and shall be withdraw able when available. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

2.3.2.5 Power and control conductors

MCC power and control conductors shall be furnished in accordance with the requirements of the articles which follow. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through a full ambient temperature range from -13° F (-25° C) to +104° F (+40° C). Expansion joints shall be furnished where required.

2.3.2.6 Main bus

The MCC main bus shall be copper bar, designed to continuously carry the current required by the Supplier's design plus a 25 percent margin without exceeding temperature rise requirements specified in the applicable standards.

The bus shall be installed with rigid, non-tracking, fire-resistant, and non-hygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the close and latch and short-time current ratings as specified.

All joints shall have silver- or tin-plated contact surfaces with minimum contact resistance.

2.3.2.7 Ground (earthing) bus

An uninsulated copper ground bus with a momentary rating at least equal to the momentary rating of the circuit breakers shall be furnished through the entire length of the switchgear. All switchgear equipment requiring grounding shall be connected to this ground bus.

2.3.2.8 External connections

Facilities for the entrance, support, termination, and connection of power and control conductors shall be furnished in accordance with the requirements of the following articles.

2.3.2.8.1 Entrance

Adequate openings shall be furnished for all conductors (metal-enclosed bus duct, power cables, and control cables, as required) entering the equipment.

2.3.2.8.2 Terminal connectors

Terminal connectors for power cable and ground (earthing) cable entering the switchgear shall be long barrel, 2-hole, bolted clamp or compression type. Solder type terminals are not acceptable.

2.3.2.8.3 Bus duct

Where bus duct is entering the switchgear, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.3.2.8.4 Ground (earthing)

Connectors shall be furnished at each end of the assembly ground bus for connection of cables from the station ground grid.

Each unit designed for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground bus to the assembly ground bus and/or bonding the bus duct enclosure to the ground system.

2.3.2.9 Instrument transformers, instruments, and associated devices

Instrument transformers, instruments, and associated devices shall be furnished as required by the Supplier's design. All instrument transformer secondary leads shall be wired out to terminal blocks.

2.3.2.9.1 Current transformers

Current transformer mechanical and thermal limits shall be coordinated with the momentary and short-time ratings of the circuit breakers with which they are used.

2.3.2.9.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second and shall be mounted and have secondary voltage, capacity, accuracy, and other ratings as required by the Supplier's design.

Each transformer shall be provided with current limiting primary fuses and secondary fuses.

Auxiliary relays mounted internally shall be surface mounted and front connected.

2.3.2.10 Wiring and wiring diagrams

The Supplier shall furnish internal switchgear and motor control assembly wiring, connections, and diagrams in accordance with the requirements of the following articles.

2.3.2.11 Control and instrument wiring

All low voltage control and instrument wiring shall be installed and tested at the factory.

All interior wiring shall be neatly and carefully installed in wiring gutters or conduit and shall be terminated at terminal blocks plainly lettered or marked in accordance with the Supplier's connection diagrams. Extra flexible wire shall be furnished at hinge points.

Switchgear units that are split for shipment shall be furnished with all wiring required to interconnect the switchgear units.

2.3.2.12 Diagrams

Wiring diagrams shall be in accordance with the requirements specified herein.

2.3.2.12.1 Diagrams for equipment within the supplier’s scope of supply

The complete connection diagram of each unit shall be on an individual sheet. Information on each connection diagram sheet shall include point-to-point wiring of the entire unit as it would appear to a person wiring the switchgear unit, including wiring on the breaker itself. Elementary diagrams of control and instrument circuits, contact arrangement of switches, and internal wiring of relays and instruments for each switchgear unit shall be on additional sheets as required. Interconnection diagrams shall be on separate sheets. All sheets shall be the same size.

Each item indicated on the diagrams shall be identified by item number and name.

Sufficient space shall be left on the customer's side of outgoing terminal blocks for adding cable color codes and circuit numbers.

2.3.2.12.2 Diagrams interconnection of purchaser’s system

At the time the Supplier's connection drawings are submitted for review, the Purchaser will mark thereon all external (interface) circuit and wire designations required, and such designations shall be added to the connection drawings by the Supplier.

2.4 Low Voltage Power Distribution Equipment

When specified to be in the Supplier's scope of supply, the Supplier shall supply low voltage power distribution equipment in accordance with the articles below and as required by the Supplier's design. The design shall be in accordance with accepted industry practices and standards for electrical power generation.

2.4.1 Low Voltage Panelboards and Switchboards

Low voltage power panelboards and switchboards shall be furnished in accordance with the following articles.

2.4.1.1 Enclosures

Panelboards and switchboards shall be furnished with enclosures of the types as follows:

Location	**Description of Enclosure Type**
Indoors - clean area	Indoor with gasketed cover, ventilated
Indoors - dusty area	Indoor dustproof enclosure, unventilated
Outdoors - protected	Combination outdoor/dustproof, unventilated
Outdoors - unprotected	Wash-down/dustproof, unventilated
Hazardous	Listed for conditions present

2.4.1.2 Busing

Main, neutral, and ground busing shall be copper. Voltage and current ratings shall be standard ratings defined in the applicable standards required to meet the requirements of the Supplier's design.

2.4.1.3 Circuit breakers

Main breakers shall be provided in all panelboards and switchboards. Main and feeder breakers shall be molded case, bolt-in type. Voltage and current ratings shall be standard ratings defined in the applicable standards required to meet the requirements of the Supplier's design. Breakers and busing shall be individually rated and labeled for the required short-circuit amperes available. Tandem or miniature circuit breakers shall not be used.

2.4.1.4 Spares

Total expected load on each panelboard or switchboard shall not exceed 80 percent of its continuous current rating. At least one spare feeder breaker of each size and number of poles used for loads shall be provided in each panelboard and switchboard. At least six poles of spare space shall be provided in each panelboard and switchboard.

2.4.2 Dry Type Distribution Transformers

Dry type distribution transformers shall be used indoors in dry areas only and shall meet the following requirements:

Shall have copper windings rated for 302° F (150° C) temperature (by resistance) rise above 104° F (40° C) ambient.

Shall be sized to approximately match the nominal ampacity of the panelboard or switchboard which is connected to its secondary terminals.

Sound level shall not exceed 45 dBA when measured in accordance with NEMA standards.

When installed in areas where dirt and dust are present, shall have filters installed on vent openings or shall be non-ventilated.

Shall be appropriately derated when the ambient temperature exceeds 104° F (40° C).

2.4.3 Nameplates

Engraved nameplates shall be furnished for the front of each item of equipment.

PART 3 – EXECUTION

Not Applicable.

Medium Voltage Switchgear	
Medium voltage switchgear enclosure type	Indoor with gasketed doors, ventilated **or** Outdoor walk-in, protected aisle **or** As required by Supplier's design
Power supply to medium voltage switchgear assemblies provided by Purchaser	120 VAC **or** 230 VAC **or** 125 VDC **or** 110 VDC **or** 250 VDC
Separate control power supply to medium voltage switchgear assemblies provided by Purchaser	120 VAC **or** 230 VAC **or** 125 VDC **or** 110 VDC **or** 250 VDC
Separate space heater power supply to medium voltage switchgear assemblies provided by Purchaser (single supply)	120 VAC **or** 230 VAC
Medium Voltage Controller	
Medium voltage controller enclosure type	Indoor with gasketed doors, ventilated **or** Outdoor walk-in, protected aisle **or** Outdoor without enclosed operating and maintenance aisle **or** As required by Supplier's design
Power supply to medium voltage controller assemblies provided by Purchaser	120 VAC **or** 230 VAC **or** 125 VDC **or** 110 VDC **or** 250 VDC
Separate control power supply to medium voltage controller assemblies provided by Purchaser	120 VAC **or** 230 VAC **or** 125 VDC **or** 110 VDC **or** 250 VDC
Separate space heater power supply to medium voltage controller assemblies provided by Purchaser (single supply)	120 VAC **or** 230 VAC
Medium voltage controller main incoming power circuit breaker required	Yes **or** No
Single or dual shunt trip coils	Single

Controller construction	Maximum two-high stacking **or** Maximum one-high stacking **or** Maximum three-high stacking **or** Manufacturer's standard
Drawout contractors required	Yes **or** No
Bus bar insulation required	Yes **or** No
Controller cable entrance	Above **or** Below **or** As required by Supplier's design
Clamp type connectors required on compartment ground (earthing) bus for attachment of power circuit ground cable	Yes **or** No
Control voltage	120 VAC **or** 230 VAC **or** 125 VDC **or** 250 VDC
Low Voltage Switchgear and Motor Control Centers	
Single power supply to assembly provided by Purchaser	120 VAC **or** 230 VAC **or** 125 VDC **or** 110 VDC **or** 250 VDC
Low voltage switchgear enclosure type	Indoor with gasketed doors, ventilated **or** Outdoor walk-in, protected aisle **or** As required by Supplier's design
Motor control center enclosure type	Indoor, gasketed **or** Indoor, dustproof **or** Outdoor, non walk-in weatherproof with filters **or** As required by Supplier's design
Low Voltage Panelboards and Switchboards	
Enclosure type	Indoors with gasketed cover, ventilated **or** Indoor, dustproof enclosure, unventilated **or** Outdoor, combination outdoor/dustproof, unventilated **or** Outdoor, wash-down/dustproof, unventilated **or** Hazardous, listed for conditions present **or** As required by Supplier's design

END OF SECTION 260510

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for single-conductor and multi-conductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
2. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2 and 3 control cables.
3. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

A. VFC: Variable frequency controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. See WSU design standards.

B. Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2.

D. Multi-conductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for nonmetallic-sheathed cable, Type NM with ground wire.

2.2 CONNECTORS AND SPLICES

A. See WSU design standards.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger, except VFC cable, which shall be extra flexible stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

E. Feeders in Cable Tray: Type THHN/THWN-2, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway, Armored cable, Type AC, Metal-clad cable, or Type MC as per applicable code.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

I. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

J. Branch Circuits in Cable Tray: Type THHN/THWN-2, single conductors in raceway.

K. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

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

3.7 FIRESTOPPING

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

3.8 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 test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test conductors feeding the following critical equipment and services for compliance with requirements.

a. Back-up generators, Panelboards, automatic transfer switches, uninterruptable power sources, transformers, and associated switches.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
    b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Test and Inspection Reports: Prepare a written report to record the following:

    1. Procedures used.
    2. Results that comply with requirements.
    3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
1. Ground rods.
2. Ground rings.
3. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to Operation and Maintenance Data include the following:

a. Instructions for periodic testing and inspection of grounding features

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Comply with WSU Standard requirements.

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad 3/4 inch by 10 feet.

1. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Hand-holes: Install a driven ground rod through manhole or hand-hole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or hand-hole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.4 EQUIPMENT GROUNDING

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

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Receptacle circuits.
3. Single-phase motor and appliance branch circuits.
4. Three-phase motor and appliance branch circuits.
5. Flexible raceway runs.
6. Armored and metal-clad cable runs.
7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

C. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

D. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will 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. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Owner's representative promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Hangers.
b. Steel slotted support systems.
c. Nonmetallic support systems.
d. Trapeze hangers.
e. Clamps.
f. Turnbuckles.
g. Sockets.
h. Eye nuts.
i. Saddles.
j. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawing: For fabrication and installation details for electrical hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Nonmetallic slotted-channel systems.
4. Equipment supports.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which hangers and supports will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Items penetrating finished ceiling, including the following:
   a. Access panels.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
1. Material: Galvanized steel.
2. Channel Width: 1-5/8 inches.
3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
7. Channel Dimensions: Selected for applicable load criteria.

B. Aluminum Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
   1. Channel Width: 1-5/8 inches.
   2. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   4. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
   5. Channel Dimensions: Selected for applicable load criteria.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

   1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
   4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
   5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
   6. Toggle Bolts: All-steel springhead type.
   7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or

greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 4000psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

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

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Hand-holes and boxes for exterior underground cabling.

B. Related Requirements:

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

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

D. EMT: Electrical metallic tubing.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. GRC: Comply with ANSI C80.1 and UL 6.

C. ARC: Comply with ANSI C80.5 and UL 6A.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ENT: Comply with NEMA TC 13 and UL 1653.

C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. LFNC: Comply with UL 1660.

E. Rigid HDPE: Comply with UL 651A.

F. Continuous HDPE: Comply with UL 651B.

G. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

H. RTRC: Comply with UL 1684A and NEMA TC 14.

I. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

J. Fittings for LFNC: Comply with UL 514B.

K. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

L. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

A. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

B. Wireway Covers: **Screw-cover type** unless otherwise indicated.

C. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

C. Description: PVC, extruded and fabricated to required size and shape, and having snap on cover, mechanically coupled connections, and plastic fasteners.

D. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

E. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Owner

2.6 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, with gasketed cover.

E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

F. Cabinets:

1. NEMA 250, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Hand-holes and Boxes:

1. Boxes and hand-holes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Fiberglass Hand-holes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers.

1. Standard: Comply with SCTE 77.
2. Color of Frame and Cover: Gray.
3. Configuration: Designed for flush burial unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and hand-hole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering.
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

2.8 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Hand-hole and Pull-Box Prototype Test: Test prototypes of hand-holes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: EMT.
3. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms.
    d. Gymnasiums.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches of enclosures to which attached.

I. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inchtrade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

J. Stub-ups to Above Recessed Ceilings:

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

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Surface Raceways:

1. Install surface raceway with a minimum 2-inch radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with 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 according to NFPA 70.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.

3. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
4. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Mount boxes at heights indicated on Drawings.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

AA. Locate boxes so that cover or plate will not span different building finishes.

BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

DD. Set metal floor boxes level and flush with finished floor surface.

EE. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install hand-holes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level 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: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

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

3.5 FIRESTOPPING

A. Install fire-stopping at penetrations of fire-rated floor and wall assemblies.

3.6 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water-stop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, water-stop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber water-stop collar with center opening to match piping OD.

2.4 GROUT

A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 4000-psi 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

2. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

   a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
   b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using **steel** pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water-stop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels, including arc-flash warning labels.
8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

C. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.3 LABELS

A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. See WSU design standards.

B. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.

1. See WSU design standards.

C. Self-Adhesive Labels:

1. See WSU design standards.
2. Preprinted, 3-mil thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the raceway diameter, such that the clear shield overlaps the entire printed legend.

3. Vinyl, thermal, transfer-printed, 3-mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

a. Nominal Size: 3.5-by-5 inch.

4. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
5. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 BANDS AND TUBES:

A. Snap-Around, Color-Coding Bands for Raceways and Cables: Slit, pre-tensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceways or cables they identify, and that stay in place by gripping action.

1. See WSU design standards.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

1. See WSU design standards.

2.5 TAPES AND STENCILS:

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. See WSU design standards.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

1. See WSU design standards.

C. Tape and Stencil for Raceways Carrying Circuits 600 V or Less: 4 inch wide black stripes on 10 inch centers placed diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.

1. See WSU design standards.

D. Underground-Line Warning Tape

1. See WSU design standards.
2. Tape:

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

3. Color and Printing:

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

4. Tag: Type I:

    a. Pigmented polyolefin, bright colored, compounded for direct-burial service.
    b. Width: 3 inches.
    c. Thickness: 4 mils.
    d. Weight: 18.5 lb/1000 sq. ft.
    e. Tensile according to ASTM D 882: 30 lbf and 2500 psi.

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

2.6 Tags

A. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory screened permanent designations; punched for use with self-locking cable tie fastener.

1. See WSU design standards.

B. Write-On Tags:

1. See WSU design standards.

2. Polyester Tags: 0.010 inc thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 Signs

A. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:

a. For signs up to 20 sq. inches, minimum 1/16-inch.
b. For signs larger than 20 sq. inches, 1/8 inch thick.
c. Engraved legend with black letters on white face.
d. Punched or drilled for mechanical fasteners.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

3. See WSU design standards.

2.8 CABLE TIES

A. See WSU design standards.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

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

I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

J. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

L. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.3 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch centers. Stop stripes at legends. Apply stripes to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at 30-foot maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl label. Install labels at 30-foot maximum intervals.

D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and hand-holes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase-and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.

d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and hand-holes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

G. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.

H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and hand-holes, use self-adhesive vinyl labels with the conductor or cable designation, origin, and destination.

I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive vinyl labels with the conductor designation.

J. Conductors To Be Extended in the Future: Attach marker tape to conductors and list source.

K. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

L. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

M. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

    a. Power-transfer switches.
    b. Controls with external control power connections.

O. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.

1. Comply with NFPA 70E and ANSI Z535.4.
2. Comply with Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

P. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

Q. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch high letters for emergency instructions at equipment used for power transfer.

R. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.

1. Labeling Instructions:

    a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine plastic label. Unless otherwise indicated, provide a single line of text with 1/2-inch high letters on 1-1/2-inch high label; where two lines of text are required, use labels 2 inches high.
    b. Outdoor Equipment: Engraved, laminated acrylic or melamine label
    c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
    d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment To Be Labeled:

    a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, laminated acrylic or melamine label.
    b. Enclosures and electrical cabinets.
    c. Access doors and panels for concealed electrical items.
    d. Switchgear.
    e. Switchboards.
    f. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
    g. Substations.
    h. Emergency system boxes and enclosures.
    i. Motor-control centers.
    j. Enclosed switches.
    k. Enclosed circuit breakers.
    l. Enclosed controllers.
    m. Variable-speed controllers.
    n. Push-button stations.
    o. Power-transfer equipment.
    p. Contactors.
    q. Remote-controlled switches, dimmer modules, and control devices.
    r. Battery-inverter units.
    s. Battery racks.
    t. Power-generating units.
    u. Monitoring and control equipment.
    v. UPS equipment.

END OF SECTION 260553

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes: distribution, energy efficient dry-type transformers rated 600 V and less, with capacities up to 1500 kVA. Nominally: 408V 3Ø 60Hz delta input; transformer to output 208V 3Ø 60Hz/ (120V 1Ø).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformers, accessories, and components, from manufacturer.

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.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

G. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated.

1. NEMA 250, type 2: Core and coil shall be encapsulated within resin compound utilizing a vacuum pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: NSF/ANSI 61 gray.

F. Taps for Transformers 3 kVA and Smaller: None

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature. Chosen

J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 -deg C rise above 40-deg C ambient temperature.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for non-sinusoidal load current-handling capability to the degree defined by designated K-factor. Chosen

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

M. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

N. Wall Brackets: Manufacturer's standard brackets or floor mounted.

O. Fungus Proofing: Permanent fungicidal treatment for coil and core.

P. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
1. 51 to 150 kVA: ~55 dBA+0-10
2. 751 to 1000 kVA: ~70 dBA +0-10
3. 1001 to 1500 kVA: ~70 dBA +0-10

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
2. Ratio tests at the rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at the rated voltage connections.
4. No load losses, and excitation current and rated voltage at the rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

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

END OF SECTION 262200

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Load centers.
4. Electronic-grade panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.

2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.
11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards 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 [minus 22 deg F (minus 30 deg C)] [23 deg F (minus 5 deg C)] to plus 105 deg F (plus 40 deg C).
b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

C. 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 WSU no fewer than two days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without WSU written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. 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.

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

F. Enclosures: Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5.

2. Height: 84 inches (2.13 m) maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
7. Finishes:

a. Panels and Trim: Galvanized Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

b. Back Boxes: Galvanized Steel.
c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

G. Incoming Mains:

1. Location: Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

a. Plating shall run entire length of bus.
b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
7. Split Bus: Vertical buses divided into individual vertical sections.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.

9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: Ten percent.

L. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.

1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

M. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE.

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."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards.

2.3 POWER PANELBOARDS

A. See WSU Construction Design Standard

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches (914 mm)] high, provide two latches, keyed alike.

D. Mains: Lugs only.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

G. Branch Overcurrent Protective Devices: Fused switches.

H. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. See WSU Construction Design Standard.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: lugs only.

D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

G. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 LOAD CENTERS

A. See WSU Construction Design Standard.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. See WSU Construction Design Standard.

B. MCCB: Comply with UL 489, to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:

a. RMS sensing.
b. Field-replaceable rating plug or electronic trip.
c. Digital display of settings, trip targets, and indicated metering displays.
d. Multi-button keypad to access programmable functions and monitored data.
e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
f. Integral test jack for connection to portable test set or laptop computer.
g. Field-Adjustable Settings:

1) Instantaneous trip.
2) Long- and short-time pickup levels.
3) Long and short time adjustments.
4) Ground-fault pickup level, time delay, and I squared T response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."
2. Fused Switch Features and Accessories:

a. Standard ampere ratings and number of poles.
b. Mechanical cover interlock with a manual interlock override, to prevent the opening of the cover when the switch is in the on position. The interlock shall prevent the switch from being turned on with the cover open. The operating handle shall have lock-off means with provisions for three padlocks.

2.7 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

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

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting:

1. Install panelboards on cast-in-place concrete equipment base(s) where applicable.
2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
3. Comply with requirements for seismic control devices.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim 90” above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mounting panelboards with space behind is recommended for damp, wet, or dirty locations. The steel slotted supports in the following paragraph provide an even mounting surface and the recommended space behind to prevent moisture or dirt collection.

K. Mount surface-mounted panelboards to steel slotted supports 5/8 inch to 1 1/4 inch in depth. Orient steel slotted supports vertically.

L. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

M. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

N. Install filler plates in unused spaces.

O. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

P. Arrange conductors in gutters into groups and bundle and wrap with wire ties**.** Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate.

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate.

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform 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.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers.
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 panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 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.

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

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

3.5 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.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Isolated-ground receptacles.
4. Weather-resistant receptacles.
5. Cord and Plug receptacles.
6. Communications outlets.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from

mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

2.5 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
1. Description:

a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.6 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.8 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: Per Owner, match existing in room or area of work.

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

a. Cut back and pigtail, or replace all damaged conductors.
b. Straighten conductors that remain and remove corrosion and foreign matter.
c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.
D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Non-fusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Molded-case switches.
5. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 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."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of NRTL listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

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.

C. 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.

D. Manufacturer's field service report.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

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

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. 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.

E. Comply with NFPA 70.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

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

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. See WSU construction design standards.

B. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge fuse interiors to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
6. Hook-stick Handle: Allows use of a hook-stick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.
9. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.2 NONFUSIBLE SWITCHES

A. See WSU design standards.

B. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hook-stick Handle: Allows use of a hook-stick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 MOLDED-CASE CIRCUIT BREAKERS

A. See WSU design standards.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I2t response.

F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

G. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

H. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

I. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

J. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system,
6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
8. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11. Zone-Selective Interlocking: Integral with [electronic] [ground-fault] trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: Integrally mounted, self-powered.

2.4 MOLDED-CASE SWITCHES

A. See WSU design standards.

B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Features and Accessories:

1. Standard frame sizes and number of poles.

2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NO contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered.

2.5 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, [Type 1] <Insert type>.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in section 260529.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 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 enclosed switch and circuit breaker, 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 enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 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

END OF SECTION 262816

STATIC THREE PHASE UNINTERRUPTIBLE POWER SUPPLY

TOSHIBA G9000 100kVA/90KW UPS Unit

SECTION 263353 – TOSHIBA STATIC THREE PHASE UNINTERRUPTIBLE POWER SUPPLY

PART 1 - SCOPE

1.1 SYSTEM

These specifications describe a high efficiency continuous duty, three-phase, on-line, double conversion, solid-state Uninterruptible Power Supply system (UPS). The UPS shall operate utilizing the existing power distribution system to provide high quality, uninterruptible power to critical loads.
The model T90S31KS6XSN UPS shall consist of an AC/DC multi-level Insulated Gate Bipolar Transistor (IGBT) Rectifier, DC/DC Converter/Battery Charger, DC/AC multi-level IGBT Inverter, integral static bypass, front-accessible controls, display, and monitor.

1.2 Preferred UPS Vendor

The contractor is to purchase and supply the specified Toshiba UPS from WSU preferred UPS vendor (Ancona Controls). Contact information as follows:

WSU Assign Sales Rep: Beth Ancona
Ancona Controls
28021 Grand Oaks Ct.
Wixom, MI 48393
248-924-2747

PART 2 - SYSTEM DESCRIPTION

2.1 Applicable Standards:

The UPS shall be designed in accordance with and be compliant with the following sections of the current revisions of the following standards:

UL 1778/UL Listed
FCC Class A, Article 47, Part 15.B
ISO 900, ISO 14001
ANSI C62.41
NFPA – 70 National Electric Code
OSHA

2.2 Components:

The UPS shall consist of the following components:

1. Multi-level IGBT AC/DC Rectifier
2. IGBT DC/DC Battery Converter/Charger
3. Multi-level IGBT DC/AC Inverter
4. Hybrid Integral Static Bypass (Thyristor switch with wrap around contactor)
5. Microprocessor Logic and Control Panel
6. Battery Cabinets with DC Breaker (T90-1K007EN-VC)
7. Maintenance Bypass Panel (Circuit Breakers) (T90MBSS10K-S3KK)
8. RemotEye II UPS remote communications and web-based monitor card
9. Network communications with MODBUS interface adapter

2.3 System Operation:

The UPS shall operate as a fully automatic on-line system in the following modes:

1. Normal

   IGBT Rectifier converts AC input power to DC power for the inverter and for charging the batteries. The IGBT inverter supplies clean and stable AC power continuously to the critical load. The UPS Inverter output shall be synchronized with the bypass AC source when the bypass source is within the AC input voltage and frequency specifications.

2. Loss of Main Power

   When Main Power is lost, the batteries shall automatically back up the inverter so there is no interruption of AC power to the critical load.

3. Return of Main Power

   The system shall recover to the operating mode in Item 1 and shall cause no disturbance to the critical load while simultaneously recharging the backup battery.

4. Transfer to Bypass AC source

   If the UPS becomes overloaded the UPS controls shall automatically transfer the critical load from the inverter output to the bypass AC source without interruption. When the overload condition is removed, after a preset “hold” period the UPS will automatically re-transfer the critical load from the bypass to the inverter output without interruption of power to the critical load.

5. Maintenance Bypass

An optional manual make-before-break maintenance bypass panel may be provided to electrically isolate the UPS for maintenance or test without affecting load operation. This bypass mode when selected facilitates testing or repair intervals.

PART 3 - GENERAL CONDITIONS FOR INSTALLATION

3.1 Required Output Capacity:

The 100 kVA (90 KW) UPS unit shall be capable of being operated either independently or connected in parallel.

3.2 UPS Environment:

3.2.1 Standard Environmental Parameters

Operating Temperature Allowance	: 77°F +/-3°F (25°C) Environs within enclosure
Operating Temperature	: 32° to 104°F (0° to 40°C)
Operating Humidity	: 5 - 95% (Non-condensing)
Altitude	: < 700 ft. (<213 m) (without derating)

3.2.2 Discharge Heat from UPS at full load.

100 kVA	: ≥14,100 Btu/Hr

3.2.3 Grounding System:

It is necessary that UPS electrical loads be grounded to the same facility ground as the UPS ground, and that ground wiring shall be for the exclusive use of the UPS and load. Ground wiring for resistance shall be less than ≤ 10 Ohms between the facility ground net and the UPS.

3.2.4 Clearances for installation

Ceiling Level	: 30” minimum from top of UPS to ceiling
Front	: 40” minimum for maintenance (Local and regional codes may apply)
Bottom	: Knockouts for power cable access
Rear	: Zero clearance possible
Sides	: Zero clearance if using bottom cable

	access (Standard knockouts for left/right side cable access)
Base	: Channel mounted

3.2.5 Cable Access

100 kVA	: Bottom access standard : Side knockouts for left/right side access standard (For use with Optional Side Car)

3.2.6 Seismic Mount Provisions

: Manufacturer to specify installation geometry requirements.
(Detroit BOCA inputs basis)

PART 4 - SYSTEM PARAMETERS

4.1 UPS Requirements:

4.1.1 General Requirements:

Rated Output Capacity	: 100 kVA (90 kW)
AC/DC Rectifier Type	: AC/DC multi-level IGBT Rectifier
DC/AC Inverter Type	: DC/AC multi-level IGBT Inverter
External Dimensions	(W) (D) (H)
100 kVA	: 29.5 in.x 40 in.x 78.7 (80.6*) in. * Unit height with fan assembly installed
Weight	
100 kVA	: 880 lbs
Paint Color	: Black (Munsell N1.5)

4.1.2 AC Input:

Configuration	: 3-Phase/3-Wire + Ground
Rated Voltage	: 480V
Voltage Variation	: +15% to –20%
Rated Frequency	: 60Hz
Frequency Variation	: +/-10%
Input Power Factor	: Greater than 0.99 lagging at 25%-115% load

Current THD	: 3% maximum THD at 60%–100% load 6% maximum THD at 25%–59% load (No input harmonic filter required)

4.1.3 Charging Function:

DC Nominal Voltage	: 480 V
AC Ripple on DC Bus	: < 0.2% of DC Voltage
DC Voltage Range	: 400 V to 545 V
DC Float Charging Voltage	: 545 V Maximum charging current:
100 kVA	: 25 A
AC Ripple on DC Charging Circuit	:
100 kVA	: 0.23%

4.1.4 Bypass Input:

Configuration	: 3-Phase/3-Wire + Ground
Rated Voltage	: 480 V
Input Voltage Synchronous Range	: +/-10%
Rated Frequency	: 60Hz
Frequency Variation	: +/-5%
Frequency Synchronous Range	: +/-1 – 5% (0.6 – 3.0 Hz) Selectable
Bypass Overload Capacity	: 1000% for one cycle

4.1.5 AC Output: Configuration

Configuration	: 3-Phase/3-Wire + Ground
Rated Capacity	: 100 kVA (90 kW)
Rated Voltage	: 480 V
Efficiency at % Full Load	: 20% 40% 60% 80% 100%
100 kVA	92.5% 95.6% 95.6% 95.6% 95.6%
Voltage Regulation	: +/-1% (0-100% Unbalanced Load)
	: +/-1% (0-100% Balanced Load)
Voltage Adjustment Range	: +/-3%
Rated Frequency	: 60 Hz
Frequency Regulation	: +/-0.04% (Free-Running Mode)
Frequency Slew Rate	: +/-1.0 Hz/s to +/-5.0 Hz/s (Selectable)
Rated Load Power Factor	: 0.9 PF lagging
Overload Capacity (Inverter)	: 125% for 2 min.,

	150% for 1 min.
Harmonic Voltage Distortion	: 2% maximum THD (100% Linear Load)
	: 5% maximum THD (100% Non-linear Load)
Phase Displacement	: 1° Maximum at 100% Load
Voltage Transients:	
100% Load Step Change	: +/-2% Maximum (Without battery)
Loss or Return of Input	: +/-1% Maximum
Transfer from Bypass to Inverter (At Bypass Rated Voltage)	: +/-5% Maximum
Recovery Time	: 20 ms
Crest Factor	: 2.3

PART 5 - FUNCTIONAL DESCRIPTION

The UPS shall protect the load against surges, sags, undervoltage, and voltage fluctuation. The UPS shall have built-in protection against permanent damage to itself and the connected load for all predictable types of malfunctions. The load shall be automatically transferred to the bypass line without interruption in the event of an internal UPS malfunction. The status of protective devices shall be indicated on a LCD graphic display screen on the front of the UPS.

5.1 IGBT Rectifier

5.1.1 General

A solid-state, multi-level IGBT Rectifier shall convert the incoming AC power into DC power to supply the inverter input and system battery.

5.1.2 Voltage Regulation

The rectifier output voltage shall not deviate by more than +/- 1.0% RMS under the following conditions:

- 0% - 100% loading (balanced and unbalanced non-transient loading)
- +15% – 20% utility voltage change
- +/-10.0% utility frequency change

5.1.3 Reflected Harmonic Content

Input current THD shall be:

- 3% maximum at 60%-100% load
- 6% maximum at 25%-59% load.

5.2 IGBT DC-DC Converter

5.2.1 General

A solid-state IGBT Battery Converter/Charger shall control battery charging.

5.2.2 Battery Charge Current Limit

The Converter logic shall provide DC for controlled battery charging. The battery current sensing shall be independent of the Converter DC Output current sensing to provide precise battery recharging control. The DC/DC Charging Converter shall include a circuit to regulate the battery charging current to between 100% and 125% of maximum battery charging current..

5.2.3 Battery Protection
The converter shall be provided with monitoring and control circuits to protect the battery system from damage due to excessive discharge. Converter shutdown shall be initiated when the battery voltage reaches a discharge cutoff voltage of 400 VDC. Automatic shutdown based on discharge time is not acceptable.

5.2.4 DC Ripple (Without batteries)
AC Ripple on the DC Bus shall be less than 0.2%.
AC Ripple on the Battery charging circuit shall be less than 0.23% for the 80/100/160 kVA UPS, and less than 0.29% for the 225 kVA UPS.

5.3 IGBT Inverter:

5.3.1 General

The inverter shall be composed of multi-level IGBT power transistors controlled utilizing an Advanced Technology PWM logic. The Inverter shall continuously convert DC power from the IGBT Rectifier to AC power for the critical loads. When the utility voltage or frequency exceeds the specified UPS input tolerances, the inverter shall continuously convert DC power from the battery source to AC power for the critical load.

The inverter shall be capable of providing rated output while operating at any battery voltage within the battery operating range. When the DC battery voltage reaches the operational low voltage limit during a loss of utility AC power, the inverter shall automatically shut off.

5.3.2 Output Voltage

The Inverter output voltage shall not deviate by more than +/- 1.0% RMS under the following steady state conditions as the Inverter DC input voltage varies from maximum to cutoff:

- 0% to 100%Unbalanced load
- 0% to 100%Balanced load

5.3.3 Synchronization

The Inverter output voltage shall be automatically synchronized with the bypass AC source as long as the source is within the tolerable frequency and voltage range. If the bypass AC source is not within the range, the control circuitry will stop synchronization and operate the inverter in free running mode. When the bypass AC source recovers to within tolerance, the inverter shall change its frequency (slew rate 1 to 5 Hz/sec, selectable) and track the bypass AC source until synchronization is achieved without causing any disturbance to the load.

5.3.4 Output Control

The Inverter can be manually started and stopped using the LCD touch screen controls.

5.3.5 Overload Capacity:

The Inverter output shall be capable of providing an overload current of 125% for 2 min. and 150% for 1 min. A message on the control panel shall indicate this condition. If the time limit associated with the overload condition expires, or the overload is in excess of the set current limit, the load power shall transfer to the bypass source without interruption.

5.4 Static Bypass Circuit:

5.4.1 General:

An integral static bypass circuit shall be provided to supply an alternate source of power to the critical load in the event the inverter cannot supply rated output power. The bypass circuit shall be capable of supplying the UPS rated load current and accommodate fault clearing.

The 100% duty rated static bypass panel shall be composed of a thyristor switch with a wrap-around contactor. The thyristor switch shall be a high-speed transfer device. The wrap-around contactor shall be electrically connected in parallel to the thyristor switch and shall, at the same time as the thyristor switch, be energized and, upon closure, maintain the bypass source to the load to improve the efficiency and reliability of the system. The thyristor switch shall only be utilized for the time needed to energize the contactor closure.

The UPS system logic shall employ sensing which shall cause the thyristor switch to energize and provide an uninterrupted transfer of the load to the bypass source when any of the following limitations are exceeded:

- Inverter output undervoltage or overvoltage.
- Overloads exceeding 125% for 2 min., or 150% for 1 min. DC circuit undervoltage or overvoltage.
- Final discharge voltage of system battery is reached and the bypass source is present, available, and within tolerance range

Transferring the output from the inverter to the bypass source and vice versa shall be performed by pressing "START/STOP" icon on the touchscreen display.

Operating Mode	Transfer mode	Transfer Type	
		Synchronized	Unsynchronized
Automatic	Inverter to Bypass (Overload, Internal Fault)	Uninterrupted	Interrupted
"BYPASS" switch operated	Inverter to Bypass	Uninterrupted	Interrupted (forced transfer)
Automatic	Bypass to Inverter (Auto-Retransfer Mode)	Uninterrupted	Transfer inhibited
"UPS" switch operated	Bypass to Inverter	Uninterrupted	Transfer inhibited

If the bypass source is beyond the conditions stated below, interrupted transfer shall be made upon detection of a fault condition.

- Bypass voltage greater than + 10%, -10% from the UPS rated output voltage.
- Bypass frequency exceeds ± 3 Hz from the UPS rated output frequency.

5.4.2 Overload Capacity in Bypass:

- Continuous duty : 125% of the system rated capacity
- Overload duty : 1000% of ampere rating for 1 cycle.

5.4.3 Retry function:

When an internal warning/failure has been detected, power flow shall automatically switch from the main circuit (inverter) to the bypass circuit without interruption to the load. If the internal warning is cleared, UPS shall automatically switch the power flow from the bypass circuit to the main circuit (inverter) without interruption.

5.5 Metering, Monitoring, Alarms, and Controls

5.5.1 Status Indicators

The Front Panel shall include LED status indicators for the following states:

Load on Inverter
Battery Operation
Load on Bypass Overload
LCD Fault
UPS Fault

5.5.2 EPO (Emergency Power Off) Button

The Front Panel shall have an Emergency Power Off button (EPO) located on the front panel that, when pressed, will shut down the UPS.

5.5.3 Liquid Crystal Display (LCD) Touch Panel

The Front Panel shall include a LCD touch panel that shall provide performance data, statistics, and operating conditions. The following metering will be displayed on LCD touch panel:

AC Input Voltage
AC Input Frequency
AC Output Voltage
AC Output Current
AC Output Frequency
Battery DC Voltage
Battery DC Current
AC Bypass Voltage
AC Bypass Frequency

5.5.4 Mimic Panel

A one-line diagram of the system shall be displayed on the touch panel display panel to provide a visual status of contactors within UPS. The panel shall display the followings:

AC Input, DC Input
Rectifier in Operation
Inverter in Operation
UPS/Bypass supply
Battery Operating Condition (float charge/discharge)
Fault, Warning
Operation Guidance (LCD Display)
Fault Guidance (LCD Display)

5.5.5 Isolated Control Signals

Ten (10) Normally Open isolated annunciation signal outputs for remote use will be furnished. Eight (8) alarms shall be user programmable, and shall be factory default set as follows

Summary Alarm
Output 1: Load on Bypass
Output 2: Load on Inverter
Output 3: Battery Operation
Output 4: Rectifier Operation
Output 5: Battery Low Voltage
Output 6: Overload
Output 7: Spare
Output 8: Total alarm
Output Contactor Closed

Contact rating:
Output: 1 A @ 30 VDC.
Input: 24 VDC

UPS module accepts remote switches to initiate the following remote operations. These contacts shall be field supplied):
Remote Start
Remote Stop
Battery Temperature High
Power Demand
Remote Emergency Power Off (EPO)

Contact rating:
Input: 24 VDC

The contact signal inputs and outputs shall be wired to a terminal block located inside the UPS.

PART 6 - MECHANICAL DESIGN

6.1 UPS Enclosure Sections

The UPS shall be a freestanding NEMA1 enclosure equipped with a leveling channel base. The enclosure shall include provisions for hoisting, jacking, and forklift handling.

6.2 The seismic structural mounting requirements (welded or bolted) shall be detailed for each/all cabinet modules.

6.3 Cable Access

Cable access to the UPS shall be

- Bottom entry
- Side entry when using optional side cabinet
- Top entry when using optional side cabinet

PART 7 - WARRANTY

7.1 UPS Warranty

The UPS system shall come with a comprehensive two year on-site warranty on all mechanical, electrical, electronic components. Parts, labor, freight and travel are included during warranty period.

7.2 UPS Battery Warranty

The battery system shall come with a full two-year warranty with 3 year's prorata total of five years. Parts, labor, and travel are included during warranty period.

7.3 Warranty Support Availability

Typical on-site response time shall be 4 hours (24 hours maximum).

7.4 UPS Service Agreement

UPS Preferred Vendor status has already been determined by the Owner. And, thus in addition to warranty requirements listed herein, additional warranty and service requirements shall apply.

PART 8 - BATTERY CABINETS

The UPS manufacturer will provide TWO T90-10K007EN-VC matching battery cabinets with DC breaker.

PART 9 - COMMUNICATIONS

9.1 RemotEye II Network Adapter

The UPS shall provide either an internal or external support for an internet web/SNMP adapter RemotEye II. for the optional capability of remote or internet system monitoring.

9.1.1 SNMP Ability

RemotEye II shall provide a SNMP interface for the UPS. The SNMP interface shall provide for easy integration of UPS management into an existing SNMP Network Management System. At any given time, SNMP queries shall be able to poll the RemotEye II agent for the current status of its connected UPS.

9.1.2 HTTP Familiarity

The RemotEye II shall provide a HTTP interface for the UPS to allow easy access of the UPS information from any machine with a web browser. At any time, a network workstation or management station shall be able to open a RemotEye II website. RemotEye II website shall enable the UPS system information to be configured and monitored remotely. RemotEye II shall provide access to 3 java applets for monitoring, event logging, and trend analysis.

9.1.3 Shutdown Capability

The RemotEye II application software shall allow RemotEye II to remotely notify and shutdown selected network servers.

Network Adapter/External Hardware
AMD 188ES-20MHz
512kB SRAM: 512kB Flash
Two asynchronous serial ports
10 BaseT RJ-45 connector
Manufacturer's UPS communication protocol
SNMP over UDP/IP : HTTP over TCP/IP:ARP, RARP, TFTP and ICMP
MIB_II : Manufacturer v1.2_MIB :JEM MIB : RFC 1628
Traffic LED for network : Status LED for status : Power LED for Power
2 digit (default setting is Switches 1 and 2 off)
Temperature Range: 0 – 40 C
Relative Humidity: 10 – 80 %
Power Requirements: 12 VDC ungrounded
2.0 Watts Maximum
Dimensions: 5.28"(134mm) x 3.40"(86mm) x 1.10"(27mm) (LxWxH)
Weight: 0.38lbs(170g)

PART 10 – NOT USED

PART 11 - MAINTENANCE BYPASS PANEL

The manufacturer can optionally provide a MBS (Maintenance Bypass Panel) for the UPS.

11.1 Site Installation

The MBS can be available in a floor mount cabinet configuration.

11.2 Electrical Configuration

The MBS can be available in two, three, or four breaker configurations.

11.3 Mechanical Interlock

The MBS can have the option for a two-kirk-key interlock system.

11.4 External Maintenance Bypass:

- A manually operated maintenance bypass panel can be provided to bypass the power feeding the critical load from inverter to a static switch panel without causing any power interruption.
- Bypass input breaker can supply input power to the UPS module static bypass input. If the system design calls for separate UPS and bypass inputs, a bypass input breaker can be installed on each input.
- UPS maintenance bypass breaker can allow power flow to the load when the UPS is bypassed. This can be a normally open circuit breaker.
- The UPS module output can feed the UPS output isolation breaker.
- Optionally, the two input bypass breaker can be used to feed both the UPS converter input and the UPS bypass input.

PART 12 – NOT USED

PART 13 – NOT USED

PART 14 - EXTENDED SERVICES

The UPS supplier resource may offer:

- Startup Service
- Maintenance Contracts
- Preventive Maintenance Contracts
- Spare-parts kits
- Extended warranty coverage for up to an additional 2 years
- Enhanced warranty contract (24/7 + Holiday coverage)
- Load bank testing by Contractor
- Factory witness testing
- Site monitor and power audits

PART 15 – DOCUMENT TRANSMITTALS AND DATA HANDLING

STATIC THREE PHASE UNINTERRUPTIBLE POWER SUPPLY

TOSHIBA G9000 100kVA/90KW UPS Unit

15.1 ACTION SUBMITTALS

15.1.1 Product Data: For each type of product indicated. Include data on features, components, electrical duration ratings, and performance.

15.1.2 Shop Drawings: For UPS. Include plans, elevations, sections, details, and attachments to other work.

- Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show operations and termination access, workspace, and clearance requirements; details of control display panels; and battery arrangement.
- Wiring Diagrams: For power, signal, and control wiring. (one-line with all secondary and monitoring circuit equipment details).
- Provide heat resection rate data. (consider a 73° F +/- 3° F enclosure space).
- Provide wet cell storage battery hydrogen evolution into a closed space. State ventilation requirement data. (consider a 73°F +/- 3°F environment).

15.2 INFORMATIONAL SUBMITTALS

15.2.1 Qualification Data: For qualified testing agency provide the test QA results data. .

15.2.2 Seismic Qualification Certificates: For UPS equipment, from manufacturer.

- Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

15.2.3 Manufacturer Certificates: For each product, from manufacturer.

15.2.4 Factory Test Reports: Comply with specified requirements.

15.2.5 Field quality-control reports.

15.2.6 Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

15.2.7 Warranties: Sample of special warranties.

15.3 CLOSEOUT SUBMITTALS

15.3.1 Operation and Maintenance Data: For UPS units to include in emergency, operation, and systems maintenance manuals.

15.4 MAINTENANCE MATERIAL SUBMITTALS

15.4.1 Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- Fuses: Three each for each type and rating.
- Cabinet Ventilation Filters: Two complete set(s).

15.5 QUALITY ASSURANCE

15.5.1 Power Quality Specialist Qualifications: A registered professional electrical engineer or engineering technician, currently certified by the National Institute for Certification in Engineering Technologies, NICET Level 4, minimum, experienced in performance testing UPS installations and in performing power quality surveys similar to that required in "Performance Testing" Article.

15.5.2 Testing Agency Qualifications: Member company of NETA or an NRTL.

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

15.5.3 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.

15.5.4 UL Compliance: Listed and labeled under UL 1778 by an NRTL.

15.5.5 NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

PART 16 – QUALITY PROGRAM INSTALLATION AND TESTING RESULTS REQUIREMENTS

16.1 BATTERY QUALITY CONTROL

16.1.1 Factory test complete UPS system before shipment. Use actual batteries that are part of final installation battery testing. Include the following:

- Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
- Full-load test.

- Transient-load response test.
- Overload test.
- Power failure test.

16.1.2 Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice. WSU site test demonstrations shall be conducted during the Monday through Friday normal work week between 0830-1700 hours. WSU will observe testing. The seller shall submit the QA program test plan for WSU acceptance.

16.1.3 Report test results. Include the following data:

- Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
- List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
- List of instruments and equipment used in factory tests.

16.2 FIELD QUALITY CONTROL

16.2.1 Testing Agency: Engage a qualified testing agency to perform tests and inspections.

16.2.2 Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

16.2.3 Perform tests and inspections.

- Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

16.2.4 Tests and Inspections:

- Comply with manufacturer's written instructions.
- Inspect interiors of enclosures, including the following:
  - Integrity of mechanical and electrical connections.
  - Component type and labeling verification.
  - Ratings of installed components.
- Inspect batteries and chargers according to requirements in NETA Acceptance Testing Specifications.
- Test manual and automatic operational features and system protective and

alarm functions.

- Test communication of status and alarms to remote monitoring equipment.
- Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for the UPS unit's rating. Use instruments calibrated within the previous six months according to NIST standards.
    - Simulate malfunctions to verify protective device operation.
    - Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
    - Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.
    - Test output voltage under specified transient-load conditions.
    - Test efficiency at 50, 75, and 100 percent of rated loads.
    - Test remote status and alarm panel functions.
    - Test battery-monitoring system functions.

16.2.5 Seismic-restraint tests and inspections shall include the following:

- Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
- Test mounting and anchorage devices according to requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

16.2.6 The UPS system will be considered defective if it does not pass tests and inspections.

16.2.7 Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

16.2.8 Prepare test and inspection reports.

16.3 PERFORMANCE TESTING

16.3.1 Engage the services of a qualified power quality specialist to perform tests and activities indicated for each UPS system.

16.3.2 Monitoring and Testing Schedule: Perform monitoring and testing in a single 10-day period scheduled for the: 100 KVA/90 KW Chemistry Building,

- Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
- Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.

16.3.3 Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:

- Current: Each phase and neutral and grounding conductors.
- Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
- Frequency transients.
- Voltage swells and sags.
- Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
- High-frequency noise.
- Radio-frequency interference.
- THD of the above currents and voltages.
- Harmonic content of currents and voltages above.

16.3.4 Monitoring and Testing Procedures[for Each Test Period]:

- Exploratory Period: For the first [two] <Insert number> days[of the first scheduled monitoring and testing period], make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.
- Remainder of Test Period: Perform continuous monitoring of at least two circuit locations selected on the basis of data obtained during exploratory period.
    - Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
    - Perform load and UPS power source switching and operate

the UPS on generator power during portions of test period according to directions of Owner's power quality specialist.

- Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.
- Using loads and devices available as part of the facility's installed systems and equipment[and a temporarily connected portable generator set], create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
- Using temporarily connected resistive/inductive load banks, create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
- Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing and repeat appropriate monitoring and testing to verify success of corrective action.

16.3.5 Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.

- Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
- Coordinate printouts with recordings for monitoring performed according to this article, and resolve and report any anomalies in and discrepancies between the two sets of records.

16.3.6 Monitoring and Testing Assistance by Contractor:

- Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
- Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.
- Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist shall design this portion of monitoring and testing operations to

expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
- Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
- Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.

16.3.7 Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

16.3.8 Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in [each]report:
- Description of corrective actions performed during monitoring and survey work and their results.
- Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
- Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
- Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
- Recommendations for operating, adjusting, or revising UPS controls.
- Recommendation for alterations to the UPS installation.
- Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
- Recommendations for power distribution system revisions.
- Recommendations for adjusting or revising electrical loads, their connections, or controls.

16.3.9 Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

16.4 DEMONSTRATION

16.4.1 Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

STATIC THREE PHASE UNINTERRUPTIBLE POWER SUPPLY

TOSHIBA G9000 100kVA/90KW UPS Unit

TOSHIBA Static Uninterruptible Power Supply Data Sheet

I. State model number data: each cabinet, (include dimensions and weight data)

a. UPS 100 kVA/90 kW power Electronics cabinet: T90S3S10KS6XSN

b. Battery Storage Cabinet: T90-10K007EN-VC

c. Maintenance Bypass Switch Cabinet: T90BMSS10K-S3KK

d. Remote Communication Module Features: RMTI-EXT-R4

e. UPSTARTUP100G9 Services

II.

Input Power Parameter Data:	
Voltage/Wiring Features	
Voltage Range/Variation	
Power Factor	
Current THD Harmonics	
Frequency/Variation	
Output Power Parameter Data:	
Voltage/Wiring Features	
Frequency/Variation	
Voltage Regulation	
Power Factor: LAG	
Voltage THD	
Overload, Inverter 120sec/60sec	
Overload, Bypass	

III. State environment operating parameter requirements:

- Temperature
- Humidity
- Noise
- Heat rejection
- Efficiency ratings data
- Seismic

STATIC THREE PHASE UNINTERRUPTIBLE POWER SUPPLY

TOSHIBA G9000 100kVA/90KW UPS Unit

Static Uninterruptible Power Supply Data Sheet

IV. System Topology: State UPS Description Data: _____
V. State UPS battery features and operation life features.
VI. State UPS monitoring, alarm, control interface switch features and signal handling provision.
VII. State UPS international and national standards compliance adherence data (e.g: UL ISO ANSI IEEE, other NFPA-NEC)
VIII. State UPS warranty duration and features.

END OF SECTION 263353

320006
Wayne State University
Biology Building
Electrical Reliability Upgrades
November 24, 2014 – For Bids

089 - BIOLOGY BUILDING
WSU PROJECT NO. 089-248858
ELECTRICAL RELIABILITY UPGRADES
BID PACKAGE NO.5

Project Specifications

Prepared for:

Wayne State University

For Bids
11/24/2014

Prepared by

320006
Wayne State University
Biology Building
Electrical Reliability Upgrades
November 24, 2014 – For Bids

Biology Building

Building No. 089
5047 Gullen Mall
Detroit, MI 48201

Specifications **Table of Contents**

320006
Wayne State University
Biology Building
Electrical Reliability Upgrades
November 24, 2014 – For Bids

Specification Sections – Table of Contents

SECTION 012100 - ALLOWANCES

PART 1 - GENERAL

1.1 SUMMARY

A. Selected labor are shown and specified in the Contract Documents by allowances. Allowances have been established in lieu of additional requirements and to defer selection of actual labor to a later date.

1. Cash Allowances: Base bid shall include an allowance to cover costs associated with premium time associated with overtime work in amount of $5,000.00. The allowance expenditure must be accounted for and approved in advance by WSU during the construction phase of the project, unused allowances will be returned to the University.

B. Type of allowance is "Lump-sum" cash allowance.

1.4 SUBMITTALS

A. Submit in writing to the WSU Rep in advance allocation of expected monies required to perform pre-approved work.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION (NOT APPLICABLE)

3.1 SCHEDULE OF CASH ALLOWANCES

END OF SECTION 012100

SECTION 017823 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:

1. Operation and maintenance documentation directory.
2. Emergency manuals.
3. Operation manuals for systems, subsystems, and equipment.
4. Product maintenance manuals.
5. Systems and equipment maintenance manuals.

1.3 DEFINITIONS

A. System: An organized collection of parts, equipment, or subsystems united by regular interaction.

B. Subsystem: A portion of a system with characteristics similar to a system.

1.4 CLOSEOUT SUBMITTALS

A. Manual Content: Operations and maintenance manual content is specified in individual Specification Sections to be reviewed at the time of Section submittals. Submit reviewed manual content formatted and organized as required by this Section.

1. Architect will comment on whether content of operations and maintenance submittals are acceptable.
2. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.

B. Format: Submit operations and maintenance manuals in the following format:

1. PDF electronic file. Assemble each manual into a composite electronically indexed file. Submit on digital media acceptable to Architect.

a. Name each indexed document file in composite electronic index with applicable item name. Include a complete electronically linked operation and maintenance directory.

b. Enable inserted reviewer comments on draft submittals.

2. Three paper copies. Include a complete operation and maintenance directory. Enclose title pages and directories in clear plastic sleeves. Architect, through Construction Manager, will return two copies.

C. Initial Manual Submittal: Submit draft copy of each manual at least 30 days before commencing demonstration and training. Architect and Commissioning Authority will comment on whether general scope and content of manual are acceptable.

D. Final Manual Submittal: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least 15 days before commencing demonstration and training. Architect and Commissioning Authority will return copy with comments.

1. Correct or revise each manual to comply with Architect's and Commissioning Authority's comments. Submit copies of each corrected manual within 15 days of receipt of Architect's and Commissioning Authority's comments and prior to commencing demonstration and training.

PART 2 - PRODUCTS

2.1 OPERATION AND MAINTENANCE DOCUMENTATION DIRECTORY

A. Directory: Prepare a single, comprehensive directory of emergency, operation, and maintenance data and materials, listing items and their location to facilitate ready access to desired information. Include a section in the directory for each of the following:

1. List of documents.
2. List of systems.
3. List of equipment.
4. Table of contents.

B. List of Systems and Subsystems: List systems alphabetically. Include references to operation and maintenance manuals that contain information about each system.

C. List of Equipment: List equipment for each system, organized alphabetically by system. For pieces of equipment not part of system, list alphabetically in separate list.

D. Tables of Contents: Include a table of contents for each emergency, operation, and maintenance manual.

E. Identification: In the documentation directory and in each operation and maintenance manual, identify each system, subsystem, and piece of equipment with same designation used in the Contract Documents. If no designation exists, assign a designation according to ASHRAE Guideline 4, "Preparation of Operating and Maintenance Documentation for Building Systems."

2.2 REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS

A. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:

1. Title page.
2. Table of contents.
3. Manual contents.

B. Title Page: Include the following information:

1. Subject matter included in manual.
2. Name and address of Project.
3. Name and address of Owner.
4. Date of submittal.
5. Name and contact information for Contractor.
6. Name and contact information for Construction Manager.
7. Name and contact information for Architect.
8. Name and contact information for Commissioning Authority.
9. Names and contact information for major consultants to the Architect that designed the systems contained in the manuals.
10. Cross-reference to related systems in other operation and maintenance manuals.

C. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.

1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.

D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.

E. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF file for each manual type required.

1. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.
2. File Names and Bookmarks: Enable bookmarking of individual documents based on file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel on opening file.

F. Manuals, Paper Copy: Submit manuals in the form of hard copy, bound and labeled volumes.

1. Binders: Heavy-duty, three-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

    a. If two or more binders are necessary to accommodate data of a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary to provide essential information for proper operation or maintenance of equipment or system.
    b. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, and subject matter of contents. Indicate volume number for multiple-volume sets.

2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment.
4. Supplementary Text: Prepared on 8-1/2-by-11-inch white bond paper.
5. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.

    a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
    b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

2.3 EMERGENCY MANUALS

A. Content: Organize manual into a separate section for each of the following:

1. Type of emergency.
2. Emergency instructions.
3. Emergency procedures.

B. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:

1. Fire.
2. Flood.
3. Gas leak.
4. Water leak.
5. Power failure.
6. Water outage.
7. System, subsystem, or equipment failure.

8. Chemical release or spill.

C. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of Owner's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.

D. Emergency Procedures: Include the following, as applicable:

1. Instructions on stopping.
2. Shutdown instructions for each type of emergency.
3. Operating instructions for conditions outside normal operating limits.
4. Required sequences for electric or electronic systems.
5. Special operating instructions and procedures.

2.4 OPERATION MANUALS

A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:

1. System, subsystem, and equipment descriptions. Use designations for systems and equipment indicated on Contract Documents.
2. Performance and design criteria if Contractor has delegated design responsibility.
3. Operating standards.
4. Operating procedures.
5. Operating logs.
6. Wiring diagrams.
7. Control diagrams.
8. Piped system diagrams.
9. Precautions against improper use.
10. License requirements including inspection and renewal dates.

B. Descriptions: Include the following:

1. Product name and model number. Use designations for products indicated on Contract Documents.
2. Manufacturer's name.
3. Equipment identification with serial number of each component.
4. Equipment function.
5. Operating characteristics.
6. Limiting conditions.
7. Performance curves.
8. Engineering data and tests.
9. Complete nomenclature and number of replacement parts.

C. Operating Procedures: Include the following, as applicable:

1. Startup procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.

4. Regulation and control procedures.
5. Instructions on stopping.
6. Normal shutdown instructions.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

E. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

2.5 PRODUCT MAINTENANCE MANUALS

A. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual and drawing or schedule designation or identifier where applicable.

C. Product Information: Include the following, as applicable:

1. Product name and model number.
2. Manufacturer's name.
3. Color, pattern, and texture.
4. Material and chemical composition.
5. Reordering information for specially manufactured products.

D. Maintenance Procedures: Include manufacturer's written recommendations and the following:

1. Inspection procedures.
2. Types of cleaning agents to be used and methods of cleaning.
3. List of cleaning agents and methods of cleaning detrimental to product.
4. Schedule for routine cleaning and maintenance.
5. Repair instructions.

E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.

F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

1. Include procedures to follow and required notifications for warranty claims.

2.6 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS

A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.

B. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual and drawing or schedule designation or identifier where applicable.

C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:

1. Standard maintenance instructions and bulletins.
2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
3. Identification and nomenclature of parts and components.
4. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:

1. Test and inspection instructions.
2. Troubleshooting guide.
3. Precautions against improper maintenance.
4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
5. Aligning, adjusting, and checking instructions.
6. Demonstration and training video recording, if available.

E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.

1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual, and annual frequencies.
2. Maintenance and Service Record: Include manufacturers' forms for recording maintenance.

F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.

G. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

1. Include procedures to follow and required notifications for warranty claims.

PART 3 - EXECUTION

3.1 MANUAL PREPARATION

A. Operation and Maintenance Documentation Directory: Prepare a separate manual that provides an organized reference to emergency, operation, and maintenance manuals.

B. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.

C. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.

D. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.

1. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
2. Prepare a separate manual for each system and subsystem, in the form of an instructional manual for use by Owner's operating personnel.

E. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

1. Prepare supplementary text if manufacturers' standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.

F. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in record Drawings to ensure correct illustration of completed installation.

1. Do not use original project record documents as part of operation and maintenance manuals.
2. Comply with requirements of newly prepared record Drawings in Section 017839 "Project Record Documents."

END OF SECTION 017823

SECTION 031000 – CONCRETE FORMWORK

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.

1.2 SUMMARY

A. This Section includes the design, installation and removal of forms for cast-in-place concrete.

B. Related Sections include the following:
   1. Division 3 Section “Concrete Reinforcement.”
   2. Division 3 Section “Concrete Accessories.”
   3. Division 3 Section “Cast-In-Place Concrete.”

C. Division of Work:
   1. In accordance with the General Conditions, Contractor is responsible for dividing the Work among the Subcontractors and Suppliers and for delineating the work to be performed by specific trades. The following are suggestions as to how the Work may be divided. This is not a complete list of all the work:
      a. Mechanical, Electrical and Plumbing Trades: Supply, locate and install premanufactured items including inserts, sleeves, and other embedded items required by those respective trades.
      b. Formwork Subcontractor:
         1) Supply and install Site fabricated box-outs for chases, sleeves and other openings for mechanical, electrical and plumbing trades.
         2) Install other inserts, embedded parts, box-outs for openings, chases, reveals and recesses, except those specifically mentioned above that are by mechanical, electrical or plumbing trades. Special inserts, embedded parts or other special requirements needed by a specific trade shall be supplied by that trade to the formwork Subcontractor for installation.
      c. Contractor: Coordinate location of mechanical, electrical and plumbing inserts, embedded parts, openings and recesses with respective trades.

1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
   1. ACI - American Concrete Institute:
      a. 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
      b. 301 - Standard Specifications for Structural Concrete for Buildings.
      c. 303R - Guide to Cast-In-Place Architectural Concrete Practice.
      d. 347R - Guide to Formwork for Concrete.

1.4 DESIGN AND PERFORMANCE REQUIREMENTS

A. Form Construction:
   1. Provide required forms, shores, bracing, breast timbers, form ties, and accessories in sufficient quantities so as not to delay the Work, and of strength to support vertical and horizontal loads to which they are subjected.
   2. Deflection: Maximum deflection of forms shall be 1/240 of span or 1/4-inch, whichever is less.

1.5 SUBMITTALS

A. Manufacturer's Literature: For form release agent**.**

1.6 QUALITY ASSURANCE

A. Design: The design and engineering of formwork, as well as its construction, shall be the responsibility of Contractor.

B. Notifications: Notify special inspector at least 24 hours in advance of placing concrete.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Formwork Facing Materials:
   1. Smooth Form Finish Areas:
      a. Locations: All locations unless otherwise noted.
      b. The form facing material shall produce a smooth, hard, uniform surface on the concrete.
      c. Form facing materials may be plywood, tempered concrete-form-grade hardboard, metal, plastic, paper; or other approved material capable of producing the desired finish.
      d. Facing materials shall be supported by studs or other backing capable of preventing deflections in excess of those specified herein.
      e. Material with damaged surfaces, worn edges, patches, dents or other defects which will impair the texture of the concrete surface shall not be used.

B. Pan Forms:
   1. Steel or fiberglass, formed to profiles required to produce indicated shapes.
   2. Designed to be strong enough to carry construction live loads and the weight of plastic concrete without deflection detrimental to the structure.
   3. Formed for secure attachment to formwork platforms.
   4. Formed for removal in a manner which will not damage concrete.

C. Cylindrical Forms:
   1. Steel or fiberglass, formed to diameters required to produce indicated shapes.
   2. Strong enough to carry pressure of plastic concrete.
   3. Formed to produce shapes free from abrupt changes in shape, and to produce smooth uniform surface.

D. Void Forms:

1. Degradable paper or cardboard forms, to suit slab and beam applications.
2. Strong enough to carry construction live load and the weight of plastic concrete without significant deformation.
3. Configurations to suit application indicated on the Drawings, as chosen by Contractor.
4. Sure Void Products, Inc.; or equal.

E. Chamfer Strips:
1. Wood, metal, rubber, or PVC.
2. Sizes as indicated, 3/4-inch x 3/4-inch minimum.

F. Form Ties:
1. At Smooth Form Finish Areas:
a. Factory fabricated metal ties.
b. Removable or snap type, with tapered cones as required to leave no tie portion within 1-inch of concrete surface plane.
c. Designed to leave no larger than a 7/8-inch diameter hole at concrete surface.
d. Chosen by Contractor to suit application and to resist pressure of fresh concrete.
e. For concrete tank walls, in addition to the above requirements, provide waterstop type feature on the tie.

G. Form Release Agent:
1. Products for General Use: Magic Kote by Symons, Crete-lease 727 by Cresset Company; or equal.
2. Chemically neutral agent in hydrocarbon solvent that will effectively prevent absorption of moisture and prevent bond with the concrete.

PART 3 - EXECUTION

3.1 FORMWORK CONSTRUCTION

A. General:
1. Install wall form ties in a regular repetitive pattern.
2. Align and secure joints to avoid offsets.
3. Provide chamfered strips in exposed corners of exterior corners, internal corners and for similar conditions throughout the Work.
4. Construct forms to allow for installation of water-stops, bentonite waterproof bead, and waterproofing termination.
5. Tie water-stops up to prevent folding when concrete is placed.
6. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only.
7. The arrangement of facing material shall be orderly and symmetrical with the number of seams kept to the practical minimum.
8. Retighten forms after concrete placement if required to eliminate mortar leaks.
9. Inspection Ports and Cleanouts:
a. Provide temporary openings where interior area of formwork is inaccessible for cleanout and inspection.
b. Securely brace temporary openings and set tightly to forms to prevent loss of concrete mortar.
c. Locate temporary openings on forms at inconspicuous locations.

B. Openings and Embedded Items:
   1. Set and build into the work anchorage devices and other embedded items required for work that is attached to, or supported by, cast-in-place concrete.
   2. Coordinate work of other Sections and cooperate with trade involved in forming and setting openings, slots, recesses, chases, sleeves, bolts, anchor and other inserts.
   3. Use setting drawings, diagrams, instructions and directions provided by Suppliers of the respective items.
   4. Do not perform work unless specifically indicated on Drawings or reviewed prior to installation.

C. Cleaning:
   1. Clean forms as erection proceeds, to remove foreign matter.
   2. Remove cuttings, shavings and debris from within forms.
   3. Flush with water or use compressed air to remove remaining foreign matter.
   4. Ensure that water and debris drain to exterior through clean-out ports.
   5. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints.
   6. Thoroughly clean embedded waterstops and concrete surfaces prior to constructing forms for the next pour.

D. Applying Form Release Agent:
   1. Temperature of release agent and surfaces to which it is applied shall be a minimum of 70 degrees F.
   2. Apply by spray only.
   3. Uniformly coat surfaces with a thin film.
   4. Wipe off excess with clean towels.
   5. Apply in accordance with Manufacturer's recommendations.
   6. Do not allow to stand in puddles in the forms and prevent bonding of concrete at construction joints.

E. Provisions for Form Removal:
   1. Fabricate forms for easy removal without hammering or prying against the concrete surfaces.
   2. Kerf wood inserts for forming keyways, reglets, recesses and the like to prevent swelling and for easy removal.

3.2 FORM AND SUPPORT REMOVAL

A. Forms and supports shall remain in place for not less than the following periods of time:
   1. Tunnel Walls: 12 to 24 hours.
   2. Vault and Tunnel Top Slabs:
      a. Under 10 Feet Clear Span Between Supports: 96 hours (4 days).
      b. 10 to 20 Feet Clear Span Between Supports: 168 hours (7 days).
      c. Over 20 Feet Clear Span Between Supports: 240 hours (10 days).

B. In any event, do not remove forms and supports until concrete in walls has reached 30% of design strength, and in structural members and slabs has reached 75% of design strength.

C. Special precautions shall be taken when concrete is placed in average temperatures of 50 degrees F or below to ensure that forms are not removed before design strengths specified above are met.

D. If Contractor elects to use high-early-strength cement, the specified periods of time may be reduced as allowed by Engineer. This does not relieve Contractor of Contractor's liability.

E. Remove forms in such a manner and at such times as required to ensure safety of persons involved and so as to protect and maintain structural integrity of members.

F. Particular care shall be taken in removing forms to minimize damage to concrete surfaces; use crush or wrecking plates as necessary.

G. Whenever the formwork is removed, cure the exposed concrete as specified under Division 3 Section “Cast-in-Place Concrete.”

3.3 FIELD QUALITY CONTROL

A. Inspect and check completed formwork, shoring and bracing to ensure that work is in accordance with formwork design, and that supports, fastenings, wedges, ties and parts are secure.

B. Form Surface Repairs:
   1. Repair surfaces of forms to be reused in the work.
   2. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable.
   3. Apply new form release agent to new concrete contact form surfaces.
   4. Do not use patched forms for exposed concrete surfaces.

C. Special Inspections:
   1. Inform Engineer when formwork is complete and has been cleaned, to allow for inspection.
   2. Allow inspection of each section of plywood type of formwork prior to reuse.
   3. Obtain inspections prior to placing concrete.

END OF SECTION 031000

CONCRETE REINFORCING

SECTION 032000 – CONCRETE REINFORCEMENT

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.

1.2 SUMMARY

A. This Section includes the furnishing and placement of concrete reinforcement.

B. Related Sections include the following:
   1. Division 3 Section “Concrete Formwork.”
   2. Division 3 Section “Concrete Accessories.”
   3. Division 3 Section “Cast-In-Place Concrete.”

1.3 REFERENCES

A. Except as herein specified or as indicated on the Drawings, the work of this Section shall comply with the following:
   1. ACI:
      a. 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
      b. 315 - Details and Detailing of Concrete Reinforcement.
      c. 315R - Manual of Engineering and Placing Drawings for Reinforced Concrete Structures.
      d. 318 - Building Code Requirements for Reinforced Concrete.
   2. ASTM Specifications:
      a. A615 - Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   3. AWS:
      a. D1.4: Structural Welding Code - Reinforcing Steel.
   4. CRSI:
      a. Manual of Standard Practice.
      b. Reinforcing Bar Detailing.
      c. Placing Reinforcing Bars.

1.4 SUBMITTALS

A. Prepare Shop Drawings in accordance with ACI 315 and 315R and the CRSI Manual of Standard Practice and Reinforcing Bar Detailing. Include the following:
   1. Number, size, length, mark, and location of concrete reinforcement.
   2. Bending diagrams.

B. Certified Mill Test Reports:
   1. Submit upon request by Engineer.
   2. Showing physical and chemical analysis for each heat of reinforcement used on Project.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver reinforcement free of loose rust, scale, paint, oil and structural defects, and store on the site so as to maintain that condition.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
   1. All concrete reinforcement and accessories shall be new, free from rust, scale, paint, oil and structural defects.
   2. Reinforcement shall be the sizes indicated on the Drawings.

B. Reinforcing Bars:
   1. ASTM A615.
   2. Yield stress: Fy = 60,000 psi.
   3. Deformed unless otherwise noted; smooth where specifically indicated on the Drawings.

C. Accessories:
   1. Chairs, bolsters, anchors, spacers, stirrups, ties and other devices as required for spacing and fastening reinforcement in place shall conform to CRSI Manual of Standard Practice.
   2. At exposed underside of concrete, use plastic-tipped chairs and bolsters.

2.2 FABRICATION

A. General:
   1. Fabricate reinforcement to the dimensions indicated on the Drawings and the reviewed Shop Drawings in accordance with the CRSI Manual of Standard Practice.
   2. Tolerances: As indicated in ACI 117.
   3. Bundle and tag reinforcement with suitable identification to permit checking, sorting and placing.
   4. Welding:
      a. Not permitted, unless specifically indicated on the Drawings.
      b. When permitted, comply with AWS D1.4.
      c. No tack welding permitted.

B. Hooks:
   1. Bend hooks in accordance with ACI 318.
   2. Extension on 90 degree hook shall satisfy the requirements of a standard hook unless indicated longer on the Drawings.
   3. Cold bend bars in such a way that will not damage the reinforcement.

C. Reinforcement with any of the following defects will not be permitted in the Work:
   1. Bar lengths, depths and bends exceeding specified fabrication tolerances.
   2. Bends or kinks not indicated on Drawings or reviewed Shop Drawings.
   3. Bars with reduced cross-section due to excessive rusting or other cause.

PART 3 - EXECUTION

3.1 PLACEMENT

CONCRETE REINFORCING

A. Place concrete reinforcement in accordance with:
   1. Shop Drawings reviewed by Engineer.
   2. CRSI Placing Reinforcing Bars and Manual of Standard Practice.
   3. Tolerances indicated in ACI 117.

B. Clearance:
   1. Preserve clear space between bars of not less than 1 times the normal diameter of round bars.
   2. In no case let the clear distance be less than 1-inch or less than 1-1/3 times the maximum size of aggregate.
   3. In the absence of specific cover requirements on the Drawings, provide the following minimum concrete cover for reinforcement:
      a. Cast Against and Permanently Exposed to Earth: 3 inches.
      b. Exposed to Earth, Weather or Water:
         1) No. 6 Through No. 18 Bars: 2 inches.
         2) No. 5 Bars, 5/8-Inch Wire and Smaller: 1-1/2 inches.
      c. Not Exposed to Weather or in Contact with the Ground:
         1) Slabs, Walls, and Joists:
            a) No. 14 and No. 18 Bars: 1-1/2 inches.
            b) No. 11 Bars and Smaller: 3/4-inch.
         2) Beams, Girders, and Columns: 1-1/2 inches.
         3) Shells and Folded Plate Members:
            a) No. 6 Bars and Larger: 3/4-inch.
            b) No. 5 Bars, 5/8-Inch Wire and Smaller: 1/2-inch.

C. Splices:
   1. Comply with ACI 318 and this Section.
   2. In the absence of specific lap requirements on the Drawings, lap in accordance with ACI 318, Class B.
   3. Laps of Circular Ring Tension Steel: Not less than 40 bar diameters.

D. Corner Bars:
   1. Provide corner bars for all horizontal wall steel.
   2. In the absence of specific lap requirements on the Drawings, lap in accordance with ACI 318, Class B.

E. Field Cutting and Bending: Field cutting or bending of bars will be permitted only under special conditions approved by Engineer.

F. Field Welding:
   1. In accordance with AWS D1.4.
   2. Only when specifically indicated on the Drawings.
   3. No tack welding permitted.

G. Slabs On Grade:
   1. Do not hook up welded wire fabric; either tie on supports at correct elevation, or lay on partial slab thickness of fresh concrete just prior to placing remainder of slab.
   2. For Chairs or Bolsters Resting on Soil, Place on Either:
      a. Sand plates.
      b. Concrete bricks set flush with soil to provide bearing surface for chairs or bolsters.

3.2 FIELD QUALITY CONTROL

A. Notification:
   1. Notify Engineer when reinforcing is in place so Engineer may review the reinforcement placement.
   2. Provide a minimum of 24 hours notice prior to placement of concrete.

END OF SECTION 032000

CAST IN PLACE CONCRETE

SECTION 033000 – CAST IN PLACE CONCRETE

PART 1 – GENERAL

1.1 SUMMARY

A. Work Included: Cast in place concrete.
   1. Spread footing foundation pads.
   2. Continuous wall footings and grade beams.
   3. Slab on grade.
   4. Elevated structural reinforced slabs.

1.2 QUALITY ASSURANCE

REFERENCE STANDARDS

A. Comply with the latest editions of the following design guides and standards:
   1. ACI 301 "Specifications for Structural Concrete for Buildings"
   2. ACI 302 "Guide for Concrete Floor and Slab Construction"
   3. ACI 304 "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete:"
   4. ACI 305 "Hot Weather Concreting"
   5. ACI 306 "Cold Weather Concreting"
   6. ACI 311 "Recommended Practice for Concrete Inspection"
   7. ACI 315 "Details and Detailing of concrete Reinforcement"
   8. ACI 318 "Building Code Requirements for Structural Concrete"
   9. ACI 347 "Recommended Practice for Concrete Formwork"
   10. ACI SP-15 Field Reference Manual
   11. CRSI "Manual of Standard Practice"

1.3 SUBMITTALS

A. Shop Drawings: Submit Shop Drawings for fabrication, bending, and placement of concrete reinforcement. Show bar bending schedules, stirrup spacing, diagrams of bent bars, and arrangements of concrete reinforcement. Include special reinforcement required for openings through concrete. Show elevation of reinforcement for all members at a minimum of ¼ inch – 1'-0" scale. Show locations of all construction and control joints.

B. Mix Designs: Submit proposed mix designs for concrete at least 15 days before start of concreting. Submittal shall include: cement content and type, admixture content and type, aggregate source and gradation, water content, air content, slump, yield, and documentation of average strength by field experience method or laboratory prepared trial mixtures in accordance with ACI 318 Article 4.3.

C. Product Data: Submit data and installation instructions for proprietary materials.

D. Material Certificates: Submit materials certificates certifying that each material complies with Specifications.

1.4 TESTING SERVICES

A. Owner will engage a testing laboratory acceptable to the Architect-Engineer to perform material evaluation tests and for quality control during placement.

B. Sample and test concrete for quality control during placement as follows:
   1. Sampling Fresh Concrete: ASTM C172 except modified for slump to comply with ASTM C94.
   2. Slump: ASTM C143 – one for each concrete truck, measured at point of discharge.
   3. Air Content: ASTM C231 pressure method – one for each truck load of ready-mixed air-entrained concrete.
   4. Temperature: Test concrete temperature hourly when ambient temperature is 40°F and below, and when 80°F and above.
   5. Compressive Strength Test: ASTM C39, one set of six cylinders for each 50 cubic yards or fraction thereof, of each concrete class placed in any one day, two lab specimens tested at 7 days, two lab specimens tested at 28 days and two specimens retained in reserve for later testing if required.

C. Test Reports
   1. Forward results to Architect-Engineer and Contractor on same day that tests are made.
   2. Reports of compressive strength tests shall contain the general information of project identification name and number, date of concrete placement, name of Contractor, name of concrete supplier, truck number and delivery ticket number, name of concrete testing agency, concrete type and class, name of individual making specimen, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials; and the specific information of slump, air content, temperature, compressive strength and type of break for both 7-day and 28-day tests.
   3. Field reports of concrete inspection shall contain general information noted above, plus ambient temperature, concrete temperature, weather, slump, air content, and cylinder numbers.

D. Additional Testing

   1. Testing agency shall make additional test of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure.
   2. Testing agency shall conduct tests to determine adequacy of concrete cored cylinders complying with ASTM C42 or by other methods acceptable to Architect-Engineer.

3. Contractor shall pay for such tests conducted, and any other additional testing required, if concrete testing confirms specified strengths have not been met.

1.5 JOB CONDITIONS

A. Store materials so as to ensure preservation of their quality and fitness for the Work. Store reinforcement and formwork in a manner to prevent damage and accumulation of dirt.

B. Contractor shall be responsible for correction of concrete work which does not conform to specified requirements, including strength, tolerances and finishes. Correct deficient concrete as directed by Architect-Engineer.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Formwork

1. Exposed Concrete: Unless otherwise shown or specified, construct formwork for concrete surfaces, which will be exposed to view in the completed project, with form plywood, metal or other acceptable panel-type material, to provide continuous, straight, smooth exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system show on Drawings. Provide form material with sufficient thickness to withstand pressure of newly-placed concrete without bow or deflection.

2. Unexposed Concrete: Form concrete surfaces which will be unexposed to view in the completed Project with plywood, lumber, metal or other acceptable material. Provide lumber dressed on at least 2 edges and 1 side for tight fit.

B. Form Ties

1. Exposed Concrete: Plastic cone snap tie, Type 3M by Superior or accepted equal.

2. Unexposed Concrete: Snap-off metal ties, designed to prevent form deflection and prevent spalling surfaces upon removal. Portion remaining after removal shall be at least 1” from concrete surface.

C. Form Coatings: Commercial formulation form-coating compounds shall not bond with, stain, nor adversely affect concrete surfaces, and shall not impair subsequent treatments of concrete surfaces requiring bond or adhesion, nor impede wetting of surfaces to be cured with water or curing compound.

D. Reinforcement
   1. Deformed bars: ASTM A615, Grade 60.
   2. Welded Wire Fabric: ASTM A185. Furnish in flat sheets only.
   3. All chairs, spacers, clips, wire anchors and related items necessary to accurately space and secure reinforcement.
   4. Additional bars, if required, to anchor or space reinforcement.
   5. Chairs shall be plastic booted at points of bearing on forms for exposed concrete.
   6. Minimum 16-gauge annealed tie wire, ASTM A82.

E. Cement: ASTM C150, Type I or Type II.

F. Aggregates: ASTM C33 and as herein specified.
   1. Fine Aggregate: Clean, sharp, natural sand free from loam, clay, lumps or other deleterious substances with less that 10% passing the #100 sieve and less than 3% passing the #200 sieve.
   2. Coarse Aggregate: Clean, uncoated, processed aggregate containing no clay, mud, loam or foreign matter, as follows:
      a. Crushed stone: Processed from natural rock or stone for concrete slabs meeting MDOT 6AA, with a ¾ inch maximum aggregate size.
      b. Clean, sharp, natural or processed gravel, or, crushed stone, free from loam, clay, lumps, or other deleterious substances for footings and miscellaneous concrete.
      c. Maximum aggregate Size: Footings and Walls – 1 ½ “, Slabs – ¾”.

G. Water: Clean, fresh, and potable.

H. Air Entraining: ASTM C260.

I. Water Reducing Admixture: ASTM C494, Type A.

J. Non Corrosive, Non Chloride Accelerator: ASTM C494, Type C or E.

K. Prohibited Admixtures: Calcium chloride, thiocyanates. Admixtures containing more than 0.05% chloride ions are not permitted.

L. Evaporation Retarder: Confilm by Master Builders, or accepted equal.

M. Curing Sheet Materials: ASTM C171, including waterproof paper, polyethylene film or polyethylene coated burlap.

N. Liquid Membrane Curing/Sealing Compound: Masterkure by Master Builders or accepted equal.

O. Exterior Anti-Spalling Sealer: Penetrating Sealer 40 by Sonneborn or approved equal.

P. Hardener: Lapidolith by Sonneborn or approved equal.

Q. Mineral Aggregate Floor Surface Hardener: Colorcron by Master Builders or approved equal. French gray color. Apply at rate of 1.00 pounds per square foot.

R. Joint Filler: ½" thick ASTM D994 premolded expansion joint filler strips; vinyl removable filler cap strip, 940 Series by Green Streak or approved equal.

S. Sleeves: ASTM A120, Hot-dipped galvanized.

T. Anchor Bolts: Furnished in Section 05100 ande installed under this Section.

U. Dowel Bars: 1-inch square steel bars with ¼-inch compressible foam on vertical faces; or 1-inch diameter steel bars, greased.

V. Non-shrink Grout: Sonogrout 14 by Sonneborn, or approved equal.

W. Water Stop: Volclay Waterstop RX, 1' x 3/4"' by American Colloid Co. or approved equal.

X. Dovetail Slot: Standard Dovetail Slot #180, 26 gauge galvanized steel with foam filler by Heckmann Building Products or approved equal.

2.2 PROPORTIONING AND MIX DESIGN

A. Prepare design mixes for concrete. Use independent testing facility acceptable to Architect-Engineer for preparing and reporting proposed mix designs.

B. Where the concrete production facility can establish the uniformity of its production for concrete of similar strength and materials based on recent test data, the average strength used as a basis for determining mix design proportions shall exceed the specified design strength by the requirements of ACI 318, section 4.3.2 or ACI 301, Section 3.9.

C. Concrete Quality

Location	**Required 28 day Compressive Strength**	**Maximum Water/Cement Ratio**	**Air-Content**	**Unit Weight**
Footings, foundation walls and all other below grade concrete, miscellaneous concrete	3,000 psi	0.55	4% - 6%	147 – 153 pcf

Location	Required 28 day Compressive Strength	Maximum Water/Cement Ratio	Air-Content	Unit Weight
Interior slab on grade	4,000 psi	0.45	0%	147 – 153 pcf
Elevated structural slabs	4,000 psi	0.45	0%	147 – 153 pcf
Exterior concrete subject to freezing and thawing, exterior slab on grade	4,000 psi	0.45	5% - 7%	147 – 153 pcf
Interior elevated structural lightweight slab	4,000 psi	0.45	4% - 6%	114 – 120 pcf

D. Slump

1. Footings and Foundation Walls: 3" to 5".
2. Slabs: 4" maximum.

E. Ready Mix Concrete: ASTM C94.

F. The quantity of coarse aggregate in pounds must be in the range of 1.25 to 1.5 times the quantity of fine aggregate in pounds.

G. Fly ash may be substituted for cement for interior slabs only, at a maximum rate of 15 percent by weight. Submittals shall include actual mix design, including percentage of fly ash and test results showing that mix meets specified compressive strength, and air content. Fly ash is not permitted in cold weather concreting unless extended protection is provided. Protection and heat shall be maintained until 70 percent of specified design strength is achieved.

H. Pumping of concrete is permitted only if mix designs specifically prepared and used previously for pumping are submitted. Pumpline shall have a 5-inch minimum inside diameter and shall be used with 5-inch pumps.

2.3 REINFORCING FABRICATION

A. Fabricate bars to required lengths, shapes and bends. Do not rebend or straighten reinforcement in a manner that shall weaken the material

2.4 FORMWORK

A. Design formwork to support vertical and lateral loads that might be applied until such loads can be supported by concrete structure.

PART 3 – EXECUTION

3.1 INSPECTION

A. Examine conditions under which concrete shall be placed. Do not proceed with work until all unsatisfactory conditions are corrected..

3.2 NOTIFICATION

A. Notify Architect-Engineer 24 hours before anticipated time of completion of reinforcement in any section.

B. Do not place concrete until reinforcement has been observed and corrections, if any, made.

3.3 FORMWORK INSTALLATION

A. Erect, brace, and maintain formwork to support vertical and lateral loads.

B. Construct forms to sizes, lines and dimensions shown to obtain accurate alignment, location, grades, level and plumb work in finished structure.

C. Provide for openings, offsets, keys and other features required in work. Accurately position and support items.

D. Solidly butt joints and provide backup at joints to prevent leakage of cement paste.

E. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces.

F. Kerf wood inserts for forming keys and the like to prevent swelling and for easy removal.

G. Provide openings in concrete form to accommodate work of other trades. Determine size and location of openings, recesses and chases from trades providing such.

H. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete is placed. Retighten forms after concrete placement if required to eliminate concrete leaks.

I. Reuse of Forms: Clean and repair surfaces of forms to e reused in the work. Split, frayed, delaminated, or otherwise damaged form facing material is not acceptable. Apply new form coating compound material. When forms are reused for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close all joints. Align and secure joints to avoid offsets.

3.4 REINFORCEMENT PLACING

A. Clean reinforcement of loose rust, mill scale, earth, ice and other materials which reduce or destroy bond with concrete.

B. Accurately position, support and secure reinforcement against displacement by formwork, construction or concrete placement operations. Locate and support reinforcement by metal chairs, runners, bolsters, spacers and hangers as required. Do not use brick.

C. Place reinforcement to obtain at least the minimum coverage's for concrete protection.

D. Arrange, space and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.

E. Lap bar splices as indicated. Stagger splices in adjacent bars. Wire tie all splices.

3.5 WELDED WIRE FABRIC REINFORCEMENT PLACEMENT

A. Place welded wire fabric one-third of the slab thickness below top surface of slab.

B. Place flat sheets in as long lengths as practical. Lap adjoining sheets at least one full mesh. Offset laps to prevent continuous laps in either direction.

C. Do not continue welded wire fabric through any control joints or construction joints for slabs on grade.

3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, reinforcing steel and items to be embedded or cast in the concrete.

B. Notify other trades to permit installation of their work. Cooperate with other trades in setting such work as required.

C. Install anchor bolts and sleeves.

D. Deposit concrete continuously or in layers of such thickness that no concrete shall be placed on concrete which has hardened sufficiently to cause formation of seams or planes of weakness within section. Provide construction joints if section cannot be placed continuously.

E. Deposit concrete as nearly as practicable to its final location to avoid segregation caused by rehandling or flowing.

F. Keep excavations free of water. Do not deposit concrete in water, mud, snow or on frozen ground.

G. Maximum drop of concrete shall not exceed 5 feet. Use hopper and trunk for greater drops.

H. Contractor shall be responsible for controlling the proper placing of all embedded pipe, conduit and other embedded items.

I. Contractor shall be responsible for finishing of all concrete slabs to proper elevations to insure that all surface moisture will drain freely to floor drain, and that no puddle areas exist. During finishing operation, Contractor shall pay particular attention to this criterion, and shall make all efforts to obtain this. Any cost of corrections to provide for this positive drainage will be the responsibility of Contractor.

3.7 CONSOLIDATION

A. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand spading, rodding or tamping.

B. Do not use vibrators to transport concrete inside formwork.

C. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of mix.

D. Do not allow vibrator to come in contact with form.

3.8 SURFACE FINISHES

A. Finish of Formed Surfaces:
   1. Rough Form Finish: For formed concrete surfaces not exposed to view in the finished work or concealed by other construction unless otherwise indicated. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective areas repaired and patched and fins and other projections exceeding ¼" in height removed.
   2. Smooth Form Finish: For formed concrete surfaces exposed to view. This is as cast concrete surface obtained with selected form facing material, arranged orderly and

symmetrically with a minimum of seams. Repair and patch defective areas with fins or other projections completely removed and smoothed. Lightly rub all exposed surfaces to achieve a uniform appearance. Or Lightly sandblast to expose fine aggregate with occasional exposure of coarse aggregate and to make the color uniform.

B. Monolithic Slab Finishes
   1. Scratch Finish: Apply scratch finish to monolithic slab surfaces to receive concrete floor topping or mortar setting beds for tile, and other bonded applied cementitious finish flooring material. After placing slabs, roughen surface before final set with stiff brushes, brooms or rakes.
   2. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed to view, and slab surfaces to be covered with carpet, resilient flooring, paint or other thin film finish coating system. After floating, begin first trowel finish operation using a power drive trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand trowel operation, free of trowel marks.
   3. Non-Slip Broom Finish: Apply non-slip broom finish to exterior concrete platforms, steps and ramps, and elsewhere as indicated. Immediately after trowel finishing, slightly roughen concrete surface by brooming with a fiber bristle broom perpendicular to main traffic route.

3.9 APPLICATION OF FLOOR SURFACE HARDENER

A. Bleed water shall not be present before or during the application of this shake.

B. Apply first shake to hand floated concrete adjacent to forms, entryways, columns and walls where moisture will be lost first. Apply two-thirds of the specified total shake immediately following floating of total area. Distribute evenly by hand broadcasting in all areas.

C. Finishing machines with float shoes shall be used as soon as shake has absorbed moisture (indicated by darkening of surface and when surface is firm enough to support a float machine and operator). Float just sufficiently to bring moisture from base slab through the shake. Immediately following floating, apply remaining one-third of total specified shake in the same manner, allow the hardener to darken and machine float as specified.

D. At no time shall water be added to the surface.

E. As surface further stiffens, indicated by loss of sheen, it shall be hand or mechanically trowelled with blades relatively flat. All marks and pin holes shall be removed during the final trowel operation. Finish troweling to produce a light swirl finish to provide skid resistance.

3.10 CURING AND PROTECTION

A. Concrete shall be protected from premature drying, excessively hot or cold temperature, and mechanical injury according to provisions of ACI 301, Chapter 12. During placing, all concrete flatwork exposed to or subject to rapid evaporation of moisture under drying conditions (including hot weather, low humidity, wind and/or sunlight) shall be protected immediately following screeding with evaporation retarder applied in accordance with recommendations of manufacturer. Application shall precede and shall be in addition to curing specified below.

B. Concrete shall be maintained in a continuously moist condition for at least 7 days after placement. Curing shall begin as soon as possible after concrete has been placed and finished. Materials and methods of curing shall be submitted to Architect-Engineer for review and approval.

C. Curing and Protection: Surfaces not in contact with forms and surfaces in contact with forms for less than seven days.
   1. Curing shall be by water curings, application of liquid membrane curing/sealing compound or by application of sheet curing materials. Curing compounds shall be applied in accordance with manufacturer's recommendations. Liquid membrane curing compound used on floor slabs receiving applied finish flooring shall be guaranteed by the manufacturer, in writing, not to impair bonding of adhesive.
   2. For slabs use a curing treatment of water curing, curing sheet materials, or by applying and removing curing/sealing compound. The curing compounds must be applied immediately after final finishing. For curing by water curing or curing sheet materials, the concrete must be continually moist-cured for at least 7 days. Curing shall begin immediately after finishing.
   3. For other surfaces (footing, walls, etc.) curing shall be by one of the accepted curing treatments listed above.
   4. Restore curing protection on all freshly cut joint edges and faces when sawing joints or removing forms.

D. Concrete placed under cold weather conditions shall be cured by completely covering exposed surface of concrete with curing sheet materials with sheets completely sealed around edges. All concrete shall be cured for a minimum of 14 days with temperatures at or above 40°F or for a minimum of 7 days with temperatures at or above 70°F.

3.11 COLD WEATHER CONCRETING

A. Place concrete during cold weather in accordance with ACI 306.

B. For cold weather concreting, (defined as a period when for more than three successive day the mean daily temperature drops below 40°F) concrete temperature shall be maintained in accordance with ACI 306.

3.12 HOT WEATHER CONCRETING

A. Place concrete in accordance with ACI 305.

B. Cool ingredients before mixing to maintain concrete temperature below 90°F at time of placement.

C. Cover reinforcing steel with water-soaked burlap if temperature of reinforcing steel exceeds ambient air temperature.

D. Wet forms thoroughly before placing concrete.

3.13 WALL JOINTS

A. Construction Joints: Locate and install construction joints as shown on Drawings. Where construction joints are not shown, locate joints at masonry control joints. Install joints maximum of 60 feet on center in locations acceptable to Architect-Engineers.

3.14 INTERIOR SLAB JOINTS

A. Construction Joints: Locate and form construction joints as shown on Drawings. Where construction joints are not shown, place in locations acceptable to Architect-Engineer.

B. Contraction Joints: Saw cut joints as soon as possible after finishing generally within 4 to 16 hours. Make sample cut to determine if concrete surface is firm enough so that it is not torn or damaged by the blade.

C. Isolation Joints: Construction isolation in slabs on grade at all points of contact with vertical surfaces and elsewhere as indicated.

3.15 EXTERIOR SLAB JOINTS

A. Expansion Joints: Locate and install expansion joints as shown on Drawings. Where expansion joints are not shown, locate and install joints a maximum of 20 feet on center in either direction.

B. Contraction Joints: Tool joints during final finishing with edging tool.

C. Isolation Joints: Construct isolation joints in slabs on grade at all points of contact with vertical surfaces and elsewhere as indicated.

3.16 TOLERANCES

A. Footings
   1. Variation of dimensions in plan: plus 2” or minus ½”.
   2. Variation of center from specified center in plan: 2 percent of footing width in direction of variation, plus or minus 2” maximum variation.
   3. Variation of bearing surface from specified elevation: plus or minus ½”.

B. Anchor Bolts and Sleeves
   1. Variation from specified location in plan: plus or minus ¼”.
   2. Variation from specified elevation: plus or minus ½”.

C. Slab on Grade
   1. Surface Flatness: F_F = 20 or greater.
   2. Surface Levelness: F_L = 17 or greater.
   3. Variation from specified elevation: plus or minus ¼”.

D. Stairs
   1. Variation in riser: 1/8”.
   2. Variation in tread: 1/8:

3.17 SLAB SEALERS

A. Interior Exposed Slabs: Apply two coats of hardener after slabs have cured a minimum of 28 days at a rate of 100 square feet/gallon; in accordance with manufacturer's recommendations.

B. Exterior Exposed Slabs: Apply two coats of Penetrating Exterior Anti-Spalling Sealer after slabs have cured a minimum of 28 days in accordance with manufacturer's recommendations.

3.18 REPAIR OF SURFACES

A. Contractor shall be responsible for cost of repairing defects.

B. Repair defective wall areas with cement mortar or proprietary patching compound, when acceptable to Architect-Engineer. Cut out honeycomb, rock pockets and voids over 1/2" inch diameter back to solid concrete but in no case to a depth of less than 1 inch. Make edges of cuts perpendicular to concrete surface.

C. Repair defective interior slab areas as follows:
   1. Correct flatness and levelness defects by grinding or removal and replacement of slab. Patching of low spots will not be permitted.
   2. For cracks less than 1/32 inch, no repairs are required. For cracks greater than 1/32 inch, use crack repair material. For cracks over 1/8 inch, fill crack with oven-dried sand prior to application of crack repair material, as recommended by manufacturer. Contractor also has option to remove and rebuild areas of cracking. Mask cracks to limit crack repair material to crack only.
   3. Curling at slab edges which exceeds ¼ inch when measured with a 10-foot straight edge shall be made level by grinding or planning. Straightedge shall be located with it's end at the slab edge, and the space between the straightedge and the slab be measured. If curling exceeds ¼ inch, core drill slab at 3-foot intervals and inject non-shrink grout to fill void beneath slab.
   4. Repair edge spalls which occur from shrinkage cracking or from contractor's operations.

D. Remove and replace all exterior slabs which are cracked or do not drain properly.

END OF SECTION 033000

SECTION 09900 PAINTING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes surface preparation and field painting of the following:
   1. Exposed conduits and conduit support stanchions and plates.
   2. Wall painting to match existing where restoration is required.
   3. Surface preparation, priming, and finish coats specified in this Section are in addition to shop priming and surface treatments.

B. Paint exposed surfaces of exposed conduits where approved by the Owner and walls that were disrupted to accommodate new electrical. Colors to match existing and/or adjacent utilities and/or walls. The entire wall section disrupted by new conduit penetrations shall be painted.

C. Do not paint prefinished items, concealed surfaces, finished metal surfaces, operating parts, and labels.

1.2 SUBMITTALS

A. Product Data: For each paint system specified. Include block fillers and primers.
   1. Material List: Provide an inclusive list of required coating materials. Indicate each material and cross reference specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.
   2. Manufacturer's Information: Provide manufacturer's technical information, including label analysis and instructions for handling, storing, and applying each coating material proposed for use.

B. Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for each type of finish coat material indicated.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain block fillers, primers, and undercoat materials for each coating system from the same manufacturer as the finish coats.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Project Site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label.

B. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 45 deg F. Maintain containers used in storage in a clean condition, free of foreign materials and residue.

   1. Protect from freezing. Keep storage area neat and orderly. Remove oily rags and waste daily. Take necessary measures to ensure that workers and work areas are protected from fire and health hazards resulting from handling, mixing, and application.

1.5 PROJECT CONDITIONS

A. Do not apply paint in when the relative humidity exceeds 85 percent; or at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the products in the paint schedules.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide products of one of the following:

Benjamin Moore & Co.
O'Leary Paint Co.
PPG Industries, Inc.
Pratt & Lambert, Inc.
Standard Detroit Paint Co.
Sherwin Williams Co.

2.2 PAINT MATERIALS, GENERAL

A. Material Compatibility: Provide block fillers, primers, undercoats, and finish coat materials that are compatible with one another and the substrates indicated under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.

B. Material Quality: Provide manufacturer's best quality paint material of the various coating types specified. Paint material containers not displaying manufacturer's product identification will not be acceptable.

C. Colors: Provide colors selected by the Owner to match existing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with the Applicator present, under which painting will be performed for compliance with paint application requirements.
   1. Do not begin to apply paint until unsatisfactory conditions have been corrected and surfaces receiving paint are thoroughly dry.
   2. Start of painting will be construed as the Applicator's acceptance of surfaces and conditions within a particular area.

C. Provide seven days' notice to the Owner's Representative prior to the application of epoxy paints.

C. Coordination of Work: Ensure compatibility of the total system for various substrates. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.

1. Notify the Owner about anticipated problems using the materials specified over substrates primed by others.

3.2 PREPARATION

A. Cleaning, General: Before applying paint or other surface treatments, clean the substrates of substances that could impair the bond of the various coatings. Remove oil and grease before cleaning.
   1. Schedule cleaning and painting so dust and other contaminants from the cleaning process will not fall on wet, newly painted surfaces.

B. Surface Preparation: Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition and as specified.
   1. Provide barrier coats over incompatible primers or remove and reprime.
   2. For coatings applied over previously painted surfaces, test application to check for lifting and other adhesion problems. Perform test in an isolated area where practicable.
   3. Ferrous Metals: Clean ungalvanized ferrous metal surfaces that have not been shop coated; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with the Steel Structures Painting Council's (SSPC) recommendations.
      a. Treat bare and sandblasted or pickled clean metal with a metal treatment wash coat before priming.
      b. Touch up bare areas and shop applied prime coats that have been damaged. Wire brush, clean with solvents recommended by paint manufacturer, and touch up with the same primer as the shop coat.

C. Materials Preparation: Mix and prepare paint materials according to manufacturer's written instructions.
   1. Maintain containers used in mixing and applying paint in a clean condition, free of foreign materials and residue.
   2. Stir material before application to produce a mixture of uniform density. Stir as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.
   3. Use only thinners approved by paint manufacturer and only within recommended limits.

3.3 APPLICATION

A. General: Apply paint according to manufacturer's written instructions. Use applicators and techniques best suited for substrate and type of material being applied.
   1. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.
   2. Provide finish coats that are compatible with primers used.

B. Scheduling Painting: Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.
   1. The number of coats and the film thickness required are the same regardless of application method. Do not apply succeeding coats until the previous coat has cured as recommended by the manufacturer. If sanding is required to produce a smooth, even surface according to manufacturer's written instructions, sand between applications.

2. Omit primer on metal surfaces that have been shop primed and touchup painted.
3. If undercoats, stains, or other conditions show through final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance. Give special attention to ensure edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.
4. Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and where application of another coat of paint does not cause the undercoat to lift or lose adhesion.

C. Application Procedures: Apply paints and coatings by brush, roller, spray, or other applicators according to manufacturer's written instructions.
   1. Brushes: Use brushes best suited for the type of material applied. Use brush of appropriate size for the surface or item being painted.
   2. Rollers: Use rollers of carpet, velvet back, or high pile sheep's wool as recommended by the manufacturer for the material and texture required.
   3. Spray Equipment: Use airless spray equipment with orifice size as recommended by the manufacturer for the material and texture required.

D. Minimum Coating Thickness: Apply paint materials no thinner than manufacturers recommended spreading rate. Provide the total dry film thickness of the entire system as recommended by the manufacturer.

E. Prime Coats: Before applying finish coats, apply a prime coat of material, as recommended by the manufacturer, to material that is required to be painted or finished and that has not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn through or other defects due to insufficient sealing.

F. Pigmented (Opaque) Finishes: Completely cover surfaces as necessary to provide a smooth, opaque surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, repines, or other surface imperfections will not be acceptable.

G. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or repaint work not complying with requirements.

3.4 CLEANING

A. Cleanup: At the end of each workday, remove empty cans, rags, rubbish, and other discarded paint materials from the site.
   1. After completing painting, clean glass and paint spattered surfaces. Remove spattered paint by washing and scraping. Be careful not to scratch or damage adjacent finished surfaces.
   2. Dispose wash water from latex paint to the sanitary sewer. Excess latex paint shall be salvaged for reuse or solidified for disposal with other construction materials. Dry empty latex paint cans and dispose with other construction materials. Coordinate disposal of alkyd paints and solvents with University project manager.

3.5 PROTECTION

A. Protect work of other trades, whether being painted or not, against damage by painting. Correct damage by cleaning, repairing or replacing, and repainting, as approved by Architect.
B. Provide "Wet Paint" signs to protect newly painted finishes. Remove temporary protective wrappings provided by others to protect their work after completing painting operations.
    1. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces. Comply with procedures specified in PDCA P1.

END OF SECTION 09900

SECTION 260510 – ELECTRICAL DESIGN AND EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE OF SUPPLY

This section includes design, performance, and technical requirements for Supplier-furnished electrical equipment. The scope of supply shall include the following items:

Medium voltage switchgear equipment. (IF APPLICABLE)

Medium voltage controller equipment. (IF APPLICABLE)

Low voltage motor control assemblies.

Low voltage power distribution equipment, including the following:

Low voltage switchboards.

Low voltage panelboards.

Dry type transformers.

1.2 ITEMS FURNISHED BY OTHERS AND INTERFACES

Items furnished by others and not in this scope of supply are identified as follows:

(Later)

1.3 PERFORMANCE AND DESIGN REQUIREMENTS

Performance and design requirements for the Supplier-furnished electrical equipment are as required by Supplier's design, as indicated in Article 16051.2, on the Electrical Design and Equipment Data Sheets included at the end of this section, and as follows:

Design ambient temperature	104° F (40° C)
Site elevation	Less than 3,300 ft (1,000 m)

1.4 CODES AND STANDARDS

Work performed under these specifications shall be done in accordance with the following codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified herein shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the current edition and addenda in effect at the date of this document shall apply. These references shall govern the work except where they conflict with the Purchaser's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Work	In Accordance With
All	The latest revisions of the applicable ANSI C37, NEMA ICS2, IEC, and UL standards

1.5 MATERIALS

The following materials shall be used:

Component	Material

1.6 APPROVED MANUFACTURERS OF COMPONENTS

For the following components, only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications. If the Supplier wants to propose a nonlisted manufacturer that is considered to provide an equivalent level of quality, this manufacturer must be identified and supporting testimony provided. Acceptance of the manufacturer as a substitute is at the discretion of the Purchaser:

Component	Manufacturer
Medium voltage switchgear equipment	Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc., Powell Electrical Manufacturing Company
Medium voltage controller equipment	Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc, Powell Electrical Manufacturing Company
Protective relays	ABB Power T&D, Basler Electric, Beckwith Electric, GE, GE - Multilin, Siemens Energy & Automation

Component	Manufacturer
Low voltage switchgear (metal-enclosed circuit breakers)	Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc., Powell Electrical Manufacturing Company
Low voltage motor control centers (motor control center assemblies)	Alstom, North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer, ABB Power T&D Company, Inc., Powell Electrical Manufacturing Company
UL/NEMA low voltage switchboards	North American Power System Sales, General Electric, Siemens Energy & Automation, Groupe Schneider - Merlin Gerin, Switchgear & Instrumentation Ltd., Cutler-Hammer

1.7 TEST REQUIREMENTS

The following testing shall be conducted in accordance with the specified source. This testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Supplier unless specifically identified as a Bid Option or Purchaser-conducted. Tests identified as an option are to be priced separately. If identified as Purchaser-conducted, costs for the initial test will be the responsibility of the Purchaser. However, the Supplier is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Tests	In Accordance With	Conducted By

1.8 TECHNICAL ATTACHMENTS

The following attachments accompany these specifications in either paper or electronic format. The information contained in these documents constitutes requirements under the defined Scope of Work:

Document Number/Description	Title	Revision

PART 2 – PRODUCTS

2.1 MEDIUM VOLTAGE SWITCHGEAR EQUIPMENT

When specified to be in the Supplier's scope of supply, the Supplier shall supply medium voltage metal-clad switchgear in accordance with the articles below and as required by the Supplier's design. The design shall be in accordance with accepted industry practices and standards for electrical power generation.

2.1.1 Switchgear Enclosures

The switchgear shall be furnished with enclosures of the types specified below:

Location	**Description of Enclosure Type**
Indoors	Indoor with gasketed doors, ventilated
Outdoors	Walk-in protected aisle

Switchgear equipment shall be mounted in vertical sections fabricated of steel and assembled to provide rigid self-supporting structures.

The breakers shall be removable from the front. Grounded removable steel barriers shall be provided between the instrument panels and the power cable and current transformer compartments.

Each switchgear unit shall be furnished with hinged front door(s) to allow removal of the circuit breaker(s).

Doors shall be designed and adequately constructed for the mounting of instruments, meters, relays, switches, indicating lights, and other devices. Stops and latches shall be provided for control of each door in the open and closed positions. Each unit of switchgear section shall have a removable rear panel.

2.1.1.1 Outdoor weatherproof

Each unit of switchgear located outdoors shall be furnished with an outdoor weatherproof enclosure furnished with interior hinged front doors as previously specified and an enclosed operating and maintenance aisle. The rear of each such unit shall be furnished with a removable gasketed panel or a hinged and gasketed door.

Each operating and maintenance aisle shall be of sufficient width to allow the removal of breakers from the front of the units and shall be furnished with a door at each end of the switchgear assembly. The doors shall be equipped with panic hardware.

Ventilation openings shall be furnished with filters. The underside of the switchgear shall be coated with a protective sealing compound.

The manufacturer's standard indoor and outdoor lighting (including switching) shall be furnished. One convenience outlet shall be furnished at each end of the operating and maintenance aisle.

2.1.1.2 Switchgear space heaters

Each unit of switchgear shall be furnished with space heaters to prevent condensation of moisture within the switchgear. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored.

Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage specified. Space heaters shall be controlled by an adjustable thermostat or fixed humidistat.

Space heater voltage rating shall be approximately twice the applied voltage to increase the operating life.

2.1.1.3 Motor space heaters

When medium voltage motors are controlled by the lineup of switchgear, the Supplier shall furnish space heater power buses throughout the switchgear, and all space heater wiring shall be integral to the switchgear with suitable branch circuit protection. Motor space heater circuits shall also include connection to switchgear breaker auxiliary contacts and connections to terminal blocks for external connections.

2.1.1.4 Nameplates

Engraved nameplates shall be furnished for the front and rear of each switchgear unit and for equipment and devices within each unit.

2.1.2 Power Circuit Breakers

The switchgear shall be furnished with high voltage power circuit breakers of standard drawout design with the following design features:

Shall not be forced cooled.

All secondary device contact surfaces and main contact surfaces shall be silver-to-silver, designed and fabricated to be self-aligning and to resist burning and deterioration.

Removable breaker units of the same type and ampere capacity shall be wired alike and shall be mechanically and electrically interchangeable.

Shall be a 3-pole single-throw unit, complete with operating mechanism and other required devices, mounted on a drawout type carriage. Each operating

mechanism shall be of the stored energy type with a closing coil and single shunt trip coils. The closing devices, tripping devices, and charging motor shall be designed and rated for operation on the nominal control voltage specified.

Operating mechanisms shall be trip-free in any position and shall be antipump. The breaker main contacts shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.

Each breaker shall be furnished with a manual trip push button which mechanically trips the breaker. The manual trip push button and its associated breaker trip linkage shall have no common components with the electrical trip mechanism, except the final breaker release device.

Each breaker shall be furnished with an operations counter which shall be readable from the front of the switchgear unit with the breaker in the connected position.

2.1.2.1 Rating

Power circuit breakers furnished under these specifications shall be provided with the ratings as required by the Supplier's design. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

2.1.2.2 Auxiliary contacts

Each breaker shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for operation of the breaker. In addition, two normally open and two normally closed sets of spare contacts shall be provided and wired out to terminal blocks for use by the Purchaser.

Breaker mechanism operated auxiliary switches shall operate only when the breaker is in the connected position.

2.1.2.3 Breaker control devices

Each remotely controlled breaker shall be furnished with a local control switch and breaker position switch arranged to provide the following control of breaker operation:

Breaker Drawout Position	**Breaker Operation**			
	Remote Control		**Local Control Switch**	
	Close	**Trip**	**Close**	**Trip**
Connected	X	X	--	--
Test	--	--	X	X

Disconnected	--	--	--	--

Each circuit breaker local control switch shall have a trip/close escutcheon, shall have a center normal position, shall be spring return to normal from close and trip, shall have red and green targets to indicate the latest operation of the switch, and shall be furnished with indicating lights. One set of these contacts shall be wired out to terminal blocks for use by the Purchaser.

The breaker position switch shall be furnished with four stages. Two breaker position switch contacts shall close only when the breaker is in the connected position; the remaining two contacts shall close only when the breaker is in the test position.

2.1.3 Power and Control Conductors

Switchgear power and control conductors shall be furnished in accordance with the requirements of the articles which follow. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through a full ambient temperature range from -13° F (-25° C) to +104° F (+40° C). Expansion joints shall be furnished where required.

2.1.3.1 Main bus

The switchgear main bus shall be copper bar, designed to continuously carry the current required by the Supplier's design plus a 25 percent margin without exceeding temperature rise requirements specified in the applicable standards.

The bus shall be installed with rigid, non-tracking, fire-resistant, and non-hygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the close and latch and short-time current ratings of the circuit breakers as specified.

The ungrounded bus bars shall be insulated with epoxy, applied using a fluidized bed system or shall be insulated in a manner approved by the Purchaser. Details of the insulation system shall be supplied with the technical data.

All power current carrying connections shall be bolted together. All joints shall have silver-to-silver contact surfaces with minimum contact resistance.

Instrument transformer primary connections shall be designed to permit removal and replacement of the transformers without damage to the connections.

When incoming and outgoing cable and bus connections are accessed from the rear of the equipment, removable insulating boots shall be used to insulate the bolted connections. The insulation rating of the boot shall not be less than the voltage rating of the equipment.

2.1.3.2 Ground (earthing) bus

An uninsulated copper ground bus with a momentary rating at least equal to the momentary rating of the circuit breakers shall be furnished through the entire length of the switchgear. All switchgear equipment requiring grounding shall be connected to this ground bus.

Each compartment containing terminals for connection of external power circuit conductors shall also contain provisions for attaching feeder cable shield ground conductors directly to the ground bus. The compartment ground buses shall also be furnished with clamp type connectors for attachment of the power circuit ground cables.

2.1.4 External Connections

Facilities for the entrance, support, termination, and connection of power and control conductors shall be furnished in accordance with the requirements of the following articles.

2.1.4.1 Entrance

Adequate openings shall be furnished for all conductors (metal-enclosed bus duct, power cables, and control cables, as required) entering the switchgear.

2.1.4.2 Terminal connectors

Terminal connectors for power cable and ground (earthing) cable entering the switchgear shall be long-barrel, 2 hole, bolted clamp or compression type. Solder type terminals are not acceptable.

2.1.4.3 Stress cones

Where power conductors entering a switchgear unit will be cable, adequate space and supporting facilities shall be furnished for flaring of power cables, for field installation of stress cones, and for support of the cable. Hot or cold shrink type termination kits shall be utilized.

2.1.4.4 Bus duct

Where bus duct is entering the switchgear, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.1.4.5 Ground (earthing) bus

Connectors shall be furnished at each end of the switchgear assembly ground bus. Each switchgear unit containing terminals for connection of external power cable shall be furnished with connectors for attaching power cable shields directly to the ground bus.

Each switchgear unit containing terminals for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground bus to the switchgear ground bus and/or bonding the bus duct enclosure to the ground system.

2.1.5 Control Power

Control power for each continuous bus switchgear assembly shall be as specified on the Electrical Design and Equipment Data Sheets included at the end of this section. Control power monitoring shall be provided. When ac control derived from control power transformers within the switchgear is specified, a capacitive charged tripping system shall be provided to permit tripping all of the circuit breakers for a period of at least 24 hours after medium voltage power has been lost.

The Supplier shall furnish all internal switchgear wiring required to distribute control power to each switchgear unit. Each breaker shall be furnished with a 2-pole control power disconnecting and protective device in the closing circuit, and shall be furnished with a 2-pole control power disconnecting and protective device in each tripping circuit. The disconnecting and protective devices shall be molded case circuit breakers or enclosed fused pullouts.

2.1.6 Instrument Transformers, Instruments, and Associated Devices.

Instrument transformers, instruments, and associated devices shall be furnished as required by the Supplier's design. All instrument transformer secondary leads shall be wired out to terminal blocks.

2.1.6.1 Current transformers

Current transformer mechanical and thermal limits shall be coordinated with the momentary and short-time ratings of the circuit breakers with which they are used.

Window type current transformers shall have a 5.25 inch (133 mm) diameter circular window or the oval equivalent. Window current transformers shall be mechanically braced to withstand the same momentary current as the circuit breakers with which they are used. Where a window current transformer braced for the same momentary current as the circuit breaker is unavailable with the ratio specified, the Supplier shall furnish a combination of a window current transformer braced for the momentary current of the circuit breaker and an associated auxiliary current transformer. The product of the ratios of the window current transformer and the auxiliary current transformer shall be equal to the ratio specified.

2.1.6.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second; shall be mounted and have secondary voltage, capacity, accuracy,

and other ratings as required by the Supplier's design; and shall be compatible with the Purchaser's equipment.

Each transformer shall be provided with current limiting primary fuses and secondary fuses, and shall be mounted with primary fuses on a drawout type removable unit designed to isolate and ground (earth) the potential circuits when the unit is in the fully withdrawn position.

2.1.6.3 Protective relays

Each breaker unit shall be provided with at least one solid-state or microprocessor type protective relay and, as a minimum, shall have the following protective functions:

	ANSI C37 Device Function Number							
	25	**27**	**46**	**49**	**50**	**50G**	**51**	**51N/G**
Incoming main breaker	X					X	X	
Tie breaker	X						X	X
Bus feeder breaker							X	X
Motor feeder breaker		X	X	X	X	X		
SUS transformer feeder				X	X	X		

Relay types to be proposed shall be submitted with the bid documents and shall be subject to approval by the Purchaser.

Auxiliary relays mounted internally shall be surface mounted and front connected.

2.1.7 Wiring and Wiring Diagrams

The Supplier shall furnish internal switchgear wiring, connections, and diagrams in accordance with the requirements of the following articles.

2.1.7.1 Control and instrument wiring

All low voltage control and instrument wiring shall be installed and tested at the factory.

All interior wiring shall be neatly and carefully installed in wiring gutters or conduit and shall be terminated at terminal blocks plainly lettered or marked in accordance with the Supplier's connection diagrams. Extra flexible wire shall be furnished at hinge points.

Switchgear units that are split for shipment shall be furnished with all wiring required to interconnect the switchgear units.

The minimum sizes of wire used in the switchgear for control and instrumentation shall be in accordance with the following table:

Minimum Wire Service	**Size, AWG (mm^2)**
Power supplies	12 (4)
Current transformer circuits	12 (4)
Indicating lights and annunciator circuits	16 (1.5)
All other wiring	14 (2.5)

2.1.7.2 Diagrams

Wiring diagrams shall be in accordance with the requirements specified herein.

The complete connection diagram of each switchgear unit shall be on an individual sheet. Information on each connection diagram sheet shall include point-to-point wiring of the entire unit as it would appear to a person wiring the switchgear unit, including wiring on the breaker itself. Elementary diagrams of control and instrument circuits, contact arrangement of switches, and internal wiring of relays and instruments for each switchgear unit shall be on additional sheets as required. Interconnection diagrams shall be on separate sheets. All sheets shall be the same size.

Each item of switchgear mounted equipment indicated on the diagrams shall be identified by item number and name.

Sufficient space shall be left on the customer's side of outgoing terminal blocks for adding cable color codes and circuit numbers.

At the time the Supplier's connection drawings are submitted for review, the Purchaser will mark thereon all external (interface) circuit and wire designations required, and such designations shall be added to the connection drawings by the Supplier.

2.2 Medium Voltage Controller Equipment Specification

When specified to be in the Supplier's scope of supply, the Supplier shall supply medium voltage metal-clad switchgear in accordance with the articles below and as required by the Supplier's design. The design shall be in accordance with accepted industry practices and standards for electrical power generation.

Design and construction of medium voltage controllers shall be in accordance with the requirements of the articles which follow.

2.2.1 Enclosures

Each assembly shall be furnished with enclosures of the types specified below:

Location	**Description of Enclosure Type**
Indoors	Indoor with gasketed doors, ventilated
Outdoors	Weatherproof, walk-in protected aisle
Outdoors	Weatherproof, without enclosed operating and maintenance aisle

Each controller assembly shall consist of a lineup of free-standing metal-enclosed vertical sections interconnected into an integrally built group.

Main contactors and, when required, main incoming circuit breakers shall be removable from the front. Grounded removable steel barriers shall be provided between the medium voltage and low voltage compartments.

2.2.1.1 Front doors

Each controller unit shall include a hinged front door for the medium voltage compartment and a separate hinged front door for the low voltage compartment.

Doors shall be designed and adequately constructed for the mounting of instruments, meters, relays, switches, indicating lights, and other specified devices. Doors shall be hinged and shall have turned-back edges and additional bracing where required to ensure rigidity.

2.2.1.2 Indoor general purpose enclosures

Each unit of switchgear specified on the Electrical Design and Equipment Data Sheets to be furnished with an indoor general purpose enclosure shall be furnished with a hinged front door, as previously specified, and a removable rear panel.

2.2.1.3 Outdoor weatherproof enclosures without an enclosed operating and maintenance aisle

Each unit of switchgear specified on the Electrical Design and Equipment Data Sheets to be furnished with an outdoor weatherproof enclosure without an enclosed operating and maintenance aisle shall be furnished with an interior hinged front door as previously specified and an exterior hinged and gasketed front door. The rear of each such unit shall be furnished with a removable gasketed panel or hinged and gasketed door.

Exterior doors shall have concealed hinge construction and three-point single handle operated latches. Exterior door handles shall be locking type; the switchgear enclosures shall be tamper resistant.

Ventilation openings shall be furnished with filters.

One convenience outlet shall be furnished in each switchgear unit. The Supplier shall furnish all convenience outlet wiring integral to the switchgear and suitable branch circuit protection.

The underside of the switchgear shall be coated with protective sealing compound.

2.2.1.4 Outdoor weatherproof enclosures with an enclosed operating and maintenance aisle

Each unit of switchgear specified on the Electrical Design and Equipment Data Sheets to be furnished with an outdoor weatherproof enclosure with an enclosed operating and maintenance aisle shall be furnished with an interior hinged front door as previously specified and an enclosed operating and maintenance aisle along the front of the controller assembly. The rear of each such unit shall be furnished with a removable gasketed panel or a hinged and gasketed door.

Each operating and maintenance aisle shall be of sufficient width to allow removal of breakers from the front of the units and shall be furnished with a door at each end of the controller assembly. The doors shall be equipped with panic hardware.

Ventilation openings shall be furnished with filters. The underside of the controller assembly shall be coated with a protective sealing compound.

One 100 watt incandescent lighting fixture shall be furnished in the operating and maintenance aisle for each two controller units, and one 150 watt outdoor incandescent lighting fixture shall be furnished over each exterior aisle door. A weatherproof light switch shall be mounted on the exterior of the controller enclosure adjacent to each exterior aisle door for control of all lights. One convenience outlet shall be furnished at each end of the operating and maintenance aisle.

2.2.1.5 Controller space heaters

Where space heaters are specified, all units and the individual compartments of divided units shall be provided with space heaters to prevent condensation of moisture within the enclosures. The heaters shall be spaced away and thermally insulated from any painted surfaces. Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage stated on the Electrical Design and Equipment Data Sheets.

Unless specified otherwise, the Purchaser will provide a single space heater supply feeder to each continuous assembly having a common bus. The Supplier shall furnish contactors, all required internal wiring, suitable branch circuit protection for each space heater circuit, and space heater power buses throughout the controller assembly.

Controller and auxiliary equipment units shall have space heaters controlled by an adjustable thermostat, factory set to close at 85° F (30° C) and to open at 95° F (35° C).

Where a common enclosure and motor space heater bus is specified on the Electrical Design and Equipment Data Sheets, the Supplier shall make connections to the space heater bus for the purpose of providing motor space heater power.

2.2.1.6 Motor space heaters

Where a separate motor space heater bus is specified on the Electrical Design and Equipment Data Sheets, the Supplier shall furnish wiring through the length of the controller assembly. The Supplier shall make a connection to a terminal block for external connection to each motor space heater from the motor space heater bus or the controller assembly space heater bus, as applicable. Each motor space heater circuit shall be routed through a normally closed auxiliary switch contact or auxiliary contact and shall include suitable branch circuit protection.

2.2.1.7 Nameplates

Engraved nameplates shall be furnished for the front of each unit. Equipment and devices within each unit shall be identified with permanently printed tags or engraved nameplates. Nameplate inscriptions will be provided by the Purchaser at a later date.

2.2.2 Incoming Power Circuit Breakers

When required on the Electrical Design and Equipment Data Sheets, the controller assembly shall be furnished with high voltage power circuit breakers of standard drawout design.

The breakers shall not be forced cooled.

All secondary device contact surfaces and main contact surfaces shall be silver-to-silver, designed and fabricated to be self-aligning and to resist burning and deterioration.

Removable breaker units of the same type and ampere capacity shall be wired alike and shall be mechanically and electrically interchangeable.

Terminal designations shall be as indicated on the typical schematic diagrams furnished by the Supplier.

2.2.2.1 Rating

Power circuit breakers furnished under these specifications shall be provided with the ratings as required by the Supplier's design. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

2.2.2.2 Low current switching capability

In addition to conforming with load current switching capability requirements of the applicable standard, breakers shall be capable of interrupting low current loads and

faults as specified herein. Breakers shall be capable of interrupting inductive loads having power factors in the range of 20 percent lagging to 80 percent lagging, with current values in the range of 2 percent to 100 percent of the breaker continuous current rating. These loads shall be interrupted without exceeding the rated interrupting time by more than 2.5 cycles for opening operations and 3.5 cycles for close-open operations.

2.2.2.3 Operating mechanism

Each power circuit breaker shall be a 3-pole single-throw unit, complete with operating mechanism and other required devices, mounted on a drawout type carriage.

The operating mechanism shall be of the stored energy type with a closing coil and single or dual shunt trip coils as specified on the Electrical Design and Equipment Data Sheets. The closing devices, tripping devices, and charging motor shall be designed and rated for operation on the nominal control voltage specified.

The operating mechanism shall be trip-free in any position and shall be antipump. The breaker main contacts shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.

Each breaker shall be furnished with a manual trip push button which mechanically trips the breaker. The manual trip push button and its associated breaker trip linkage shall have no common components with the electrical trip mechanism, except the final breaker release device.

Each breaker shall be furnished with an operations counter which shall be readable from the front of the switchgear unit with the breaker in the connected position.

2.2.2.4 Auxiliary contacts

Each breaker shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for operation of the breaker. In addition, two normally open and two normally closed sets of spare contacts shall be provided and wired out to terminal blocks for use by the Purchaser.

Breaker mechanism operated auxiliary switches shall operate only when the breaker is in the connected position.

All spare auxiliary contacts shall be wired to terminal blocks for external connection.

2.2.2.5 Breaker control devices

Each remotely controlled breaker shall be furnished with a local control switch and breaker position switch arranged to provide the following control of breaker operation:

	Breaker Operation

Breaker Drawout Position	Remote Control		Local Control Switch	
	Close	Trip	Close	Trip
Connected	X	X	--	--
Test	--	--	X	X
Disconnected	--	--	--	--

Each circuit breaker local control switch shall have a trip/close escutcheon, shall have a center normal position, shall be spring return to normal from close and trip, shall have red and green targets to indicate the latest operation of the switch, and shall be furnished with indicating lights.

The breaker position switch shall be furnished with four stages. Two breaker position switch contacts shall close only when the breaker is in the connected position; the remaining two contacts shall close only when the breaker is in the test position.

2.2.3 Controllers

Controllers shall consist of an assembly of contactors, primary disconnects, current limiting fuses, transformers, and control and instrument equipment as specified in the articles which follow.

The Supplier shall be responsible for the coordination of the contactors, current transformers, protective relays, and current limiting fuses. In selecting suitable components, the following points must be considered:

1. Protection of the load against sustained overloads and locked-rotor conditions, for motor loads, by opening of the circuit with the contactor by means of the protective relay.

2. Protection of the fuses against sustained currents above their continuous ampere rating but below their melting value by opening of the circuit with the contactor by means of the protective relay.

3. Protection of the feeder circuit within the interrupting limits of the contactor by opening the circuit with the contactor by means of the protective relay and not opening the circuit with the fuses.

4. Protection of the feeder circuit, contactor, current transformers, and protective relay from the damaging effects of maximum fault currents by opening the circuit with properly sized current limiting fuses.

2.2.3.1 Main contactors

Contactors shall be 3-pole, single-throw, vacuum break units furnished electrically and mechanically complete. Contactors shall be capable of carrying the ampere rating

as required by the Supplier's design continuously when mounted in a ventilated indoor enclosure in a 104° F (40° C) ambient. Contactors shall be of the magnetically held-in type. When the coil circuit is interrupted, the contactor shall open the feeder circuit. Controller control voltage shall be as specified on the Electrical Design and Equipment Data Sheets. Where an ac control voltage is specified, the contactor coils shall be ac rated or shall be dc rated and shall be supplied from a silicon full wave bridge rectifier furnished on the controller.

Each contactor shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for proper operation of the equipment. Not less than three spare "a" and three spare "b" auxiliary contacts shall be furnished on each contactor. In addition, mechanically operated auxiliary switches shall provide not less than four spare "a" and four spare "b" contacts. The auxiliary switches shall be stationary and shall be mounted in the controller enclosure. All auxiliary switch contacts shall be wired to terminal blocks for use with control circuits where needed.

The contactors shall be capable of carrying their rated full load current continuously without exceeding the temperature rise as specified in the latest applicable standards. The contactors shall be cooled by natural conduction, convection, and radiation. Contactor insulation shall be coordinated with that of the controller assembly structure.

All contactors of the same unit type shall be wired alike and shall be mechanically and electrically interchangeable.

Where drawout contactors are specified, the contactor drawout assembly shall be furnished complete with wheels to provide easy removal from the enclosure.

2.2.3.2 Disconnecting mechanism

A 3-pole externally operated disconnecting mechanism shall be furnished for disconnecting each controller from the bus. For drawout type contactors, operating the mechanism shall disconnect the contactor from the bus and shall operate an automatic insulated shutter to close the openings to the bus. For fixed mounted contactors, operating the mechanism shall open a disconnect switch which will disconnect power to the contactor, power fuses, and control power transformer (if applicable) from the bus. The medium voltage bus shall be isolated from the rest of the medium voltage compartment by insulated barriers or shutters when the disconnect switch is open. The disconnect switch shall have a continuous current rating not less than that of the contactor.

Mechanical interlocking means shall be provided to prevent operating the mechanism with the contactor closed. An electrical interlock shall be provided to trip the contactor before enabling operation of the mechanism. Provisions shall be made to allow padlocking of the disconnecting mechanism handle in both the ON and the OFF positions.

2.2.3.3 Fuses

Current limiting fuses shall be furnished to ensure positive interruption of faults to limit the magnitude of short-circuit current and electromechanical stresses to values within the design limits of the controller assembly components.

In addition, the fuses shall limit the surge voltage produced by short-circuit currents to within allowable limits of the applicable standard.

Power fuses shall be supplied by the Supplier. Easy identification of blown fuses shall be provided by positive action indicators.

Fuses shall be furnished for protection of control power transformers and potential transformers. Control power transformer fuses shall be Buss JCW or equal and shall be E rated.

Fuses shall be designed to prevent discharge of flame or gas when operated and shall not require discharge filters, fire boxes, special vents, or reinforcing.

For drawout design, power fuses shall be mounted on the contactor drawout assembly. Where specified, the power fuses shall be equipped with antisingle-phasing devices to open the contactor on a blown fuse and prevent single-phasing of the load.

2.2.4.1 Main bus

Each controller assembly main bus shall be made of the material specified on the Electrical Design and Equipment Data Sheets and shall be capable of carrying rated current continuously without exceeding temperature rise requirements specified in the latest applicable standards.

The bus shall be installed with rigid, non-tracking, nonflammable, and non-hygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the short-time current rating of the largest contactor.

When bus bar insulation is specified on the Electrical Design and Equipment Data Sheets, all buses which are to be insulated shall be furnished with an insulating sleeve, coated with epoxy type insulating material or acceptable equal molded around and bonded to the bus, or shall be taped, except at bolted terminations and connection points. All bolted joints; expansion joints; and all bus connections, factory or field, shall be insulated with removable boots. Removable boots shall be designed to overlap bus insulation a minimum of 1 inch (25 mm). Insulation rating of bus, joint, connection, and terminal insulation shall be at least equal to the voltage rating of the equipment.

All joints shall have minimum contact resistance and, when specified, shall have tinned or silver contact surfaces.

The main bus shall be arranged Phase A (1), Phase B (2), and Phase C (3), from left to right, from front to back, and from top to bottom when facing the front (operating side) of the controller assembly.

2.2.4.2 Ground (earthing) bus

An uninsulated copper ground (earthing) bus, with a momentary short-time rating at least equal to the momentary and short-time rating of the largest contactor, shall be furnished through the entire length of each controller assembly. All of the assembly equipment requiring grounding (earthing) shall be connected to this ground (earthing) bus. Each compartment containing terminals for connection of external power circuit conductors shall also contain provisions for attaching feeder cable shield ground (earthing) conductors directly to the ground (earthing) bus. Where specified on the Electrical Design and Equipment Data Sheets, the compartment ground (earthing) bus shall also be furnished with a clamp type connector for attachment of the power circuit ground (earthing) cable. Provisions shall be made for the attachment of 2/0 AWG (70 mm^2) to 4/0 AWG (120 mm^2) stranded copper cable to each end of the ground (earthing) bus in each end section of the assembly for external connection to the station ground (earthing) grid.

2.2.4.3 Bus connections

Connections between the main buses and disconnecting devices, instrument transformers, and contactors shall be furnished and installed with an insulating cover equal to the insulation of the main bus (if so insulated). All main current carrying connections shall be made by bolting together flat bar. Insulated cable connections shall be furnished for the control power transformers (if applicable).

Current transformer primary connections shall be designed to allow easy removal and replacement of the transformers without damage to the connections.

All material required for field connection and insulation of bus and terminals shall be provided if an insulated bus system is furnished.

2.2.5 External Connections

Facilities for the entrance, support, termination, and connection of power supply and feeder conductors shall be provided in accordance with the requirements of the articles which follow.

2.2.5.1 Entrance

Adequate openings shall be furnished for all conductors entering each controller assembly. Cable entrance will be from above or below as indicated on the Electrical Design and Equipment Data Sheets.

2.2.5.2 Terminal connectors

Terminal connectors for all power cable and external ground (earthing) conductors entering each controller assembly shall be provided and shall be the same as, or an acceptable equal to, the following terminals. Solder type terminals are not acceptable:

Copper Conductor Cable Size, AWG (mm^2)	**Burndy Terminal Connectors Compression Type**
8 (10) and smaller	YAV
6 (16) and larger	YA-2N (long barrel)

2.2.5.3 Stress cones

Where the power conductors entering a controller unit will be cable, adequate space and supporting facilities shall be furnished for flaring of power cables, for field installation of stress cones, and for support of the cable.

Cable termination points and current transformers shall be arranged for convenient routing of the power conductors (from the direction specified) to the terminal point. Proper clearances and bending space shall be provided.

2.2.5.4 Bus duct

Where bus duct is utilized for power conductors, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.2.5.5 Ground bus

Ground cable connectors shall be furnished for the attachment of stranded copper cable to the ground (earthing) bus for external connection to the station grounding (earthing) system. Connectors shall be furnished at each end of the controller assembly ground (earthing) bus. Each controller unit containing terminals for connection of external power cable shall be furnished with connectors for attaching power cable shields directly to the ground (earthing) bus.

Each controller unit containing terminals for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground (earthing) bus to the switchgear ground (earthing) bus.

2.2.6 Control Power

Electrical power for control and instrumentation shall be as required by Supplier's design.

Where dc control power is specified on the Electrical Design and Equipment Data Sheets, the Supplier shall provide a common bus throughout the controller assembly requiring a single connection of dc control power from the Purchaser. Suitable branch circuit

protection and control power disconnecting means shall be provided for each controller unit.

The paragraphs which follow apply only to ac control power.

Where ac control power is specified on the Electrical Design and Equipment Data Sheets, all control power requirements necessary to operate each controller shall be provided by means of individual control power transformers. Each controller unit shall be provided with an individual transformer for control and instrumentation associated with that controller only.

Control power transformers shall be rated not less than 1 kVA. Each control power transformer shall be provided with primary and secondary fuses. The size of each control power transformer shall be clearly indicated on each section schematic and wiring diagram submitted for review.

Control power interlocking provisions shall be provided to allow testing of the control operation of each controller from an external source of control power with the contactor disconnected and isolated from the main bus.

Control power interlocking provisions shall not allow the control power transformer of the controller to be energized during testing as described above.

The Supplier shall furnish a manually operated switch to transfer the control power from the normal source to the external test circuit source.

2.2.7 Instrument Transformers, Instruments, and Associated Devices

Instrument transformers shall be designed for use with meters, relays, and instruments, in accordance with the latest applicable standards. Instrument transformer secondary leads shall be brought out to terminal blocks grouped for the connection of external circuits.

2.2.7.1 Current transformers

Current transformer thermal and mechanical limits shall be coordinated with the short-time rating of the controller with which they shall be used. All current transformers shall be single ratio unless otherwise specified. All current transformer leads shall be brought out to shorting type terminal blocks arranged to provide any combination of connections or polarity.

Window type current transformers for zero sequence fault current sensing shall be provided for each controller when ground (earth) fault protection is specified. The transformers shall be installed in accordance with the recommendations of the relay manufacturer. Where bottom entry is specified, the transformers shall be spaced above the enclosure bottom to allow the cable shield ground (earthing) conductor to be brought through and connected to the ground (earthing) bus.

2.2.7.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second and shall be mounted and have secondary voltage, capacity, accuracy, and other ratings as required by the Supplier's design.

Each transformer shall be provided with current limiting primary fuses and secondary fuses. When voltage transformers are supplied in a drawout assembly, the drawout unit shall have the primary fuses mounted on it and shall be designed to isolate and ground (earth) the potential circuits when the unit is in the fully withdrawn position.

2.2.7.3 Protective relays

Protective relays shall be as required by the Supplier's design. In addition, specific relay types and/or functions, if required by the Purchaser, are indicated on the Electrical Design and Equipment Data Sheets. Protective relays shall be flush mounted, induction or static drawout type, or microprocessor type, equipped with built-in test switches and operation counters.

Auxiliary relays mounted internally shall be surface mounted, front connected.

Field application relays and controls shall be provided for all synchronous motors.

2.2.7.4 Control and instrument switches

All controllers shall have, mounted on the front instrument panel, red and green indicating lights and either START and STOP push buttons or a multistage control switch equipped with modern pistol grip handle.

Unless specified otherwise on the Electrical Design and Equipment Data Sheets, each local control switch shall be wired to close its contactor only when the contactor is in the TEST position. When in the OPERATE position, the contactor may be tripped with either the local emergency stop push button, protective relay trip, or the remote input.

2.2.8 Wiring and Wiring Diagrams

The Supplier shall provide internal wiring, connections, and diagrams in accordance with the requirements of the articles which follow.

2.2.8.1 Control and instrument wiring

All low voltage control and instrument wiring used within the controller assemblies.

All internal wiring shall be neatly and carefully installed and shall be terminated on terminal blocks or devices. Conductors and terminals shall be plainly lettered or marked in accordance with the manufacturer's connection diagrams. Any controller assembly that is split for shipment shall have terminal blocks adjacent to the split and shall be provided with wiring required to interconnect the shipping sections.

All leads for external circuit wiring shall be connected to terminal blocks located for convenient connection of external circuits. Splices will not be permitted in control wiring or instrument leads.

The minimum sizes of wire used in the controller assembly for control and instrumentation shall be in accordance with the following table:

Minimum Wire Service	**Size, AWG (mm^2)**
Power supplies	12 (4)
Current transformer circuits	12 (4)
Indicating lights and annunciator circuits	16 (1.5)
All other wiring	14 (2.5)

All spare contacts on relays, control switches, limit switches, or similar devices shall be wired to accessible terminal blocks for the Purchaser's future connections. All wiring leaving an enclosure shall leave from terminal blocks and not from other devices within the enclosure.

Terminal blocks shall not be mounted in compartments containing cable or bus operating at voltages above 600 volts.

Control and potential buses, as required, shall be switchboard wire installed at the rear of the instrument and control compartment.

Each terminal block, conductor, relay, circuit breaker, fuse block, and other auxiliary devices and terminals shall be permanently labeled to coincide with the identification indicated on the drawings. All wiring terminations shall be identified by legible markings on the device terminals.

2.2.8.2 Diagrams

Wiring diagrams shall be in accordance with the requirements specified herein. Controller schematic, connection, and interconnection diagrams furnished by the Supplier shall be based on schematic (elementary) diagrams and connection diagrams furnished by the Purchaser.

The typical schematic diagram of each type of controller specified shall be submitted with the proposal.

The Supplier shall prepare his schematic (elementary), connection, and interconnection diagrams which shall have terminal designations and terminal arrangement acceptable to the Engineer.

The complete connection diagram of each controller unit shall be on an individual sheet. Information on each connection diagram sheet shall include point-to-point wiring of the entire controller as it will be physically constructed, including wiring on the contactor itself. Elementary diagrams of control and instrument circuits, contact

arrangement of switches, and internal wiring of relays and instruments for each section shall be on additional sheets as required. Interconnection diagrams shall be on separate sheets. All sheets shall be the same size.

Information indicated on the Supplier's drawings shall include wiring of the individual units as they will actually appear in the assembly, contact arrangements of switches, and internal wiring of relays and instruments.

Each item of mounted equipment indicated on the diagrams shall be identified by item number and name.

2.2.8.3 Wiring method

If the wiring method is to be an internal programmable logic controller (PLC) as indicated on the Electrical Design and Equipment Data Sheets, then the Supplier shall furnish a Purchaser-approved PLC in each shipping split of each controller assembly. All control wiring from the device contacts and protective relays to the internal PLC shall be installed by the Supplier as indicated on the typical schematics. The Purchaser will program the PLCs as required.

If a remote PLC is to be used as indicated on the Electrical Design and Equipment Data Sheets, the Supplier has no responsibility to provide or connect device contacts and protective relays to the PLC.

2.2.9 Tightening of Connections

The Supplier shall include on his erection and assembly drawings complete information for tightening of all electrical connections secured with bolts or studs. The information furnished shall include torque wrench settings or complete details of other tightening procedures recommended for bus joints, connector attachments, and contact attachments.

2.3 Low Voltage Switchgear and Motor Control Equipment

This technical specification is intended for procurement of low voltage metal-clad switchgear and low voltage motor controllers provided as part of a furnish and erect contract. The Supplier shall provide a standard design for items within the scope of this specification, but not covered in detail by these specifications. The standard design shall be in accordance with accepted industry practices and standards for electrical power generation.

2.3.1 Low Voltage Switchgear

Low voltage switchgear shall be in accordance with the standards specified and the general articles below and shall meet the requirements of the Supplier's design.

2.3.1.1 Switchgear enclosures

The switchgear shall be furnished with enclosures of the types specified below:

Location	Description of Enclosure Type
Indoors	Indoor with gasketed doors, ventilated
Outdoors	Walk-in protected aisle

Switchgear equipment shall be mounted in vertical sections fabricated of steel and assembled to provide rigid self-supporting structures.

The breakers shall be removable from the front and shall be furnished with hinged front door(s) to allow removal of the circuit breaker(s).

Each unit of switchgear section shall have a removable rear panel.

2.3.1.2 Switchgear space heaters

Each vertical section of switchgear shall be furnished with space heaters to prevent condensation of moisture within the switchgear. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored.

Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage specified. Space heaters shall be controlled by an adjustable thermostat or fixed humidistat.

2.3.1.3 Motor space heaters

When motors are controlled by the lineup of switchgear, the Supplier shall furnish space heater power buses to the required sections. All space heater wiring shall be integral to the switchgear and have suitable branch circuit protection. Motor space heater circuits shall also include connection to switchgear breaker auxiliary contacts and connections to terminal blocks for external connections.

2.3.1.4 Nameplates

Engraved nameplates shall be furnished for the front and rear of each switchgear unit and for equipment and devices within each unit.

2.3.1.5 Power circuit breakers

The switchgear shall be furnished with low voltage power circuit breakers of standard drawout design with the following design features:

Shall not be forced cooled.

All secondary device contact surfaces and main contact surfaces shall be silver- or tin-plated, designed and fabricated to be self-aligning and to resist burning and deterioration.

Removable breaker units of the same type and ampere capacity shall be wired alike and shall be mechanically and electrically interchangeable.

Shall be a 3-pole single-throw unit, complete with operating mechanism and other required devices, mounted on a drawout type carriage. Each operating mechanism shall be of the stored energy type with a closing coil and single shunt trip coils. The closing devices, tripping devices, and charging motor shall be designed and rated for operation on the nominal control voltage specified.

Operating mechanisms shall be trip-free in any position and shall be antipump. The breaker main contacts shall not touch or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied.

Motor-operated breakers shall be provided with means to manually trip the breaker in an emergency.

Each breaker shall be furnished with an operations counter which shall be readable from the front of the switchgear unit with the breaker in the connected position.

2.3.1.5.1 Rating

Power circuit breakers furnished under these specifications shall be provided with the ratings as required by the Supplier's design. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

2.3.1.5.2 Auxiliary contacts

Each breaker shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for operation of the breaker. In addition, two normally open and two normally closed sets of spare contacts shall be provided and wired out to terminal blocks for use by the Purchaser.

Breaker mechanism operated auxiliary switches shall operate only when the breaker is in the connected position.

2.3.1.5.3 Breaker control devices

Each remotely controlled breaker shall be furnished with a local control switch and breaker position switch arranged to provide the following control of breaker operation:

	Breaker Operation

Breaker Drawout Position	Remote Control		Local Control Switch	
	Close	Trip	Close	Trip
Connected	X	X	--	--
Test	--	--	X	X
Disconnected	--	--	--	--

Each circuit breaker local control switch shall have a trip/close escutcheon, shall have a center normal position, shall be spring return to normal from close and trip, shall have red and green targets to indicate the latest operation of the switch, and shall be furnished with indicating lights. One set of these contacts shall be wired out to terminal blocks for use by the Purchaser.

2.3.1.6 Power and control conductors

Switchgear power and control conductors shall be furnished in accordance with the requirements of the articles which follow. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through a full ambient temperature range from -13° F (-25° C) to 104° F (+40° C). Expansion joints shall be furnished where required.

2.3.1.7 Main bus

The switchgear main bus shall be copper bar, designed to continuously carry the current required by the Supplier's design plus a 25 percent margin without exceeding temperature rise requirements specified in the applicable standards.

The bus shall be installed with rigid, non-tracking, fire-resistant, and non-hygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the close and latch and short-time current ratings of the circuit breakers as specified.

All power current carrying connections shall be bolted together. All joints shall have silver- or tin-plated contact surfaces with minimum contact resistance.

Instrument transformer primary connections shall be designed to permit removal and replacement of the transformers without damage to the connections.

2.3.1.8 Ground (earthing) bus

An uninsulated copper ground bus with a momentary rating at least equal to the momentary rating of the circuit breakers shall be furnished through the entire length of the switchgear. All switchgear equipment requiring grounding shall be connected to this ground bus.

2.3.1.9 External connections

Facilities for the entrance, support, termination, and connection of power and control conductors shall be furnished in accordance with the requirements of the following articles.

2.3.1.9.1 Entrance

Adequate openings shall be furnished for all conductors (metal-enclosed bus duct, power cables, and control cables, as required) entering the switchgear.

2.3.1.9.2 Terminal connectors

Terminal connectors for power cable and ground (earthing) cable entering the switchgear shall be long barrel, 2-hole, bolted clamp or compression type. Solder type terminals are not acceptable.

2.3.1.9.3 Bus Duct

Where bus duct is entering the switchgear, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.3.1.9.4 Ground (earthing) bus

Connectors shall be furnished at each end of the switchgear assembly ground (earthing) bus. Each switchgear unit containing terminals for connection of external power cable shall be furnished with connectors for attaching power cable shields directly to the ground (earthing) bus.

Each switchgear unit containing terminals for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground (earthing) bus to the switchgear ground (earthing) bus and/or bonding the bus duct enclosure to the ground system.

2.3.1.10 Control power

Control power for each continuous bus switchgear assembly shall be as specified on the Electrical Design and Equipment Data Sheets. Control power monitoring shall be provided. When ac control derived from control power transformers within the switchgear is specified, a tripping system shall be provided to permit tripping all of the circuit breakers for a period of at least 24 hours after power has been lost.

The Supplier shall furnish all internal switchgear wiring required to distribute control power to each switchgear unit. Each breaker shall be furnished with a 2-pole control power disconnecting and protective device in the closing circuit, and shall be furnished with a 2-pole control power disconnecting and protective device in each tripping circuit. The disconnecting and protective devices shall be molded case circuit breakers or enclosed fused pullouts.

2.3.1.11 Instrument transformers, instruments, and associated devices

Instrument transformers, instruments, and associated devices shall be furnished as required by the Supplier's design. All instrument transformer secondary leads shall be wired out to terminal blocks.

2.3.1.11.1 Current transformers

Current transformer mechanical and thermal limits shall be coordinated with the momentary and short-time ratings of the circuit breakers with which they are used.

2.3.1.11.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second and shall be mounted and have secondary voltage, capacity, accuracy and other ratings as required by the Supplier's design.

Each transformer shall be provided with current limiting primary fuses and secondary fuses and shall be mounted with primary fuses on a drawout type removable unit designed to isolate and ground (earth) the potential circuits when the unit is in the fully withdrawn position.

2.3.1.12 Protective relaying devices

Each breaker unit shall be provided with a solid-state protective device and, as a minimum, shall have the following protective functions. Long-time and short-time functions shall have field adjustable current and time-delay settings. The current setting for instantaneous phase trip shall have a field adjustable current setting:

	Long-Time Phase Trip	**Short-Time Phase Trip**	**Instantaneous Phase Trip**
Incoming main breaker	X	X	
Tie breaker	X	X	
Feeder breaker	X	X	X
Motor controller	X	X	X

Ground fault protection shall also be provided for all breakers for solidly grounded systems and shall be coordinated upstream and downstream as appropriate.

Auxiliary relays mounted internally shall be surface mounted and front connected.

2.3.2 Low Voltage Motor Control Assemblies

Low voltage control assemblies shall be in accordance with the standards specified and the general articles below and shall meet the requirements of the Supplier's design.

2.3.2.1 Enclosures

The motor control assemblies shall be furnished with enclosures of the types specified below:

Location	**Description of Enclosure Type**
Indoors - clean	Indoor gasketed
Indoors - dusty areas	Indoor dustproof
Outdoors	Non walk-in weatherproof with filters

Each assembly shall consist of motor controllers, main and tie breakers (as required), and feeder breakers mounted in vertical sections fabricated of steel and assembled to provide rigid self-supporting structures. Controllers and feeder breakers shall be mounted as individual units separated by grounded steel barriers for other units and, where possible, shall be withdraw able from the front. Each controller or breaker unit shall be furnished with hinged front door(s). Each vertical section shall have a removable rear panel (except in the case of back-to-back construction).

2.3.2.1.1 Space heaters

When located outdoors, each vertical section shall be furnished with space heaters to prevent condensation of moisture within the section. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored.

Space heater capacity shall be as required to maintain the compartment and unit internal temperature above the dew point using the voltage specified. Space heaters shall be controlled by an adjustable thermostat or fixed humidistat.

2.3.2.1.2 Motor space heaters

When motors controlled by the lineup have space heaters, the Supplier shall furnish space heater power buses throughout the motor control lineup. All space heater wiring shall be integral to the lineup and have suitable branch circuit protection. Motor space heater circuits shall also include connections to controller auxiliary contacts and connections to terminal blocks for external connections.

2.3.2.1.3 Nameplates

Engraved nameplates shall be furnished for the front and rear of each switchgear unit and for equipment and devices within each unit.

2.3.2.2 Motor controllers

Combination motor controllers shall be of standard drawout design (when possible) with the following features. Except where required by the Supplier's design, single-speed, full voltage, non-reversing starters shall be used:

Molded case circuit protectors (MCCP) for disconnecting power and magnetic-only short-circuit protection for high magnitude faults. The drawout function shall be disabled when the MCCP is closed.

When the manufacturer's design does not permit the starter unit to be drawout type because of size limitations, a fused, load-break, disconnect device shall be provided in lieu of an MCCP. The fuses shall be disconnected from the power source when the switch is open. Single phasing protection shall be provided.

Bimetallic or solid-state, 3-phase, ambient compensated, overload devices provide suitable overload protection for the motors.

Auxiliary relays as required for the Supplier's design.

Interposing relays as required by the Supplier's process controller.

Control power transformers (with primary and secondary fuses, 100 VA minimum).

2.3.2.3 Main and tie breakers

Main and tie circuit breakers, when furnished in motor control centers, shall be fixed mounted, molded case design. Means to coordinate instantaneous (and ground fault for solidly grounded systems) tripping functions of feeder breakers and MCCPs with main and tie breakers shall be provided. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with th e indicated industry standards for the nominal system voltage utilized.

2.3.2.4 Feeder breakers

Feeder circuit breakers, when furnished in motor control centers, shall be molded case design and shall be withdrawable when available. All current ratings shall be at least 10 percent greater than the values required by the design. Voltage ratings shall be in accordance with the indicated industry standards for the nominal system voltage utilized.

2.3.2.5 Power and control conductors

MCC power and control conductors shall be furnished in accordance with the requirements of the articles which follow. Provisions shall be made for bus expansion, to prevent undesirable or destructive mechanical strains in the bus supports and connections, through a full ambient temperature range from -13° F (-25° C) to +104° F (+40° C). Expansion joints shall be furnished where required.

2.3.2.6 Main bus

The MCC main bus shall be copper bar, designed to continuously carry the current required by the Supplier's design plus a 25 percent margin without exceeding temperature rise requirements specified in the applicable standards.

The bus shall be installed with rigid, non-tracking, fire-resistant, and non-hygroscopic insulating supports capable of withstanding the mechanical forces imposed by short-circuit currents equal to the close and latch and short-time current ratings as specified.

All joints shall have silver- or tin-plated contact surfaces with minimum contact resistance.

2.3.2.7 Ground (earthing) bus

An uninsulated copper ground bus with a momentary rating at least equal to the momentary rating of the circuit breakers shall be furnished through the entire length of the switchgear. All switchgear equipment requiring grounding shall be connected to this ground bus.

2.3.2.8 External connections

Facilities for the entrance, support, termination, and connection of power and control conductors shall be furnished in accordance with the requirements of the following articles.

2.3.2.8.1 Entrance

Adequate openings shall be furnished for all conductors (metal-enclosed bus duct, power cables, and control cables, as required) entering the equipment.

2.3.2.8.2 Terminal connectors

Terminal connectors for power cable and ground (earthing) cable entering the switchgear shall be long barrel, 2-hole, bolted clamp or compression type. Solder type terminals are not acceptable.

2.3.2.8.3 Bus duct

Where bus duct is entering the switchgear, all flanges, supports, gaskets, bolting material, insulation, and connection material shall be furnished as required to terminate the bus duct.

2.3.2.8.4 Ground (earthing)

Connectors shall be furnished at each end of the assembly ground bus for connection of cables from the station ground grid.

Each unit designed for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground bus to the assembly ground bus and/or bonding the bus duct enclosure to the ground system.

2.3.2.9 Instrument transformers, instruments, and associated devices

Instrument transformers, instruments, and associated devices shall be furnished as required by the Supplier's design. All instrument transformer secondary leads shall be wired out to terminal blocks.

2.3.2.9.1 Current transformers

Current transformer mechanical and thermal limits shall be coordinated with the momentary and short-time ratings of the circuit breakers with which they are used.

2.3.2.9.2 Voltage transformers

Voltage transformers shall be capable of withstanding a secondary short circuit for not less than 1 second and shall be mounted and have secondary voltage, capacity, accuracy, and other ratings as required by the Supplier's design.

Each transformer shall be provided with current limiting primary fuses and secondary fuses.

Auxiliary relays mounted internally shall be surface mounted and front connected.

2.3.2.10 Wiring and wiring diagrams

The Supplier shall furnish internal switchgear and motor control assembly wiring, connections, and diagrams in accordance with the requirements of the following articles.

2.3.2.11 Control and instrument wiring

All low voltage control and instrument wiring shall be installed and tested at the factory.

All interior wiring shall be neatly and carefully installed in wiring gutters or conduit and shall be terminated at terminal blocks plainly lettered or marked in accordance with the Supplier's connection diagrams. Extra flexible wire shall be furnished at hinge points.

Switchgear units that are split for shipment shall be furnished with all wiring required to interconnect the switchgear units.

2.3.2.12 Diagrams

Wiring diagrams shall be in accordance with the requirements specified herein.

2.3.2.12.1 Diagrams for equipment within the supplier's scope of supply

The complete connection diagram of each unit shall be on an individual sheet. Information on each connection diagram sheet shall include point-to-point wiring of the entire unit as it would appear to a person wiring the switchgear unit, including wiring on the breaker itself. Elementary diagrams of control and instrument circuits, contact arrangement of switches, and internal wiring of relays and instruments for each switchgear unit shall be on additional sheets as required. Interconnection diagrams shall be on separate sheets. All sheets shall be the same size.

Each item indicated on the diagrams shall be identified by item number and name.

Sufficient space shall be left on the customer's side of outgoing terminal blocks for adding cable color codes and circuit numbers.

2.3.2.12.2 Diagrams interconnection of purchaser's system

At the time the Supplier's connection drawings are submitted for review, the Purchaser will mark thereon all external (interface) circuit and wire designations required, and such designations shall be added to the connection drawings by the Supplier.

2.4 Low Voltage Power Distribution Equipment

When specified to be in the Supplier's scope of supply, the Supplier shall supply low voltage power distribution equipment in accordance with the articles below and as required by the Supplier's design. The design shall be in accordance with accepted industry practices and standards for electrical power generation.

2.4.1 Low Voltage Panelboards and Switchboards

Low voltage power panelboards and switchboards shall be furnished in accordance with the following articles.

2.4.1.1 Enclosures

Panelboards and switchboards shall be furnished with enclosures of the types as follows:

Location	**Description of Enclosure Type**
Indoors - clean area	Indoor with gasketed cover, ventilated

Indoors - dusty area	Indoor dustproof enclosure, unventilated
Outdoors - protected	Combination outdoor/dustproof, unventilated
Outdoors - unprotected	Wash down/dustproof, unventilated
Hazardous	Listed for conditions present

2.4.1.2 Busing

Main, neutral, and ground busing shall be copper. Voltage and current ratings shall be standard ratings defined in the applicable standards required to meet the requirements of the Supplier's design.

2.4.1.3 Circuit breakers

Main breakers shall be provided in all panelboards and switchboards. Main and feeder breakers shall be molded case, bolt-in type. Voltage and current ratings shall be standard ratings defined in the applicable standards required to meet the requirements of the Supplier's design. Breakers and busing shall be individually rated and labeled for the required short-circuit amperes available. Tandem or miniature circuit breakers shall not be used.

2.4.1.4 Spares

Total expected load on each panelboard or switchboard shall not exceed 80 percent of its continuous current rating. At least one spare feeder breaker of each size and number of poles used for loads shall be provided in each panelboard and switchboard. At least six poles of spare space shall be provided in each panelboard and switchboard.

2.4.2 Dry Type Distribution Transformers

Dry type distribution transformers shall be used indoors in dry areas only and shall meet the following requirements:

Shall have copper windings rated for 302° F (150° C) temperature (by resistance) rise above 104° F (40° C) ambient.

Shall be sized to approximately match the nominal ampacity of the panelboard or switchboard which is connected to its secondary terminals.

Sound level shall not exceed 45 dBA when measured in accordance with NEMA standards.

When installed in areas where dirt and dust are present, shall have filters installed on vent openings or shall be non-ventilated.

Shall be appropriately derated when the ambient temperature exceeds 104° F (40° C).

2.4.3 Nameplates

Engraved nameplates shall be furnished for the front of each item of equipment.

PART 3 – EXECUTION

Not Applicable.

Medium Voltage Switchgear	
Medium voltage switchgear enclosure type	Indoor with gasketed doors, ventilated or Outdoor walk-in, protected aisle or As required by Supplier's design
Power supply to medium voltage switchgear assemblies provided by Purchaser	120 VAC or 230 VAC or 125 VDC or 110 VDC or 250 VDC
Separate control power supply to medium voltage switchgear assemblies provided by Purchaser	120 VAC or 230 VAC or 125 VDC or 110 VDC or 250 VDC

Separate space heater power supply to medium voltage switchgear assemblies provided by Purchaser (single supply)	120 VAC or 230 VAC
Medium Voltage Controller	
Medium voltage controller enclosure type	Indoor with gasketed doors, ventilated or Outdoor walk-in, protected aisle or Outdoor without enclosed operating and maintenance aisle or As required by Supplier's design
Power supply to medium voltage controller assemblies provided by Purchaser	120 VAC or 230 VAC or 125 VDC or 110 VDC or 250 VDC
Separate control power supply to medium voltage controller assemblies provided by Purchaser	120 VAC or 230 VAC or 125 VDC or 110 VDC or 250 VDC
Separate space heater power supply to medium voltage controller assemblies provided by Purchaser (single supply)	120 VAC or 230 VAC
Medium voltage controller main incoming power circuit breaker required	Yes or No
Single or dual shunt trip coils	Single
Controller construction	Maximum two-high stacking or Maximum one-high stacking or Maximum three-high stacking or Manufacturer's standard
Drawout contractors required	Yes or No
Busbar insulation required	Yes or No
Controller cable entrance	Above or Below or As required by Supplier's design
Clamp type connectors required on compartment ground (earthing) bus for attachment of power circuit ground cable	Yes or No
Control voltage	120 VAC or 230 VAC or 125 VDC or 250 VDC
Low Voltage Switchgear and Motor Control Centers	
Single power supply to assembly provided by Purchaser	120 VAC or 230 VAC or 125 VDC or 110 VDC or 250 VDC
Low voltage switchgear enclosure type	Indoor with gasketed doors, ventilated or Outdoor walk-in, protected aisle or As required by Supplier's design
Motor control center enclosure type	Indoor, gasketed or Indoor, dustproof or Outdoor, non walk-in weatherproof with filters or As required by Supplier's design

Low Voltage Panelboards and Switchboards	
Enclosure type	Indoors with gasketed cover, ventilated or Indoor, dustproof enclosure, unventilated or Outdoor, combination outdoor/dustproof, unventilated or Outdoor, wash down/dustproof, unventilated or Hazardous, listed for conditions present or As required by Supplier's design

END OF SECTION 260510

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

1.3 DEFINITIONS

A. VFC: Variable frequency controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. See WSU design standards.

B. Aluminum and Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN/THWN-2.

D. Multi-conductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for nonmetallic-sheathed cable, Type NM with ground wire.

2.2 CONNECTORS AND SPLICES

A. See WSU design standards.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger, except VFC cable, which shall be extra flexible stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

E. Feeders in Cable Tray: Type THHN/THWN-2, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway; Armored cable, Type AC;[Metal-clad cable as required by Code.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

I. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

J. Branch Circuits in Cable Tray: Type THHN/THWN-2, single conductors in raceway.

K. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Pulling method, including fish tape, cable, rope, and basket-weave wire/cable grips, shall not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

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

3.7 FIRESTOPPING

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

3.8 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 test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test conductors feeding the following critical equipment and services for compliance with requirements.

    a. Back-up generators, Panelboards, automatic transfer switches, uninterruptable power sources, transformers, and associated switches.

2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

    a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.

b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Test and Inspection Reports: Prepare a written report to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

E. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications (IF APPLICABLE):

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
1. Ground rods.
2. Ground rings.
3. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to Operation and Maintenance Data include the following:

a. Instructions for periodic testing and inspection of grounding features

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Comply with WSU Standard requirements.

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad3/4 inch by 10 feet.

1. Backfill Material: Electrode manufacturer's recommended material.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.

1. Bury at least 24 inches below grade.
2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Hand-holes: Install a driven ground rod through manhole or hand-hole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.4 EQUIPMENT GROUNDING

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

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Receptacle circuits.
3. Single-phase motor and appliance branch circuits.
4. Three-phase motor and appliance branch circuits.
5. Flexible raceway runs.
6. Armored and metal-clad cable runs.
7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

C. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

D. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.5 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: **Owner will 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. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Grounding system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Owner's representative promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Hangers.
b. Steel slotted support systems.
c. Nonmetallic support systems.
d. Trapeze hangers.
e. Clamps.
f. Turnbuckles.
g. Sockets.
h. Eye nuts.
i. Saddles.
j. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawing: For fabrication and installation details for electrical hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Nonmetallic slotted-channel systems.
4. Equipment supports.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which hangers and supports will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Items penetrating finished ceiling, including the following:
   a. Access panels.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
1. Material: Galvanized steel.
2. Channel Width: 1-5/8 inches.
3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
4. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
7. Channel Dimensions: Selected for applicable load criteria.

B. Aluminum Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
   1. Channel Width: 1-5/8 inches.
   2. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   3. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   4. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
   5. Channel Dimensions: Selected for applicable load criteria.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

   1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

   3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
   4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
   5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
   6. Toggle Bolts: All-steel springhead type.
   7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts
7. To Light Steel: Sheet metal screws.

8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 4000psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

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

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Hand-holes and boxes for exterior underground cabling.

B. Related Requirements:

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

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

D. EMT: Electrical metallic tubing.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. GRC: Comply with ANSI C80.1 and UL 6.

C. ARC: Comply with ANSI C80.5 and UL 6A.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. EMT: Comply with ANSI C80.3 and UL 797.

F. FMC: Comply with UL 1; zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

A. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ENT: Comply with NEMA TC 13 and UL 1653.

C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. LFNC: Comply with UL 1660.

E. Rigid HDPE: Comply with UL 651A.

F. Continuous HDPE: Comply with UL 651B.

G. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

H. RTRC: Comply with UL 1684A and NEMA TC 14.

I. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

J. Fittings for LFNC: Comply with UL 514B.

K. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

L. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

A. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

B. Wireway Covers: **Screw-cover type** unless otherwise indicated.

C. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

C. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

D. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

E. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.5 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Owner

2.6 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, with gasketed cover.

E. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

F. Cabinets:

1. NEMA 250, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Hand-holes and Boxes:

1. Boxes and hand-holes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Fiberglass Hand-holes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers.

1. Standard: Comply with SCTE 77.
2. Color of Frame and Cover: Gray.
3. Configuration: Designed for flush burial unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and hand-hole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering.
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

2.8 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Hand-hole and Pull-Box Prototype Test: Test prototypes of hand-holes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: EMT.
3. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms.
    d. Gymnasiums.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches of enclosures to which attached.

I. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inc trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

J. Stub-ups to Above Recessed Ceilings:

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

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Surface Raceways:

1. Install surface raceway with a minimum 2-inch radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with 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 according to NFPA 70.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.

3. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
4. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Mount boxes at heights indicated on Drawings.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

AA. Locate boxes so that cover or plate will not span different building finishes.

BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

DD. Set metal floor boxes level and flush with finished floor surface.

EE. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install hand-holes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

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

3.5 FIRESTOPPING

A. Install fire-stopping at penetrations of fire-rated floor and wall assemblies.

3.6 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water-stop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, water-stop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber water-stop collar with center opening to match piping OD.

2.4 GROUT

A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 4,000psi 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

2. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

   a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
   b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels, including arc-flash warning labels.
8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Raceways and Cables Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

C. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES".

2.3 LABELS

A. Vinyl Labels for UPS devices such as receptacle cover plates shall be yellow with black lettering.

B. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. See WSU design standards.

C. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.

1. See WSU design standards.

D. Self-Adhesive Labels:

1. See WSU design standards.
2. Preprinted, 3-milthick, vinyl flexible label with acrylic pressure-sensitive adhesive.

    a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the raceway diameter, such that the clear shield overlaps the entire printed legend.

3. Vinyl, thermal, transfer-printed, 3-mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

    a. Nominal Size: 3.5-by-5-inch.

4. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
5. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 BANDS AND TUBES:

A. Snap-Around, Color-Coding Bands for Raceways and Cables: Slit, pre-tensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceways or cables they identify, and that stay in place by gripping action.

1. See WSU design standards.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

1. See WSU design standards.

2.5 TAPES AND STENCILS:

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. See WSU design standards.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

1. See WSU design standards.

C. Tape and Stencil for Raceways Carrying Circuits 600 V or Less: 4-inch wide black stripes on 10-inch centers placed diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.

1. See WSU design standards.

D. Underground-Line Warning Tape

1. See WSU design standards.
2. Tape:

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

3. Color and Printing:

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

4. Tag: Type I:

a. Pigmented polyolefin, bright colored, compounded for direct-burial service.
b. Width: 3 inches.
c. Thickness: 4 mils.
d. Weight: 18.5 lb/1000 sq. ft..
e. Tensile according to ASTM D 882: 30 lbf and 2500 psi.

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

2.6 Tags

A. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch (0.38 mm) thick, color-coded for phase and voltage level, with factory screened permanent designations; punched for use with self-locking cable tie fastener.

1. See WSU design standards.

B. Write-On Tags:

1. See WSU design standards.

2. Polyester Tags: 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 Signs

A. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:

a. For signs up to 20 sq. inches minimum 1/16-inch.
b. For signs larger than 20 sq. inches, 1/8 inch thick.
c. Engraved legend with black letters on white face.
d. Punched or drilled for mechanical fasteners.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

3. See WSU design standards.

2.8 CABLE TIES

A. See WSU design standards.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.

3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.

2. In Spaces Handling Environmental Air: Plenum rated.

I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

J. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

L. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.3 IDENTIFICATION SCHEDULE

A. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch wide black stripes on 10-inch centers over orange background that extends full length of raceway or duct and is 12 inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch high black letters on 20-inch centers. Stop stripes at legends. Apply stripes to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches of a floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to raceways concealed within wall.
3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl labels. Install labels at 30-foot maximum intervals.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl label. Install labels at 30-foot maximum intervals.

D. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and hand-holes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase-and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.

d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

F. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and hand-holes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

G. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.

H. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and hand-holes, use self-adhesive vinyl labels with the conductor or cable designation, origin, and destination.

I. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive vinyl labels with the conductor designation.

J. Conductors To Be Extended in the Future: Attach marker tape to conductors and list source.

K. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

L. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

1. Limit use of underground-line warning tape to direct-buried cables.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

M. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

a. Power-transfer switches.
b. Controls with external control power connections.

O. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.

1. Comply with NFPA 70E and ANSI Z535.4.
2. Comply with Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

P. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

Q. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch high letters for emergency instructions at equipment used for power transfer.

R. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.

1. Labeling Instructions:

a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine plastic label. Unless otherwise indicated, provide a single line of text with 1/2-inch high letters on 1-1/2-inch high label; where two lines of text are required, use labels 2 inches high.
b. Outdoor Equipment: Engraved, laminated acrylic or melamine label
c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment To Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear.
e. Switchboards.
f. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
g. Substations.
h. Emergency system boxes and enclosures.
i. Motor-control centers.
j. Enclosed switches.
k. Enclosed circuit breakers.
l. Enclosed controllers.
m. Variable-speed controllers.
n. Push-button stations.
o. Power-transfer equipment.
p. Contactors.
q. Remote-controlled switches, dimmer modules, and control devices.
r. Battery-inverter units.
s. Battery racks.
t. Power-generating units.
u. Monitoring and control equipment.
v. UPS equipment.

END OF SECTION 260553

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes: distribution, energy efficient dry-type transformers rated 600 V and less, with capacities up to 1500 kVA. Nominally: 408V 3Ø 60Hz delta input; transformer to output 208V 3Ø 60Hz/ (120V 1Ø).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformers, accessories, and components, from manufacturer.

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.

B. Qualification Data: For testing agency.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member Company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger: Comply with NEMA TP 1 energy-efficiency levels as verified by testing according to NEMA TP 2.

D. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

E. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

F. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

G. Shipping Restraints: Paint or otherwise color code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated.

1. NEMA 250, type 2: Core and coil shall be encapsulated within resin compound utilizing a vacuum pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: NSF/ANSI 61 gray.

F. Taps for Transformers 3 kVA and Smaller: None

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller than 30 kVA: 185 deg C, UL-component-recognized insulation system with a maximum of 115-deg C rise above 40-deg C ambient temperature. Chosen

J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 -deg C rise above 40-deg C ambient temperature.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for non-sinusoidal load current-handling capability to the degree defined by designated K-factor. Chosen

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
2. Indicate value of K-factor on transformer nameplate.
3. Unit shall meet requirements of NEMA TP 1 when tested according to NEMA TP 2 with a K-factor equal to one.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.

M. Neutral: Rated 200 percent of full load current for K-factor rated transformers.

N. Wall Brackets: Manufacturer's standard brackets or floor mounted.

O. Fungus Proofing: Permanent fungicidal treatment for coil and core.

P. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
1. 51 to 150 kVA: ~55 dBA+0-10
2. 751 to 1000 kVA: ~70 dBA +0-10
3. 1001 to 1500 kVA: ~70 dBA +0-10

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at the rated voltage connections and at all tap connections.
2. Ratio tests at the rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at the rated voltage connections.
4. No load losses, and excitation current and rated voltage at the rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at the rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

C. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS for dry-type, air-cooled, low-voltage transformers. Certify compliance with test parameters.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.

1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

G. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

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

END OF SECTION 262200

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.
3. Load centers.
4. Electronic-grade panelboards.

1.3 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter.

C. GFEP: Ground-fault equipment protection.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.

2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.
11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Panelboard Schedules: For installation in panelboards

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.
3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation according to NECA 407.

1.10 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards 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 [minus 22 deg F (minus 30 deg C)] [23 deg F (minus 5 deg C)] to plus 105 deg F (plus 40 deg C).
b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

C. 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 WSU no fewer than two days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without WSU written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5.

2. Height: 84 inches (2.13 m) maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
7. Finishes:

a. Panels and Trim: Galvanized Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
b. Back Boxes: Galvanized Steel.
c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

F. Incoming Mains:

1. Location: Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

G. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.

   a. Plating shall run entire length of bus.
   b. Bus shall be fully rated the entire length.

2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
7. Split Bus: Vertical buses divided into individual vertical sections.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
9. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

I. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting

and overcurrent protective devices. Panelboards or load centers shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

J. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

1. Percentage of Future Space Capacity: Ten percent.

K. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.

1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE.

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."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards.

2.3 POWER PANELBOARDS

A. See WSU Construction Design Standard

B. Panelboards: NEMA PB 1, distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches (914 mm)] high, provide two latches, keyed alike.

D. Mains: Lugs only.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

G. Branch Overcurrent Protective Devices: Fused switches.

H. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. See WSU Construction Design Standard.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: lugs only.

D. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
2. External Control-Power Source: 120-V branch circuit.

F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

G. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 LOAD CENTERS

A. See WSU Construction Design Standard.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. See WSU Construction Design Standard.

B. MCCB: Comply with UL 489, to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.
c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:

a. RMS sensing.
b. Field-replaceable rating plug or electronic trip.
c. Digital display of settings, trip targets, and indicated metering displays.
d. Multi-button keypad to access programmable functions and monitored data.
e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
f. Integral test jack for connection to portable test set or laptop computer.
g. Field-Adjustable Settings:

1) Instantaneous trip.
2) Long- and short-time pickup levels.
3) Long and short time adjustments.
4) Ground-fault pickup level, time delay, and I squared T response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
1. Fused Switch Features and Accessories:

a. Standard ampere ratings and number of poles.
b. Mechanical cover interlock with a manual interlock override, to prevent the opening of the cover when the switch is in the on position. The interlock shall prevent the switch from being turned on with the cover open. The operating handle shall have lock-off means with provisions for three padlocks.

2.7 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards according to NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

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

B. Comply with NECA 1.

C. Install panelboards and accessories according to NECA 407.

D. Equipment Mounting:

1. Install panelboards on cast-in-place concrete equipment base(s) where applicable.
2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
3. Comply with requirements for seismic control devices.

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

F. NOT USED

G. Mount top of trim 90” above finished floor unless otherwise indicated.

H. Mount panelboard cabinet plumb and rigid without distortion of box.

I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

J. Mounting panelboards with space behind is recommended for damp, wet, or dirty locations. The steel slotted supports in the following paragraph provide an even mounting surface and the recommended space behind to prevent moisture or dirt collection.

K. Mount surface-mounted panelboards to steel slotted supports 5/8 inch to 1 1/4 inch in depth. Orient steel slotted supports vertically.

L. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

M. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

N. Install filler plates in unused spaces.

O. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

P. Arrange conductors in gutters into groups and bundle and wrap with wire ties**.** Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate.

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate.

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform 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.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers.
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 panelboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 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.

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

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

3.5 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.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Isolated-ground receptacles.
4. Weather-resistant receptacles.
5. Cord and Plug receptacles.
6. Communications outlets.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from

mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

2.5 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
1. Description:

a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.6 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.8 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: Per Owner, match existing in room or area of work.

2. Wiring Devices Connected to UPS Power System: Per Owner, provide yellow receptacles with black label.

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.
D. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Non-fusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Molded-case switches.
5. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 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."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of NRTL listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

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.

C. 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.

D. Manufacturer's field service report.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two for each size and type.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

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

B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. 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.

E. Comply with NFPA 70.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

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

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

A. See WSU construction design standards.

B. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge fuse interiors to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
6. Hook-stick Handle: Allows use of a hook-stick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.
9. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.2 NONFUSIBLE SWITCHES

A. See WSU design standards.

B. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

F. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
4. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hook-stick Handle: Allows use of a hook-stick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 MOLDED-CASE CIRCUIT BREAKERS

A. See WSU design standards.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I2t response.

F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

G. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

H. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

I. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

J. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system,
6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
8. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
9. Alarm Switch: One NO contact that operates only when circuit breaker has tripped.
10. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11. Zone-Selective Interlocking: Integral with [electronic] [ground-fault] trip unit; for interlocking ground-fault protection function.
12. Electrical Operator: Provide remote control for on, off, and reset operations.
13. Accessory Control Power Voltage: Integrally mounted, self-powered.

2.4 MOLDED-CASE SWITCHES

A. See WSU design standards.

B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Features and Accessories:

1. Standard frame sizes and number of poles.

2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
7. Alarm Switch: One NO contact that operates only when switch has tripped.
8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Integrally mounted, self-powered.

2.5 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, [Type 1] <Insert type>.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in section 260529.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 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 enclosed switch and circuit breaker, 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 enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 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

END OF SECTION 262816

STATIC THREE PHASE UNINTERRUPTIBLE POWER SUPPLY

TOSHIBA 4310 F3F500XA 50kVA/45KW

SECTION 263353 – STATIC THREE PHASE UNINTERRUPTIBLE POWER SUPPLY

PART 1 - SCOPE

1.1 System

This specification describes a TOSHIBA model 4300 continuous duty, 50 kVA (45KW) three-phase, on-line, solid-state uninterruptible power supply system, hereafter referred to as the UPS.

1.2 Preferred UPS Vendor

The contractor is to purchase and supply the specified Toshiba UPS from WSU preferred UPS vendor (Ancona Controls). Contact information as follows:

WSU Assign Sales Rep: Beth Ancona
Ancona Controls
28021 Grand Oaks Ct.
Wixom, MI 48393
248-924-2747

PART 2 - SYSTEM DESCRIPTION

2.1 Applicable Standards

The UPS shall be designed in accordance with and be compliant with the following sections of the current revisions of the following standards:

- ANSI C62.41 (IEEE 587) – Standard for Surge Withstandability
- UL 1778 (UL listed)
- National Electrical Code (NFPA-70)
- FCC Part 15 Class A
- NEMA PE-1
- OSHA
- ASME
- ISO 9001, 14001

2.2 Components

The UPS shall consist of the following components:

A. Converter

B. Chopper / Charger

C. Pulse-Width Modulated (PWM) Inverter

D. Static Switch Bypass

E. Microprocessor Controlled Logic and Control Panel

F. Input Circuit Breaker

G. Input / Output EMI / RFI Filters

H. Line-up-and-Match Battery Cabinet (43B-500017ER111)

I. Line-up-and-Match MBS Maintenance Bypass Switch (431A500SXXXX)

J. RemotEye 3 Communications (4300-RMTI-3)

K. Field Startup Services (UPSSTARTUP050)

2.3 System Operation

The UPS shall operate as an on-line, fully automatic system in the following modes:

A. NORMAL - Incoming AC power is boosted using a chopper circuit, and converted into DC power. The DC power is then used to charge the (optional) battery bank while at the same time providing clean, DC power to the inverter circuitry. The inverter converts DC power to regulated AC power which feeds the load.

B. EMERGENCY - Upon failure of commercial AC power, the UPS shall derive power from the optional external battery bank and continue feeding the load with clean, regulated AC power. There is no interruption to the critical load upon failure or restoration of commercial AC power.

C. RECHARGE - Upon restoration of the commercial AC source, the rectifier/chopper powers the inverter while simultaneously recharging the optional external battery bank. The UPS shall have the following recharge process:
   a) a constant level of current is used to recharge the batteries (the process shall utilize a current-limit function to prevent overcharging batteries, thus extending the life of the batteries)
   b) as the batteries reach the normal charge level, a constant-voltage control shall begin which causes the battery recharge current to gradually decrease
   c) Under normal operation, the UPS battery bank "floats" at the 2.25-2.27 volts per cell DC level to stay fully charged and ready for the next discharge.

D. BYPASS MODE - Upon detection of an internal fault or output overload, the UPS shall automatically switch from inverter power to an internal bypass via the static switch. Transfer shall be within 4 milliseconds, causing no interruption to the critical load. “Return from Bypass mode” shall be an automatic function, without interruption to the critical load.

Transfer to Bypass may also be performed as a manual operation via the UPS front panel.

E. POWER CONDITIONING MODE - Should the optional external battery cabinet not be available, the UPS shall function and provide protection against spikes, common/normal mode noise, load steps and frequency shifts (without battery back- up capability).

PART 3 – SYSTEM PARAMETERS

3.1 SYSTEM PARAMETERS

A. UPS Input (Note: Step down transformer from main switchgear to be provided by contractor and separate from the Toshiba UPS).

1)	Input Voltage	: 208/120VAC
2)	Input Voltage Requirement	: 3 Phase, 4 Wire + Ground
3)	Voltage Variation	: +10% to -30*% *
4)	Rated Frequency	: 60 Hz
5)	Frequency Range	: 60 +/-5 Hz
6)	Power Factor	: > 0.99 lagging
7)	Input Capacity	: 110% of UPS Output Capacity
8)	Walk-In Function	: From 20% to 100% over 5 seconds
9)	Input Current Limit	: 115% of nominal capacity
10)	Inrush Current	: < 800% of rated current under: synchronous condition
11)	Input Current THD	: < 3% Total Harmonic Distortion (THD)
12)	Surge Withstandability	: Meets ANSI C62.41 (IEEE 587)
13)	Input Phase Rotation (Protection/Detection)	: Standard front-panel alarm panel shall notify user that unit has been supplied with reversed phase rotation on input to allow for correct installation. The UPS shall be fully protected to prevent damage from this event.

* For continuous operation at -20 to -30%, de-rate the maximum operating temperature to 90 ^{o}F (32 ^{o}C.)

B. UPS Output

1)	Rated Voltage	: 208/120VAC
2)	Output Voltage Rqmts	: 3 Phase, 4 Wire + Ground
3)	Output Capacities	: 50 kVA (45 kW)
4)	Rated Load Power Factor	: 0.9 lagging
5)	Voltage Regulation	: +/- 2% nominal (balanced load) : +/- 3% nominal (unbalanced load)
6)	Voltage Adjust. Range interface)	: +/- 5% manually (by front panel user
7)	Phase Displacement	: +/- 2 deg. (0 – 100% balanced load) : +/- 4 deg. (0 – 100% unbalanced load)

8) Rated Frequency : 60 Hz
9) Frequency Regulation : +/- 0.1% free running
10) Frequency Synch. Range selectable by factory rep. : +/- 0.5/1.0/1.5 Hz (+/- 1.0 Hz Standard) Switch
11) Frequency Slew Rate : 1.0 Hz/second to 3.0 Hz/second
12) Voltage Transients : +/- 5% (100% step load change)
: +/- 3% (loss or return of input power)
: +/- 8% (bypass to inverter)
13) Transient Voltage Recovery : 50ms maximum to within 2% of nominal
14) Overload Cap. (on inverter) : 125% for 90 sec., 150% for 30 sec.
15) Overload Cap. (on bypass) : 1000% for 10ms, 125% for 10 min.
16) Crest Factor
50kVA : 2.8
17) Harmonic Voltage Distortion : 1.5% THD maximum, 1% maximum for any single harmonic (linear load)
18) Inrush Current Protection : Automatic transfer to bypass, then auto- return to inverter (retransfer may be inhibited by jumper.)
19) Output Overcurrent : Hall-Effect Current Transformer and Fusing

C. Battery Charging System

1) DC Rated Voltage:

UPS Capacity	50 kVA
Nominal Voltage	288 VDC
Alarms Voltage(V low)	252 VDC
Shutdown Voltage (V min)	216 VDC
Float Charging Voltage	324_VDC (+/- 2%)

2) Recharging Current (Max) : Adjustable to 16 A DC
3) Ripple Voltage : 0.5% DC maximum
4) DC-AC Efficiency : 91.4%

D. Environmental

1) Efficiency – Double Conversion: (AC/AC)

Load	**25%**	**50%**	**75%**	**100%**
50kVA	88.8%	90.9%	91.2%	91.1%

2) Efficiency – Battery Backup: (DC/AC)

50kVA : 91.4%

3) Thermal loading: BTU/Hr.

Load	25%	50%	75%	100%
50kVA	4856	7695	11,181	15,019

4) Short Circuit Interrupt : 35kAIC

5) Dimensions (WxDxH) : 22.1 in. x 31.6 in.x 73.7 in.
(561mm x 802mm x 1872mm)

6) Weight

50kVA : 867 lb. (393 kg)

7) Audible Noise : ~65 dBA @ 1 meter from front of unit.

8) Operating Temperature: UPS : 32 to 104°F (0 to 40°C)

Optional Battery Cabinet : 68 to 77°F (20 to 25°C)

Heat Rejection : 15,019 BTU/H

9) Storage Temperature: UPS : -4 to 140°F (-20 to 60°C)

10) Operating Humidity : 5%-95% RH (non-condensing)
~720 ft./(~220m)

11) Altitude : < 6,600-ft. maximum (< 2,000 m)

12) Channel Mount

14) Seismic Provisions : Manufacturer to specify installation Geometry requirements

PART 4 – FUNCTIONAL DESCRIPTION

4.1 FUNCTIONAL DESCRIPTION

A. Converter / Charger / DC Chopper

DESCRIPTION - The converter/charger shall consist of a solid-state three phase rectifier, DC to DC converter (chopper), output filter, and transient suppresser network to regulate

and maintain DC power to the inverter.

1) TRANSIENT SUPPRESSER - The incoming AC utility shall first be connected to a molded case circuit breaker as a means of disconnecting power to the UPS. Power shall flow through a surge absorber to prevent large transients from passing through to the load or damaging the (optional) backup battery bank. Power shall then flow through a line filter to prevent sags or surges from passing to the load.

2) CONVERTER/CHARGER - The converter shall serve to change incoming AC power to DC, which shall be supplied to the DC chopper. From this point, DC power is used to recharge the optional battery bank while simultaneously providing power to the inverter.

    a. Input Frequency Range: 45-65 Hz, continuous, without battery operation
    b. Capacity: Battery recharge shall be to within 90% of nominal from a fully discharged state in 10 times the discharge time.

3) DC CHOPPER - The chopper circuit shall consist of inductors, capacitors, diodes and IGBT's (Insulated Gate Bipolar Transistors). The chopper shall have the function of providing start-up protection (by checking phase rotation of incoming utility power), boosting the DC to the inverter (during low AC input voltage conditions), providing power factor enhancement, and reducing reflected harmonics to incoming utility power.

B. Pulse Width Modulated (PWM) Inverter

DESCRIPTION - The PWM (Pulse Width Modulated) inverter shall incorporate an advanced IGBT design, and output overcurrent protection for clean, regulated output power to the critical load.

1) INVERTER - The inverter network shall consist of a high speed IGBT switching network designed to supply non-linear loads with a clean and steady voltage waveform. The inverter switching speed shall be fast enough to limit audible noise to 60 dBA at 3 feet (measured on ‘A’ scale).

2) OVERCURRENT PROTECTION - The output circuitry shall be equipped with a Hall Effect Current Transformer to detect and protect the inverter from excessively high currents.

C. Static Bypass Switch

1) TRANSFER - The static bypass switch shall consist of thyristor switches in conjunction with an output contactor to permit manual switching from bypass to UPS and UPS to bypass without power interruption. The UPS shall instantaneously transfer to bypass should a component fail during normal operation (provided the UPS and bypass are in synchronization). Auto-retransfer to UPS after an overload

condition shall be completed within one second after the bus has dropped to 100% of nominal.

2) REMOTE RUN/STOP - A set of normally open dry contacts shall be provided to remotely transfer the UPS on-line and off-line. When the UPS is in this mode of operation, the UPS front control panel shall be disabled to provide a secured configuration.

D. Microprocessor Control System

1) DESCRIPTION - The UPS system shall be provided with a microprocessor internal control system to perform start-up, transfers, monitoring, and battery recharging. The microprocessor shall provide important information to the user (via a LED touch screen interface) such as system status, fault messages and input and output parameters.
2) LED INDICATORS - The following LED indicators shall be provided on the UPS front panel:

   a. AC INPUT/Fault (Green/Red Lamp) –GREEN - Normal AC input power and UPS is On-line. RED – A UPS fault has occurred and the unit is in Bypass.
   b. WARNING (Amber Lamp) - Lights when the UPS detects an input power fault.
   c. FAULT (Red Lamp) - Lights when a fault has been detected. See “System Diagnostics” for specific fault.

3) SYSTEM METERING - The UPS shall be provided with touch screen display which displays, upon request, the following minimum information:

For AC Input, AC Output, and Bypass
- Voltage (Line to Line, Line to Neutral)
- Phase Current
- Phase Frequency
- Phase Power Factor
- Power (W and VA) per Phase
- Power (W and VA) Total

Battery
- Voltage
- Discharge current
- Rated Voltage

4) SYSTEM DIAGNOSTICS - The UPS shall provide diagnostic information to facilitate troubleshooting the UPS should a fault occur.

PART 5 – MECHANICAL DESIGN

5.0 MECHANICAL DESIGN

A. UPS Enclosure

The UPS shall be in a freestanding, NEMA1 enclosure. The overall dimensions and weights shall be as follows (with internal batteries):

UPS Size	Dimensions	Weight
50 kVA	22.1”W x 31.6”D x 73.7”H	867 lbs.

B. Cable Entry

The UPS shall be provided with cable entry at the top, bottom, left and right sides of the UPS enclosure.

C. Ventilation and Maintenance Requirements

The UPS shall require the following minimum space for ventilation and maintenance:

Front	: 36”
Top	: 24”
Rear, Left Side, Right Side	: 0"

PART 6 – STANDARD FEATURES

6.1 STANDARD FEATURES

A. Emergency Power Off (EPO)
Covered EPO Switch mounted on the UPS front
Remote EPO terminals allowing user installation of a remote EPO switch.

B. RS232 Communication Interface
Serial data link will enable the UPS to interface with a computer to provide power status and diagnostic information.

C. DB9 Dry Contact interface
The following normally open dry contacts shall be provided through a DB9 male connector located inside the front door:
1) UPS On
2) Bypass Active
3) Input Power Loss
4) Battery Voltage Low

D. Battery Test Function

The UPS shall be provided with a “Battery Test” function to allow periodically checking the condition of the optional backup batteries. Upon detection of a battery problem, the UPS shall notify the user of this condition allowing the user to perform a

detailed check of the battery string.

PART 7 – LINE-UP AND MATCH ANCILLARY CABINETS

7.1 Line-up and Match Ancillary Cabinets: Chosen

A. Maintenance Bypass Cabinet

The UPS shall be equipped with a may have an optional 3-breaker line-up and matching maintenance bypass cabinet

B. NOT USED

C. Battery Cabinet (43B-500017ER111)

The UPS will have an optional line-up and matching battery cabinet. The cabinet shall be available with one group of 3 battery strings and one circuit breaker.
Each battery string shall consist of four (4) 72V hot-swappable battery packs.

1) Battery Type: Sealed, Valve Regulated Lead Acid Cells (VLRA).
2) Protection Time:
Each optional standard matching battery cabinet shall provide the following estimated backup run-time:

UPS Model	Power Factor	Output Load	Estimated Run-time
50kVA	0.9 PF	100% Rated	15 min.

D. Optional Communications: Chosen

1) RemotEye III & Ethernet/SNMP

PART 8 – SERVICE AND WARRANTY

8.1 SERVICE AND WARRANTY

A. Reliability
System mission reliability 240,000** hours and including bypass MTBF (Mean- Time-Between-Failure) shall be in excess of 3,000,000**hours.

B. Maintainability

Calculated and demonstrated MTTR (Mean-Time-To-Repair) shall be 30 minutes including time to diagnose the problem and replace subassembly.

C. Warranty

The UPS system shall be provided with a comprehensive two-year on-site warranty. The warranty shall cover parts, labor, travel and freight for the UPS. The battery system has a full 2 year warranty with 3 year's prorata total of 5 years warranty. Typical on-site response time shall be 4 hours (24 hours maximum). The warranty period shall expire two years for UPS and two years for the battery system from date of Substantial Completion. Manufacturer and Installer agree to repair or replace components that fail in material or workmanship within the warranty period.

D. UPS Preferred Vendor status has already been determined by the Owner. And, thus in addition to warranty requirements listed herein, additional warranty and service requirements shall also apply.

PART 9 – DOCUMENT TRANSMITTALS AND DATA HANDLING

9.1 ACTION SUBMITTALS

9.1.1 Product Data: For each type of product indicated. Include data on features, components, electrical duration ratings, and performance.

9.1.2 Shop Drawings: For UPS. Include plans, elevations, sections, details, and attachments to other work.

- Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show operations and termination access, workspace, and clearance requirements; details of control display panels; and battery arrangement.
- Wiring Diagrams: For power, signal, and control wiring. (one-line with all secondary and monitoring circuit equipment details).
- Provide heat resection rate data. (consider a 73° F +/- 3° F enclosure space).
- Provide wet cell storage battery hydrogen evolution into a closed space. State ventilation requirement data. (consider a 73°F +/- 3°F environment).

9.2 INFORMATIONAL SUBMITTALS

9.2.1 Qualification Data: For qualified testing agency provide the test QA results data. .

9.2.2 Seismic Qualification Certificates: For UPS equipment, from manufacturer.

- Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

9.2.3 Manufacturer Certificates: For each product, from manufacturer.

9.2.4 Factory Test Reports: Comply with specified requirements.

9.2.5 Field quality-control reports.

9.2.6 Performance Test Reports: Indicate test results compared with specified performance requirements, and provide justification and resolution of differences if values do not agree.

9.2.7 Warranties: Sample of special warranties.

9.3 CLOSEOUT SUBMITTALS

9.3.1 Operation and Maintenance Data: For UPS units to include in emergency, operation, and systems maintenance manuals.

9.4 MAINTENANCE MATERIAL SUBMITTALS

9.4.1 Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- Fuses: Three each for each type and rating.
- Cabinet Ventilation Filters: Two complete set(s).

9.5 QUALITY ASSURANCE

9.5.1 Power Quality Specialist Qualifications: A registered professional electrical engineer or engineering technician, currently certified by the National Institute for Certification in Engineering Technologies, NICET Level 4, minimum, experienced in performance testing UPS installations and in performing power quality surveys similar to that required in "Performance Testing" Article.

9.5.2 Testing Agency Qualifications: Member company of NETA or an NRTL.

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

9.5.3 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.

9.5.4 UL Compliance: Listed and labeled under UL 1778 by an NRTL.

9.5.5 NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

PART 10– QUALITY PROGRAM INSTALLATION AND TESTING RESULTS REQUIREMENTS

10.1 BATTERY QUALITY CONTROL

10.1.1 Factory test complete UPS system before shipment. Use actual batteries that are part of final installation battery testing. Include the following:

- Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
- Full-load test.
- Transient-load response test.
- Overload test.
- Power failure test.

10.1.2 Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice. WSU site test demonstrations shall be conducted during the Monday through Friday normal work week between 0830-1700 hours. WSU will observe testing. The seller shall submit the QA program test plan for WSU acceptance.

10.1.3 Report test results. Include the following data:

- Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
- List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
- List of instruments and equipment used in factory tests.

10.2 FIELD QUALITY CONTROL

10.2.1 Testing Agency: Engage a qualified testing agency to perform tests and inspections.

10.2.2 Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

10.2.3 Perform tests and inspections.

- Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

10.2.4 Tests and Inspections:

- Comply with manufacturer's written instructions.
- Inspect interiors of enclosures, including the following:
  - Integrity of mechanical and electrical connections.
  - Component type and labeling verification.
  - Ratings of installed components.
- Inspect batteries and chargers according to requirements in NETA Acceptance Testing Specifications.
- Test manual and automatic operational features and system protective and alarm functions.
- Test communication of status and alarms to remote monitoring equipment.
- Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for the UPS unit's rating. Use instruments calibrated within the previous six months according to NIST standards.
  - Simulate malfunctions to verify protective device operation.
  - Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
  - Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.
  - Test output voltage under specified transient-load conditions.
  - Test efficiency at 50, 75, and 100 percent of rated loads.
  - Test remote status and alarm panel functions.
  - Test battery-monitoring system functions.

10.2.5 Seismic-restraint tests and inspections shall include the following:

- Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
- Test mounting and anchorage devices according to requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

10.2.6 The UPS system will be considered defective if it does not pass tests and inspections.

10.2.7 Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

10.2.8 Prepare test and inspection reports.

10.3 PERFORMANCE TESTING

10.3.1 Engage the services of a qualified power quality specialist to perform tests and activities indicated for each UPS system.

10.3.2 Monitoring and Testing Schedule: Perform monitoring and testing in a single 10-day period scheduled for the: 50 KVA/45 KW Biological Science Building,

- Schedule monitoring and testing activity with Owner, through Architect, with at least 14 days' advance notice.
- Schedule monitoring and testing after Substantial Completion, when the UPS is supplying power to its intended load.

10.3.3 Monitoring and Testing Instruments: Three-phase, recording, power monitors. Instruments shall provide continuous simultaneous monitoring of electrical parameters at UPS input terminals and at input terminals of loads served by the UPS. Instruments shall monitor, measure, and graph voltage current and frequency simultaneously and provide full-graphic recordings of the values of those parameters before and during power-line disturbances that cause the values to deviate from normal beyond the adjustable threshold values. Instruments shall be capable of recording either on paper or on magnetic media and have a minimum accuracy of plus or minus 2 percent for electrical parameters. Parameters to be monitored include the following:

- Current: Each phase and neutral and grounding conductors.
- Voltage: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
- Frequency transients.
- Voltage swells and sags.
- Voltage Impulses: Phase to phase, phase to neutral, phase to ground, and neutral to ground.
- High-frequency noise.
- Radio-frequency interference.
- THD of the above currents and voltages.
- Harmonic content of currents and voltages above.

10.3.4 Monitoring and Testing Procedures[for Each Test Period]:

- Exploratory Period: For the first [two] <Insert number> days[of the first scheduled monitoring and testing period], make recordings at various circuit locations and with various parameter-threshold and sampling-interval settings. Make these measurements with the objective of identifying optimum UPS, power system, load, and instrumentation setup conditions for subsequent test and monitoring operations.
- Remainder of Test Period: Perform continuous monitoring of at least two

circuit locations selected on the basis of data obtained during exploratory period.

- Set thresholds and sampling intervals for recording data at values selected to optimize data on performance of the UPS for values indicated, and to highlight the need to adjust, repair, or modify the UPS, distribution system, or load component that may influence its performance or that may require better power quality.
- Perform load and UPS power source switching and operate the UPS on generator power during portions of test period according to directions of Owner's power quality specialist.
- Operate the UPS and its loads in each mode of operation permitted by UPS controls and by the power distribution system design.
- Using loads and devices available as part of the facility's installed systems and equipment[and a temporarily connected portable generator set], create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
- Using temporarily connected resistive/inductive load banks[and a temporarily connected portable generator set], create and simulate unusual operating conditions, including outages, voltage swells and sags, and voltage, current, and frequency transients. Maintain normal operating loads in operation on system to maximum extent possible during tests.
- Make adjustments and repairs to UPS, distribution, and load equipment to correct deficiencies disclosed by monitoring and testing and repeat appropriate monitoring and testing to verify success of corrective action.

10.3.5 Coordination with Specified UPS Monitoring Functions: Obtain printouts of built-in monitoring functions specified for the UPS and its components in this Section that are simultaneously recorded with portable instruments in this article.

- Provide the temporary use of an appropriate PC and printer equipped with required connections and software for recording and printing if such units are not available on-site.
- Coordinate printouts with recordings for monitoring performed according to this article, and resolve and report any anomalies in and discrepancies between the two sets of records.

10.3.6 Monitoring and Testing Assistance by Contractor:

- Open UPS and electrical distribution and load equipment and wiring enclosures to make monitoring and testing points accessible for temporary monitoring probe and sensor placement and removal as requested.
- Observe monitoring and testing operations; ensure that UPS and distribution and load equipment warranties are not compromised.
- Perform switching and control of various UPS units, electrical distribution systems, and load components as directed by power quality specialist. Specialist shall design this portion of monitoring and testing operations to expose the UPS to various operating environments, conditions, and events while response is observed, electrical parameters are monitored, and system and equipment deficiencies are identified.
- Make repairs and adjustments to the UPS and to electrical distribution system and load components, and retest and repeat monitoring as needed to verify validity of results and correction of deficiencies.
- Engage the services of the UPS manufacturer's factory-authorized service representative periodically during performance testing operations for repairs, adjustments, and consultations.

10.3.7 Documentation: Record test point and sensor locations, instrument settings, and circuit and load conditions for each monitoring summary and power disturbance recording. Coordinate simultaneous recordings made on UPS input and load circuits.

10.3.8 Analysis of Recorded Data and Report: Review and analyze test observations and recorded data and submit a detailed written report. Include the following in [each]report:

- Description of corrective actions performed during monitoring and survey work and their results.
- Recommendations for further action to provide optimum performance by the UPS and appropriate power quality for non-UPS loads. Include a statement of priority ranking and a cost estimate for each recommendation that involves system or equipment revisions.
- Copies of monitoring summary graphics and graphics illustrating harmonic content of significant voltages and currents.
- Copies of graphics of power disturbance recordings that illustrate findings, conclusions, and recommendations.
- Recommendations for operating, adjusting, or revising UPS controls.
- Recommendation for alterations to the UPS installation.
- Recommendations for adjusting or revising generator-set or automatic transfer switch installations or their controls.
- Recommendations for power distribution system revisions.
- Recommendations for adjusting or revising electrical loads, their connections, or controls.

10.3.9 Interim and Final Reports: Provide an interim report at the end of each test period and a final comprehensive report at the end of final test and analysis period.

10.4 DEMONSTRATION

16.4.1 Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

TOSHIBA Static Uninterruptible Power Supply Data Sheet

I. State model number data: each cabinet, (include dimensions and weight data)

a. UPS 50 kVA 45 kW power Electronics cabinet: 4310F3F500XA

b. Battery Storage Cabinet: 431A500XXXX

c. Maintenance Bypass Switch Cabinet: 431M500-F3MS

d. Remote Communication Module Features: 4300-RMTI-3

e. Startup Service UPS System: UPSSTARTUP050

II.

Input Power Parameter Data:	
Voltage/Wiring Features	
Voltage Range/Variation	
Power Factor	
Current THD Harmonics	
Frequency/Variation	
Output Power Parameter Data:	
Voltage/Wiring Features	
Frequency/Variation	
Voltage Regulation	
Power Factor: LAG	
Voltage THD	

Overload, Inverter 120sec/60sec	
Overload, Bypass	

III. State environment operating parameter requirements:
- Temperature
- Humidity
- Noise dBA
- Heat rejection
- Efficiency ratings data
- Seismic

Static Uninterruptible Power Supply Data Sheet

IV. System Topology: State UPS Description Data: _____
V. State UPS battery features and operation life features.
VI. State UPS monitoring, alarm, control interface switch features and signal handling provision.
VII. State UPS international and national standards compliance adherence data (e.g: UL ISO ANSI IEEE, other NFPA-NEC)
VIII. State UPS warranty duration and features.
IX. State UPS Startup services; post-installation

END OF SECTION 263353