UNIVERSITY of MARYLAND
THE FOUNDING CAMPUS

ADMINISTRATION & FINANCE

OFFICE OF FACILITIES MANAGEMENT

SPECIFICATIONS FOR THE SCHOOL OF PHARMACY ELECTRICAL RENEWAL SYSYTEM AT THE UNIVERSITY OF MARYLAND

UNIVERSITY PROJECT # 19-315

BID DOCUMENTS

VOLUME 1 OF 1: PROJECT SPECFICATIONS

NOVEMBER 06, 2020

Owner
University of Maryland, Baltimore
Office of Facilities Management
Design and Construction
220 Arch Street, Office Level 3, 14th Floor
Baltimore, Maryland 21201

Board of Public Works
Lawrence J. Hogan Jr., Governor
Peter Franchot, Comptroller
Nancy K. Kopp, Treasurer

Maryland General Assembly
Thomas V. Miller Jr, Senate President
Michael Erin Busch, House Speak

MEP Engineer
RMF Engineering, Inc.
5520 Research Park Drive
Baltimore, MD 21228

UMB MASTER SPECIFICATIONS TABLE OF CONTENTS

DIVISION 26: ELECTRICAL

SECTION 01010 - SUMMARY OF WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 WORK COVERED BY CONTRACT DOCUMENTS

A. The Project consists of mainly electrical work in the UMB School of Pharmacy. The electrical work includes replacement of the 15 kV and 480 V electrical service equipment in the School of Pharmacy and replacement of the HVAC that serves the electrical spaces in this area.

1. Project Location: University of Maryland, Baltimore

2. Owner: University of Maryland, Baltimore.

B. Contract Documents, dated November 15, 2019 were prepared for the Project by:

1. RMF Engineering: 5520 Research Park Drive, Baltimore, MD 21228

1.3 CONTRACTOR USE OF PREMISES

A. General: During the construction period the Contractor shall have full use of the premises for construction operations, including use of the site. The Contractor's use of the premises is limited only by the University's right to perform work or to retain other contractors on portions of the Project.

B. Use of the Site: Limit use of the premises to work in areas indicated. Confine operations to areas within contract limits indicated. Do not disturb portions of the site beyond the areas in which the Work is indicated.

1. University Occupancy: Allow for University occupancy and use by the public.
2. Driveways and Entrances: Keep driveways and entrances serving the premises clear and available to the University, the University's employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.

C. Use of the Existing Building: Maintain the existing building in a weathertight condition throughout the construction period. Repair damage caused by construction operations. Take all precautions necessary to protect the building and its occupants during the construction period.

1.4 OCCUPANCY REQUIREMENTS

A. Full University Occupancy: The University will occupy the site and existing building during the entire construction period. Cooperate with the University during construction operations to minimize conflicts and facilitate University usage. Perform the Work so as not to interfere with the University's operations.
   1. Off Hours Work: All building outages will need to occur during off hours. This includes all building power switchovers and individual load or equipment outages.

1.5 PROTECTION OF EXISTING CONSTRUCTION AND FURNISHINGS

A. The Contractor shall take all necessary precautions to protect the University's property and furnishings. The Contractor shall promptly remedy damage and loss to the University's property caused in whole or in part by the Contractor, a Subcontractor, a Sub-Subcontractor, or anyone directly or indirectly employed by any of them, or by anyone for whose acts they may be liable and for which the Contractor is responsible.

PART 2 - PRODUCTS (Not Applicable)

PART 3 – EXECUTION (Not Applicable)

END OF SECTION 01010

SECTION 01027 - APPLICATIONS FOR PAYMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section specifies administrative and procedural requirements governing the Contractor's Applications for Payment.

B. This Section specifies administrative and procedural requirements governing each prime contractor's Applications for Payment.

1. Coordinate the Schedule of Values and Applications for Payment with the Contractor's Construction Schedule, Submittal Schedule, and List of Subcontracts.

C. Related Sections: The following Sections contain requirements that relate to this Section.

1. Schedules: The Contractor's Construction Schedule and Submittal Schedule are specified in Division 1 Section "Submittals."

1.3 SCHEDULE OF VALUES

A. Coordination: Coordinate preparation of the Schedule of Values with preparation of the Contractor's Construction Schedule.

1. Correlate line items in the Schedule of Values with other required administrative schedules and forms, including:
   a. Contractor's Construction Schedule.
   b. Application for Payment forms, including Continuation Sheets.
   c. List of subcontractors.
   d. Schedule of allowances.
   e. Schedule of alternates.
   f. List of products.
   g. List of principal suppliers and fabricators.
   h. Schedule of submittals.

2. Submit the Schedule of Values to the University at the earliest possible date but no later than 7 days before the date scheduled for submittal of the initial Applications for Payment.

3. Subschedules: Where Work is separated into phases requiring separately phased payments, provide subschedules showing values correlated with each phase of payment.

B. Format and Content: Use the Project Manual table of contents as a guide to establish the format for the Schedule of Values. Provide at least one line item for each Specification Section.

1. Identification: Include the following Project identification on the Schedule of Values:
   a. Project name and location.
   b. University's Project number.
   c. Contractor's name and address.
   d. Date of submittal.
2. Arrange the Schedule of Values in tabular form with separate columns to indicate the following for each item listed:
   a. Related Specification Section or Division.
   b. Description of Work.
   c. Name of subcontractor.
   d. Name of manufacturer or fabricator.
   e. Name of supplier.
   f. Change Orders (numbers) that affect value.
   g. Dollar value.
   h. Percentage of Contract Sum to nearest one-hundredth percent, adjusted to total 100 percent.
3. Provide a breakdown of the Contract Sum in sufficient detail to facilitate continued evaluation of Applications for Payment and progress reports. Coordinate with the Project Manual table of contents. Break principal subcontract amounts down into several line items.
4. Round amounts to nearest whole dollar; the total shall equal the Contract Sum.
5. Provide a separate line item in the Schedule of Values for each part of the Work where Applications for Payment may include materials or equipment, purchased or fabricated and stored, but not yet installed.
   a. Differentiate between items stored on-site and items stored off-site. Include requirements for insurance and bonded warehousing, if required.
6. Provide separate line items on the Schedule of Values for initial cost of the materials, for each subsequent stage of completion, and for total installed value of that part of the Work.
7. Margins of Cost: Show line items for indirect costs and margins on actual costs only when such items are listed individually in Applications for Payment. Each item in the Schedule of Values and Applications for Payment shall be complete. Include the total cost and proportionate share of general overhead and profit margin for each item.
   a. Temporary facilities and other major cost items that are not direct cost of actual work-in-place may be shown either as separate line items in the

Schedule of Values or distributed as general overhead expense, at the Contractor's option.

8. Schedule Updating: Update and resubmit the Schedule of Values prior to the next Applications for Payment when Change Orders or Construction Change Directives result in a change in the Contract Sum.

1.4 APPLICATIONS FOR PAYMENT

A. Each Application for Payment shall be consistent with previous applications for payment as paid for by the University.

1. The initial Application for Payment, the Application for Payment at time of Substantial Completion, and the final Application for Payment involve additional requirements.

B. Refer to the University of Maryland Baltimore Standard General Condition of Construction for requirements and procedures governing applications for payment.

C. Initial Application for Payment: Administrative actions and submittals, that must precede or coincide with submittal of the first Application for Payment, include the following:

1. List of subcontractors.
2. List of principal suppliers and fabricators.
3. Schedule of Values.
4. Contractor's Construction Schedule.
5. Schedule of principal products.
6. Schedule of unit prices.
7. Submittal Schedule.
8. List of Contractor's staff assignments.
9. List of Contractor's principal consultants.
10. Copies of authorizations and licenses from governing authorities for performance of the Work.
11. Initial progress report.
12. Report of preconstruction meeting.
13. Certificates of insurance and insurance policies.
14. Performance and payment bonds.
15. Data needed to acquire the University's insurance.
16. Initial settlement survey and damage report, if required.

D. Application for Payment at Substantial Completion: Following issuance of the Certificate of Substantial Completion, submit an Application for Payment.

1. This application shall reflect Certificates of Partial Substantial Completion issued previously for University occupancy of designated portions of the Work.

2. Administrative actions and submittals that shall precede or coincide with this application include:
   a. Warranties (guarantees) and maintenance agreements.
   b. Test/adjust/balance reports.
   c. Operation and Maintenance Manuals.
   d. Meter readings if appropriate.
   e. Startup performance reports.
   f. Commissioning Reports.
   g. Final cleaning.
   h. Application for reduction of retainage and consent of surety.
   i. Advice on shifting insurance coverages.
   j. Final progress photographs.
   k. List of incomplete Work, recognized as exceptions to University's Certificate of Substantial Completion.

E. Final Payment Application: Administrative actions and submittals that must precede or coincide with submittal of the final Application for Payment include the following:

1. Completion of Project closeout requirements.
2. Completion of items specified for completion after Substantial Completion.
3. Resolve all previously unsettled claims.
4. Resolve all previously incomplete Work.
5. Transmittal of required Project construction records to the University.
6. Proof that taxes, fees, and similar obligations were paid.
7. Removal of temporary facilities and services.
8. Removal of surplus materials, rubbish, and similar elements.
9. Change of door locks to University's access.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 01027

SECTION 01035 - MODIFICATION PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section specifies administrative and procedural requirements for handling and processing contract modifications.

1.3 MINOR CHANGES IN THE WORK

A. The University will issue supplemental instructions authorizing minor changes in the Work, not involving adjustment to the Contract Sum or Contract Time.

1.4 CHANGE ORDER PROPOSAL REQUESTS

A. University Initiated Change Order Proposal Requests: The University will issue a detailed description of proposed changes in the Work that will require adjustment to the Contract Sum or Contract Time. If necessary, the description will include supplemental or revised Drawings and Specifications.

1. Proposal requests issued by the University are for information only. Do not consider them as an instruction either to stop work in progress or to execute the proposed change.
2. Within a mutually agreed upon time period, submit an estimate of cost necessary to execute the change to the University for review.
    a. Include a list of quantities of products required and unit costs, with the total amount of purchases to be made. Where requested, furnish survey data to substantiate quantities. Include required labor hours and unit costs, with totals for each labor category. Include all credits for deleted work.
    b. Indicate applicable taxes, delivery charges, equipment rental, and amounts of trade discounts, for new work and deleted work.
    c. Include a statement indicating the effect the proposed change in the Work will have on the Contract Time.

B. Contractor-Initiated Proposals: When latent or unforseen conditions require modifications to the Contract, the Contractor may propose changes by submitting a request for a change to the University.

1. Include a statement outlining the reasons for the change and the effect of the change on the Work. Provide a complete description of the proposed change. Indicate the effect of the proposed change on the Contract Sum and Contract Time.
2. Include a list of quantities of products required and unit costs, with the total amount of purchases to be made. Where requested, furnish survey data to substantiate quantities. Include required labor hours and unit costs, with totals for each labor category. Include all credits for deleted work.
3. Indicate applicable taxes, delivery charges, equipment rental, and amounts of trade discounts, for new work and deleted work.
4. Comply with requirements in Section "Product Substitutions" if the proposed change requires substitution of one product or system for a product or system specified.

C. Proposal Request Form: Use forms provided by the Owner for Change Order Proposals.

1.5 CHANGE ORDER PROCEDURES

A. Upon the University's approval of a Proposal Request, the University will issue a Change Order Requisition for signatures of the Contractor followed by a Notice to Proceed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 01035

SECTION 01040 - COORDINATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes administrative and supervisory requirements necessary for coordinating construction operations including, but not necessarily limited to, the following:

1. General project coordination procedures.
2. Conservation.
3. Coordination Drawings.
4. Administrative and supervisory personnel.
5. Cleaning and protection.

1.3 COORDINATION

A. Coordinate construction operations included in various Sections of these Specifications to assure efficient and orderly installation of each part of the Work. Coordinate construction operations included under different Sections that depend on each other for proper installation, connection, and operation.

1. Schedule construction operations in the sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components to assure required minimum accessibility for maintenance, service, and repair.
3. Make provisions to accommodate items scheduled for later installation.

B. Where necessary, prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and attendance at meetings.

1. Prepare similar memoranda for the University and sub-contractors where coordination of their work is required.

C. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities to avoid conflicts and assure orderly

progress of the Work. Such administrative activities include, but are not limited to, the following:

1. Preparation of CPM schedules.
2. Installation and removal of temporary facilities.
3. Delivery and processing of submittals.
4. Progress meetings.
5. Work coordination meetings.
6. Project closeout activities.

D. Conservation: Coordinate construction operations to assure that operations are carried out with consideration given to conservation of energy, water, and materials.

1. Salvage materials and equipment involved in performance of, but not actually incorporated in, the Work.

1.4 SUBMITTALS

A. Coordination Drawings: Prepare coordination drawings where careful coordination is needed for installation of products and materials fabricated by separate entities. Prepare coordination drawings where limited space availability necessitates maximum utilization of space for efficient installation of different components. At a minimum, prepare coordination drawings for all mechanical rooms, electrical rooms and substation rooms.

1. Show the relationship of components shown on separate Shop Drawings.
2. Indicate required installation sequences.
3. Comply with requirements contained in Section "Submittals."
4. The coordination drawings shall be comprehensive drawings that show all work by all disciplines for each location on a single drawing. The drawings shall be prepared at a large enough scale to permit legibility and ease of recognition of all work.

B. Staff Names: Within 15 days of commencement of construction operations, submit a list of the Contractor's principal staff assignments, including the superintendent and other personnel in attendance at the Project Site. Identify individuals and their duties and responsibilities. List their addresses and telephone numbers.

1. Post copies of the list in the Project meeting room, the temporary field office, and at each temporary telephone.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 GENERAL COORDINATION PROVISIONS

A. Inspection of Conditions: Require the Installer of each major component to inspect both the substrate and conditions under which Work is to be performed. Do not proceed until unsatisfactory conditions have been corrected in an acceptable manner.

B. Coordinate temporary enclosures with required inspections and tests to minimize the necessity of uncovering completed construction for that purpose.

3.2 CLEANING AND PROTECTION

A. Clean and protect construction in progress and adjoining materials in place, during handling and installation. Apply protective covering where required to assure protection from damage or deterioration until Substantial Completion.

B. Clean and provide maintenance on completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components to assure operability without damaging effects.

C. Limiting Exposures: Supervise construction operations to assure that no part of the construction, completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period. Where applicable, such exposures include, but are not limited to, the following:

1. Excessive static or dynamic loading.
2. Excessive internal or external pressures.
3. Air contamination or pollution.
4. Water or ice.
5. Puncture.
6. Abrasion.
7. Heavy traffic.
8. Soiling, staining, and corrosion.
9. Combustion.
10. Electrical current.
11. Improper lubrication.
12. Unusual wear or other misuse.
13. Contact between incompatible materials.
14. Destructive testing.
15. Misalignment.
16. Excessive weathering.
17. Unprotected storage.
18. Improper shipping or handling.
19. Theft.
20. Vandalism.

END OF SECTION 01040

SECTION 01045 - CUTTING AND PATCHING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes administrative and procedural requirements for cutting and patching.

1.3 SUBMITTALS

A. Cutting and Patching Proposal: When unforeseen conditions require cutting and patching of the existing structure and/or related components the CM shall submit a cutting and patching proposal to the university, for review and approval before proceeding with any work. Include the following information, as applicable, in the proposal:

1. Describe the extent of cutting and patching required and indicate why it cannot be avoided. Include changes to the building's appearance and other significant visual elements if applicable.
2. Describe the products to be used.
3. Identify the impact to the project’s schedule and budget.
4. Indicate the dates when cutting and patching will be performed.
5. Where cutting and patching involves adding reinforcement to structural elements, the modifications to the structure shall be designed by a registered structural engineer. If the design team does not include a structural engineer the CM shall secure the services of an engineer to perform the required design. The CM shall submit the design drawings, details and engineering calculations showing integration of reinforcement with the original structure to the University.
6. Approval by the University to proceed with cutting and patching does not waive the University's right to later require complete removal and replacement of unsatisfactory work.

1.4 QUALITY ASSURANCE

A. Requirements for Structural Work: Do not cut and patch structural elements in a manner that would change their load-carrying capacity or load-deflection ratio.

1. Obtain hot work permit from the University for cutting, burning, welding, etc.
2. Obtain approval of the cutting and patching proposal before cutting and patching the following structural elements:
   a. Foundation construction.

b. Bearing and retaining walls.
c. Structural concrete.
d. Structural steel.
e. Lintels.
f. Timber and primary wood framing.
g. Structural decking.
h. Stair systems.
i. Miscellaneous structural metals.
j. Exterior curtain-wall construction.
k. Equipment supports.
l. Piping, ductwork, vessels, and equipment.
m. Structural systems of special construction in Division 13 Sections.

B. Operational Limitations: Do not cut and patch operating elements or related components in a manner that would result in reducing their capacity to perform as intended. Do not cut and patch operating elements or related components in a manner that would result in increased maintenance or decreased operational life or safety.
1. Obtain approval of the cutting and patching proposal from the University before cutting and patching the following operating elements or safety related systems:
a. Primary operational systems and equipment.
b. Air or smoke barriers.
c. Water, moisture, or vapor barriers.
d. Membranes and flashings.
e. Fire protection systems.
f. Noise and vibration control elements and systems.
g. Control systems.
h. Communication systems.
i. Conveying systems.
j. Electrical wiring systems.
k. Operating systems of special construction.

C. Visual Requirements: Do not cut and patch construction exposed on the exterior or in occupied spaces in a manner that would, in the University's opinion, reduce the building's aesthetic qualities. Do not cut and patch construction in a manner that would result in visual evidence of cutting and patching. Remove and replace construction cut and patched in a visually unsatisfactory manner when directed by the University.

1. If possible, retain the original Installer or fabricator to cut and patch the exposed Work listed below. If it is impossible to engage the original Installer or fabricator, engage another recognized experienced and specialized firm.
a. Processed concrete finishes.
b. Stonework and stone masonry.
c. Ornamental metal.
d. Matched-veneer woodwork.
e. Preformed metal panels.

f. Firestopping.
g. Window wall system.
h. Stucco and ornamental plaster.
i. Acoustical ceilings.
j. Terrazzo.
k. Finished wood flooring.
l. Fluid-applied flooring.
m. Carpeting.
n. Aggregate wall coating.
o. Wall covering.
p. HVAC enclosures, cabinets, or covers.

1.5 WARRANTY

A. Existing Warranties: Replace, patch, and repair material and surfaces cut or damaged by methods and with materials in such a manner as not to void any warranties required or existing.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Use materials identical to existing materials. For exposed surfaces, use materials that visually match existing adjacent surfaces to the fullest extent possible if identical materials are unavailable or cannot be used. Use materials whose installed performance will equal or surpass that of existing materials. Refer to applicable spec sections for materials.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine surfaces to be cut and patched and conditions under which cutting and patching is to be performed before cutting. If unsafe or unsatisfactory conditions are encountered, take corrective action before proceeding.

3.2 PREPARATION

A. Temporary Support: Provide temporary support of work to be cut.

B. Protection: Protect existing construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of the Project that might be exposed during cutting and patching operations.

C. Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.

D. Avoid cutting existing pipe, conduit, or ductwork serving the building but scheduled to be removed or relocated until provisions have been made to bypass them or to take them out of service.

3.3 PERFORMANCE

A. General: Employ skilled workmen or experienced subcontractors to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time and complete without delay.

1. Cut existing construction to provide for installation of other components or performance of other construction activities and the subsequent fitting and patching required to restore surfaces to their original condition.

B. Cutting: Cut existing construction using methods least likely to damage elements retained or adjoining construction. Where possible, review proposed procedures with the original Installer; comply with the original Installer's recommendations.

1. In general, when cutting, use hand or small power tools designed for sawing or grinding, not hammering and chopping. Cut holes and slots as small as possible, neatly to size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
2. To avoid marring existing finished surfaces, cut or drill from the exposed or finished side into concealed surfaces.
3. Cut through concrete and masonry using a cutting machine, such as a Carborundum saw or a diamond-core drill.
4. Comply with requirements of applicable Division 2 Sections where cutting and patching requires excavating and backfilling.
5. Where services are required to be removed, relocated, or abandoned, by-pass utility services, such as pipe or conduit, before cutting. Ensure all services have been de-energized or drained before cutting. Cut-off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal the remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after by-passing and cutting.

C. Patching: Patch with durable seams that are as invisible as possible. Comply with specified tolerances.

1. Where feasible, inspect and test patched areas to demonstrate integrity of the installation.
2. Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.
3. Where removing walls or partitions extends one finished area into another, patch and repair floor and wall surfaces in the new space. Provide an even surface of uniform

color and appearance. Remove existing floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance.

a. Where patching occurs in a smooth painted surface, extend final paint coat over entire unbroken surface containing the patch after the area has received primer and second coat. Prepare entire surface to receive final coat as necessary for proper adhesion.

4. Patch, repair, or rehang existing ceilings as necessary to provide an even-plane surface of uniform appearance.

D. Plaster Installation: Comply with manufacturer's instructions and install thickness and coats as indicated.

1. Unless otherwise indicated, provide 3-coat work.
2. Finish gypsum plaster to match existing adjacent surfaces. Sand lightly to remove trowel marks and arises.
3. Cut, patch, point-up, and repair plaster to accommodate other construction.

3.4 LEANING

A. Areas and spaces where cutting, and patching are performed shall be cleaned. Completely remove paint, mortar, oils, putty, and similar items. Thoroughly clean piping, conduit, and similar features before applying paint or other finishing materials. Restore damaged pipe covering to its original condition.

END OF SECTION 01045

SECTION 01095 - REFERENCE STANDARDS AND DEFINITIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 DEFINITIONS

A. General: Basic contract definitions are included in the Conditions of the Contract.

B. "Indicated": The term "indicated" refers to graphic representations, notes, or schedules on the Drawings, or other paragraphs or Schedules in the Specifications, and similar requirements in the Contract Documents. Terms such as "shown," "noted," "scheduled," and "specified" are used to help the reader locate the reference. Location is not limited.

C. "Directed": Terms such as "directed," "requested," "authorized," "selected," "approved," "required," and "permitted" mean directed by the University, requested by the University, and similar phrases.

D. "Approved": The term "approved," when used in conjunction with the University's action on the Contractor's submittals, applications, and requests, is limited to the University's duties and responsibilities as stated in the Conditions of the Contract.

E. "Regulations": The term "regulations" includes laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, as well as rules, conventions, and agreements within the construction industry that control performance of the Work.

F. "Furnish": The term "furnish" means supply and deliver to the Project Site, ready for unloading, unpacking, assembly, installation, and similar operations.

G. "Install": The term "install" describes operations at the Project Site including the actual unloading, unpacking, assembly, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.

H. "Provide": The term "provide" means to furnish and install, complete and ready for the intended use.

I. "Installer": An installer is the Contractor or another entity engaged by the Contractor, either as an employee, subcontractor, or contractor of lower tier, to perform a particular construction activity, including installation, erection, application, or similar operations. Installers are required to be experienced in the operations they are engaged to perform.

1. The term "experienced," when used with the term "installer," means having a minimum of 5 previous projects similar in size and scope to this Project, being familiar with the special requirements indicated, and having complied with requirements of authorities having jurisdiction.
2. Trades: Using terms such as "carpentry" does not imply that certain construction activities must be performed by accredited or unionized individuals of a corresponding generic name, such as "carpenter." It also does not imply that requirements specified apply exclusively to tradespersons of the corresponding generic name.

J. "Project Site" is the space available to the Contractor for performing construction activities, either exclusively or in conjunction, with others performing other work as part of the Project. The extent of the Project Site is shown on the Drawings and may or may not be identical with the description of the land on which the Project is to be built.

K. "Testing Agencies": A testing agency is an independent entity engaged to perform specific inspections or tests, either at the Project Site or elsewhere, and to report on and, if required, to interpret results of those inspections or tests.

1.3 INDUSTRY STANDARDS

A. Applicability of Standards: Except where the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced. Such standards are made a part of the Contract Documents by reference.

B. Publication Dates: Comply with the standards in effect as of the date of the Contract Documents.

C. Conflicting Requirements: Where compliance with 2 or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer to the University before proceeding for a decision on requirements that are different but apparently equal, and where it is uncertain which requirement is the most stringent.

1. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum acceptable. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of the requirements. Refer uncertainties to the University for a decision before proceeding.

D. Copies of Standards: Each entity engaged in construction on the Project is required to be familiar with industry standards applicable to its construction activity. Copies of applicable standards are not bound with the Contract Documents.

1. Where copies of standards are needed to perform a required construction activity, the Contractor shall obtain copies directly from the publication source.

E. Abbreviations and Names: Trade association names and titles of general standards are frequently abbreviated. Where such acronyms or abbreviations are used in the Specifications or other Contract Documents, they mean the recognized name of the trade association, standards-generating organization, authorities having jurisdiction, or other entity applicable to the context of the text provision. Refer to Gale Research Co.'s "Encyclopedia of Associations," available in most libraries.

1.4 SUBMITTALS

A. Permits, Licenses, and Certificates: For the University's records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established in conjunction with compliance with standards and regulations bearing upon performance of the Work.

PART 1 - PRODUCTS (Not Applicable)

PART 2 - EXECUTION (Not Applicable)

END OF SECTION 01095

SECTION 01200 - PROJECT MEETINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section specifies administrative and procedural requirements for project meetings, including, but not limited to, the following:
   1. Preconstruction conferences.
   2. Progress meetings.

1.3 PRECONSTRUCTION CONFERENCE

A. The University shall schedule a preconstruction conference before starting construction, at a time convenient to the Contractor and the University, but no later than 15 days after execution of the Agreement. The conference will be held at a site identified by the University.

   1. The University will conduct the meeting. Minutes will be recorded and distributed to participants in accordance with contract requirements.

B. Attendees: Authorized representatives of the University, University, and their consultants; the Contractor and its superintendent; major subcontractors; and other concerned parties shall attend the conference. All participants at the conference shall be familiar with the Project and authorized to conclude matters relating to the Work.

C. Agenda: Discuss items of significance that could affect progress, including, but not limited to, the following:

   1. Tentative construction schedule.
   2. Critical work sequencing.
   3. Designation of responsible personnel.
   4. Procedures for processing field decisions and Change Orders.
   5. Procedures for processing Applications for Payment.
   6. Procedures for processing Requests for Information (RFI's).
   7. Procedures for processing University's Supplemental Instructions and Contract Clarification.
   8. Distribution of Contract Documents.
   9. Submittal of Shop Drawings, Product Data, and Samples.
   10. Preparation of record documents.
   11. Use of the premises.
   12. Parking availability.

13. Office, work, and storage areas.
14. Equipment deliveries and priorities.
15. Safety procedures.
16. First aid.
17. Security.
18. Housekeeping.
19. Working hours.
20. Utility outages.
21. Testing.

1.4 PROGRESS MEETINGS

A. The University shall schedule and administer bi-weekly progress meetings throughout the progress of work. The progress meetings will be held at a site identified by the University.

1. The University will conduct the meeting, record minutes, and distribute copies to participants.

B. Attendees: In addition to representatives of the University and the University, each subcontractor, or other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the conference shall be familiar with the Project and authorized to conclude matters relating to the Work.

C. Agenda: Review and correct or approve minutes of the previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to the status of the Project.

1. Contractor's CPM Construction Schedule: Review progress since the last meeting. Determine status of each activity in relation to the Contractor's Construction Schedule, whether on time, ahead or behind schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to insure that current and subsequent activities will be completed within the Contract Time. Determine status of tasks on critical path. Identify additional tasks becoming critical due to delays.
2. Review the present and future needs of each entity present, including, but not limited to, the following:
    a. Interface requirements.
    b. Time.
    c. Sequences.
    d. Status of submittals.
    e. Deliveries.
    f. Off-site fabrication problems.
    g. Access.
    h. Site utilization.

i. Temporary facilities and services.
j. Hours of work.
k. Hazards and risks.
l. Housekeeping.
m. Quality and work standards.
n. Change Orders.
o. Documentation of information for payment requests.
p. Review submittal log.
q. Review RFI log.
r. Review Change Order log.
s. Review upcoming outages, testing and inspections.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 01200

SECTION 01300 - SUBMITTALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes administrative and procedural requirements for all submittals, required for the installation and completion of the work for the project. Submittals include three (3) types of submittals, Construction Submittals, Administrative Submittals and Quality Control Submittals as defined hereinafter.

B. UM Standard Project Forms:

1. The CM, Contractors, and A/E shall use the following UM Standard Project Submittal Forms for all submissions as follows:

   a. UM Standard Project Submittal Form
   b. UM Standard Project RFI Form

2. These forms are included in Part 2 Products for reference and each form's individual electronic file is available at the UM Architecture Engineering and Construction Documents web site at http://www.umbfm.umaryland.edu then through the link for AEC and AEC Documents.

1.3 DEFINITIONS

A. Construction Submittals: Construction Submittals are defined as submittals which include all information related to products, materials, and equipment used for the construction of the project. Unless otherwise indicated all references to "Submittals" in the documents are for Construction Submittals. Construction Submittals: Such submittals shall include, but are not limited to, the following:
   1. Contractor's construction schedule.
   2. Submittal schedule.
   3. Daily construction reports.
   4. Shop Drawings.
   5. Product Data.
   6. Samples.
   7. Quality assurance submittals.
   8. Fabrication drawings.
   9. Installation drawings.

10. Setting diagrams.
11. Shopwork manufacturing instructions.
12. Templates and patterns.
13. Schedules.
14. Coordination drawings.
15. Requests for Information (RFI's).

B. Administrative Submittals: Administrative Submittals are defined as submittals which include all information related to administrative documentation for the project. Refer to other Division 1 Sections and other Contract Documents for requirements for administrative submittals. Such submittals shall include, but are not limited to, the following:
   1. Permits.
   2. Applications for Payment.
   3. Performance and payment bonds.
   4. Insurance certificates.
   5. List of subcontractors.

C. Quality Control Submittals: Quality-control submittals are defined as submittals which include all information related to administrative documentation for the project. Such submittals shall include, but are not limited to, the following:

   1. Design data.
   2. Certifications.
   3. Manufacturer's instructions.
   4. Manufacturer's field reports.

D. Coordination Drawings: Coordination Drawings show the relationship and integration of different construction elements that require careful coordination during fabrication or installation to fit in the space provided or to function as intended.

   1. Preparation of Coordination Drawings is specified in Division 1 Section "Coordination" and may include components previously shown in detail on Shop Drawings or Product Data.

E. Samples: Samples include, but are not limited to, the following:
   1. Partial Sections of manufactured or fabricated components.
   2. Small cuts or containers of materials.
   3. Complete units of repetitively used materials.
   4. Swatches showing color, texture, and pattern.
   5. Color range sets.
   6. Components used for independent inspection and testing.
   7. Field samples.
   8. Field mock-ups

F. Product Data: Product data shall include, but are not limited to, the following:

1. Manufacturer's product specifications.
2. Manufacturer's installation instructions.
3. Standard color charts.
4. Catalog cuts.
5. Roughing-in diagrams and templates.
6. Standard wiring diagrams.
7. Printed performance curves.
8. Operational range diagrams.
9. Mill reports.
10. Standard product operating and maintenance manuals.
11. Certified capacity and performance data.

1.4 GENERAL SUBMITTAL PROCEDURES

A. Submissions: UM requires that all construction and administration type submittals be transmitted electronically in "pdf" format for all products, materials, and equipment related to construction and all documentation related to the administration of the project. However UM will accept hard copies (paper copies) of construction and administration type submittals from the Contractor and CM when electronic files cannot be used.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities. Transmit each submittal sufficiently in advance of performance of related construction activities to avoid delay, and in accordance with the project CPM schedule.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.

2. Coordinate transmittal of different types of submittals for related elements of the Work so processing will not be delayed by the need to review submittals concurrently for coordination.

    a. The University reserves the right to withhold action on a submittal requiring coordination with other submittals until all related submittals are received.

3. Scheduling: Division 1 Section "Schedules and Reports" includes the Submittal Schedule listing submittals and indicating time requirements for coordination of submittal activity with related construction operations.

4. Processing: To avoid the need to delay installation as a result of the time required to process submittals, allow sufficient time for submittal review, including time for resubmittals.

a. Allow four (4) weeks for initial review. Allow additional time if the University must delay processing to permit coordination with subsequent submittals.
b. If an intermediate submittal is necessary, process the same as the initial submittal.
c. Allow four (4) weeks for reprocessing each submittal.
d. No extension of Contract Time will be authorized because of failure to transmit submittals to the University sufficiently in advance of the Work to permit processing.
e. The Contractor and CM shall conduct an internal review of every submittal to ensure accuracy and completeness prior to submission to the A/E.

C. Submittal Preparation: The Contractor or CM shall attach the UM Standard Project Submittal Form to the electronic file for each submittal. The contractor or CM shall complete the upper portion of the forms as appropriate.

D. Submittal Transmittal: Include an electronic transmittal with each submittal file for transmittal and handling. Each submittal file shall be transmitted electronically from the Contractor to the CM, then to the A/E. Forward a copy of the electronic transmittal to the UM OFM Project Manager. The A/E and the University will not accept submittals received from sources other than the Contractor or CM.

1. On the transmittal, record relevant project information.
2. Include Contractor's certification that information submitted complies with Contract Document requirements.
3. Transmittal Form: Prepare. Use the UM Standard Submittal Transmittal Form. In the places on the form provide the following information:

a. Project name.
b. Date.
c. Destination (To:).
d. Source (From:).
e. Names of the subcontractor, manufacturer, and supplier.
f. Category and type of submittal.
g. Submittal purpose and description.
h. Submittal and transmittal distribution record.
i. Remarks.
j. Signature of transmitter.

E. Requests for Information (RFI's): Use the UM Standard RFI Form for all Requests for Information. The CM or contractor shall submit each RFI to the A/E and copy the UM OFM Project Manager.

F. Contractor's Construction Schedule: Refer To Division 1 Section CPM Schedules

G. Daily Construction Reports

1. Prepare a daily construction report recording the following information concerning events at the site, and submit duplicate copies to the University at weekly intervals:

    a. List of subcontractors at the site.
    b. Approximate count of personnel at the site.
    c. High and low temperatures, general weather conditions.
    d. Accidents and unusual events.
    e. Meetings and significant decisions.
    f. Stoppages, delays, shortages, and losses.
    g. Meter readings and similar recordings.
    h. Incident reports with emergency procedures followed.
    i. Orders and requests of governing authorities.
    j. Change Orders received, implemented.
    k. Services connected, disconnected.
    l. Equipment or system tests and startups.
    m. Partial Completions, occupancies.
    n. Substantial Completions authorized.

H. Shop Drawings and Coordinated Drawings

1. In addition to the general submittal procedures, the following requirements apply to shop drawings and coordination drawings:

    a. Submit newly prepared information drawn accurately to scale. Indicate deviations from the Contract Documents. The CM or contractor shall not reproduce Contract Documents or copy standard information as the basis of Shop Drawings. Standard information prepared without specific reference to the Project is not a Shop Drawing.

2. Shop Drawings include fabrication and installation drawings, setting diagrams, schedules, patterns, templates and similar drawings. Include the following information:

    a. Dimensions.
    b. Identification of products and materials included by sheet and detail number.
    c. Compliance with specified standards.
    d. Notation of coordination requirements.
    e. Notation of dimensions established by field measurement.

3. Submit Coordination Drawings where required for integration of different construction elements, and in compliance with the requirements of Division 1

Section "Coordination". Show construction sequences and relationships of separate components where necessary to avoid conflicts in utilization of the space available.

4. Sheet Size: Except for templates, patterns, and similar full-size Drawings, submit Shop Drawings on sheets at least 8-1/2 by 11 inches (215 by 280 mm) but no larger than 30 by 40 inches (750 by 1000 mm).

5. Hard Copy Submittals: When hard copy submittals are used submit one (1) reproducible drawing for review by the A/E. The A/E will review and make appropriate comments on the reproducible drawing, sign off the UM forms with action taken, make one (1) print for their record, and forward the reproducible drawing to the University. The University will review and make additional comments as necessary, forward their comments to the A/E for their record and information, make one (1) copy for their use and return the reproducible drawing to the Contractor. For submittals requiring resubmission, the process will be repeated until submittals are considered acceptable by the A/E and the University.

6. Electronic Submittals: When shop drawings are transmitted electronically, submit one (1) electronic file for each shop drawing. Each file shall include all required submittal data and the UM Submittal Form for each submittal. The A/E will review and make appropriate comments on the electronic file, sign off the UM forms with action taken, retain one (1) copy for their record, and forward the electronic file to the University. The University will review and make additional comments as necessary; forward their comments to the A/E for their record and information, retain one (1) copy of the electronic file for their use, and return the electronic file to the CM or Contractor. For submittals requiring resubmission, the process will be repeated until submittals are considered acceptable by the A/E and the University.

7. Shop Drawing shall not be used without an appropriate final stamp indicating the action taken.

I. Product Data

1. In addition to the general submittal procedures, the following requirements apply to product data submittals:

   a. Collect Product Data into a single submittal for each element of construction or system. Product Data shall include printed information, such as manufacturer's general product information, installation instructions, catalog cuts, standard color charts, roughing-in dimensions, diagrams and templates, standard wiring diagrams, and performance data and curves.

   b. Mark each copy to show applicable choices and options. Where printed product data includes information on several products that are either not

required or are optional materials, arrangements or components that require a selection or indicator, mark copies to indicate the applicable information. Include the following information:

1) Manufacturer's printed recommendations.
2) Compliance with trade association standards.
3) Compliance with recognized testing agency standards.
4) Application of testing agency labels and seals.
5) Notation of dimensions verified by field measurement.
6) Notation of coordination requirements.
7) Compliance with contract documents.
8) Specification Section and paragraph.

c. Do not submit Product Data until compliance with requirements of the Contract Documents has been confirmed.

d. Hard Copy Submittals: When hard copy submittals are used submit six (6) copies, plus the number required for the CM and Contractor's use, of each required submittal for review by the A/E. The A/E will review and make appropriate comments on each copy, sign off the UM forms with action taken, retain two (2) copies for their records and forward the remaining submittals to the University. The University will review the submittals, make additional comments as necessary, forward their comments to the A/E for their records, retain one (1) copy of each submittal, and return the remaining submittals to the Contractor. For submittals requiring resubmission, the process will be repeated until submittals are considered acceptable by the A/E and the University.

e. Electronic Submittals: When product data submittals are transmitted electronically, submit one (1) electronic file for each shop submittal. Each file shall include all required submittal data and the UM Submittal Form for each submittal. The A/E shall review and make appropriate comments on the electronic file, sign off the UM forms with action taken, retain one (1) copy for their record and forward the electronic file to the University. The University will review and make additional comments as necessary, sign off the UM forms, retain one (1) copy of the electronic file for their use, forward their comments to the A/E for their record and information, and return the electronic file to the CM or Contractor. For submittal files requiring resubmission, the process will be repeated until submittals are considered acceptable by the A/E and the University.

f. Distribution: Forward one (1) copy of each approved submittal file to installers, subcontractors, suppliers, manufacturers, fabricators, and others required for performance of construction activities. Show distribution on transmittal forms.

g. Do not proceed with installation until a copy of approved Product Data is in the Installer's possession.

h. Do not permit use of unmarked copies of Product Data in connection with construction.

i. The Contractor shall retain three (3) copies of the final submittals for inclusion in the O&M Manuals.

J. Samples

1. In addition to the general submittal procedures, the following requirements apply to samples:

a. Submit full-size, fully fabricated Samples cured and finished as specified and physically identical with the material or product designed and specified. Samples include partial sections of manufactured or fabricated components, cuts or containers of materials, color range sets, and swatches showing color, texture, and pattern.

b. Mount or display Samples in a manner to facilitate review of qualities indicated. Include the following:

1) Specification Section number and reference.
2) Generic description of the Sample.
3) Sample source.
4) Product name or name of the manufacturer.
5) Compliance with recognized standards.
6) Availability and delivery time.
7) Size limitations.
8) Compliance with governing regulations.

c. Submit Samples for review of size, kind, color, pattern, and texture. Submit Samples for a final check of these characteristics with other elements and a comparison of these characteristics between the final submittal and the actual component as delivered and installed.

1) Where variation in color, pattern, texture, or other characteristic is inherent in the material or product represented, submit at least three (3) multiple units that show approximate limits of the variations.
2) Refer to other Specification Sections for requirements for Samples that illustrate workmanship, fabrication techniques, & details of assembly, connections, operation, and similar construction characteristics.

3) Refer to other Sections for Samples to be returned to the Contractor for incorporation in the work. Such Samples must be undamaged at time of use. On the transmittal, indicate special requests regarding disposition of Sample submittals.
4) Samples not incorporated into the work or otherwise designated as the University's property, are the property of the Contractor and shall be removed from the site prior to Substantial Completion.

d. Submittals: Submit three (3) sets. The A/E will retain one (1) set and send two (2) sets marked with the action taken to the University. The University will retain one (1) set and return the other set to the CM or Contractor.

e. Maintain sets of Samples, as returned, at the project Site, for quality comparisons throughout the course of construction.

1) Unless noncompliance with Contract Document provisions is observed, the submittal may serve as the final submittal.
2) Approved sample sets will be used by the A/E and the University to determine final acceptance of the construction associated with each set.

K. Quality Assurance Submittals

1. In addition to the general submittal procedures, the following requirements apply to quality assurance submittals:

a. Submit quality-control submittals, including design data, certifications, manufacturer's instructions, manufacturer's field reports, and other quality-control submittals as required under other Sections of the Specifications.

b. Certifications: Where other Sections of the Specifications require certification that a product, material, or installation complies with specified requirements, submit a notarized certification from the manufacturer certifying compliance with specified requirements.

c. Signature: Certification shall be signed by an officer of the manufacturer or other individual authorized to sign documents on behalf of the company.

d. Inspection and Test Reports: Requirements for submittal of inspection and test reports from independent testing agencies are specified in Division 1 Section "Quality Control."

L. Architect/Engineer’s (A/E) Action

1. The A/E will review each submittal, mark to indicate action taken, and transmit the submittals promptly to the UM OFM Project Manager.

a. Compliance with the contract documents is the Contractor's responsibility.

2. Submittal Action: The A/E will fill in the appropriate boxes on the UM Standard Project Submittal Form attached to each submittal and attach their comments as necessary. The University will fill in the lower portion of the form as necessary on each submittal to indicate the University has reviewed the submittals. The A/E's submittal stamp shall not be used on submittals for UM projects.

M. Construction Manager's (CM) or Contractor Action

1. The CM or Contractor shall be responsible for the collection of all project submittals from the suppliers and subcontractors for distribution to the A/E and the University for review. The CM is responsible for the redistribution of the reviewed submittals back to the subcontractors and suppliers for appropriate action based on the A/E and University review comments.
2. Submittal Action: The UM Standard Project Submittal Form will indicate how the CM or Contractor needs to proceed with each submittal as follows:

a. Action – "No Exceptions Taken": Submittals returned to the CM or Contractor as "No Exceptions Taken" indicates the submitted material and equipment appears to comply with requirements of the Contract Documents and therefore the work related to the submittal can proceed. Final payment depends on that compliance.

b. Action – "Note Markings/Attachments": Submittals returned to the CM or Contractor as "Note Markings/Attachments" indicates the submitted material and equipment will appear to comply with requirements of the Contract Documents provided the noted comments become a part of the submission and therefore the work related to the submittal can proceed. Final payment depends on that compliance.

c. Action – "Amend & Resubmit": Submittals returned to the CM or Contractor as "Amend & Resubmit" indicates some of the submitted material and equipment does not comply with the requirements of the Contract Documents and therefore the work related to the submittal cannot proceed until the re-submittal process confirms that the material and equipment complies with the requirements of the Contract Documents. Final payment depends on that compliance.

d. Action–"Rejected/Resubmit": Submittals returned to the CM or Contractor as "Rejected/Resubmit" indicates that there are significant and fundamental deficiencies indicated in the submitted material and equipment, and does not comply with the requirements of the Contract Documents. Therefore the work related to the submittal cannot proceed until the re-submittal process

confirms that the material and equipment complies with the requirements of the Contract Documents. Final payment depends on that compliance.

3. When the CM or Contractor receives submittals as “Amend & Resubmit” or “Rejected/Resubmit," the CM or Contractor shall not proceed with work covered by these submittals, including purchasing, fabrication, delivery, or other activity. Revise or prepare new submittals according to the notations; resubmit without delay. Repeat as necessary to obtain acceptance from the A/E and UM.

4. Do not use, or allow others to use, submittals marked “Amend & Resubmit" or “Rejected/Resubmit” at the Project Site or elsewhere where work is in progress.

5. Other Action: Where a submittal is for information or record purposes or special processing or other activity, the University will return the submittal marked "Action Not Required."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 UM STANDARD PROJECT SUBMITTAL FORM

A. The electronic file for this form is available at the UM Architecture Engineering and Construction Documents web site.

UMB STANDARD PROJECT SUBMITTAL FORM

UMB PROJECT NAME: _____

UMB PROJECT NUMBER: _____ UM SYSTEM CAMPUS: _____

CONTRACTOR: Submission is in compliance with contract requirements, including dimensions, quantities and all trade coordination. ___Submitted as specified ___Substitution in accordance with ***Insert Spec Section Here*** Date: ___/___/___ By:_____	C M: Submittal No. _____ ***Insert Submittal # above*** ___Submission to the University and AE is in accordance with ***Contract Insert Contract No. Here*** ___ Disapproved Date: ___/___/___ By:_____
PROJECT ARCH: __ No Exceptions Taken __Note Markings/Attachments __Amend & Resubmit __Rejected/Resubmit Review of the submission by the Architect is in accordance with and governed by the Architect Agreement ***Insert Contact # here.*** For explanation of the Architect's review comments, refer to Section ***Insert Spec Section here*** of the Specifications. Date: ___/___/___ By:_____	ASSOCIATED ARCH: __ No Exceptions Taken __Note Markings/Attachments __Amend & Resubmit __Rejected/Resubmit Date: ___/___/___ By:_____
CIVIL ENGINEER: __ No Exceptions Taken __Note Markings/Attachments __Amend & Resubmit __Rejected/Resubmit Date: ___/___/___ By:_____	STRUCTURAL ENGINEER: __ No Exceptions Taken __Note Markings/Attachments __Amend & Resubmit __Rejected/Resubmit Date: ___/___/___ By:_____
MEP ENGINEER: __ No Exceptions Taken __Note Markings/Attachments __Amend & Resubmit __Rejected/Resubmit Date: ___/___/___ By:_____	CONSULTANT __No Exceptions Taken __Note Markings/Attachments __Amend & Resubmit __Rejected/Resubmit Date: ___/___/___ By:_____
OWNER: Date: ___/___/___ Regional Review By:_____ Date: ___/___/___ UMB Review By:_____ Owner Comments: _____ _____ _____ Review by Owner does not relieve the CM and/or AE of their obligations under the above noted contracts respectively.	

3.2 UM STANDARD PROJECT RFI FORM

A. The electronic file for this form is available at the UM Architecture Engineering and Construction Documents web site.

UMB STANDARD REQUEST FOR INFORMATION FORM

REQUEST FOR INFORMATION (RFI) No.:	**Date:**
Subject:	**UMB Project Title:**
Discipline:	**UMB Project No.:**
Specification Reference:	**Importance:**
Drawing Reference:	**Return RFI By:**

Information Requested:

Requested By:	**Date Requested:**

Contractors Proposed Solution:

Submitted By:	**Date Submitted:**

A/E Response:

Reviewed By:	**Date Reviewed:**

UMB Response:

Reviewed By:	**Date Reviewed:**

END OF SECTION 01300

SECTION 01311 - SCHEDULES AND REPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes administrative and procedural requirements for schedules, reports, and critical path method scheduling required for proper performance of the Work, including:

1. Submittal schedule.
2. Schedule of inspections and tests.
3. Daily construction reports.
4. Material location reports.
5. Field correction reports.
6. Special reports.

B. The contractor shall submit a CPM schedule that identifies the overall project construction phasing plan as well as phasing plans for each of the project areas as identified in the document packages A, B, and C sets.

1.3 SUBMITTAL PROCEDURES

A. Coordination: Coordinate preparation and processing of schedules and reports with performance of other construction activities.

1.4 DEFINITIONS

A. Critical Path Method (CPM): A method of planning and scheduling a construction project where activities are arranged based on activity relationships and network calculations determine when activities can be performed and the critical path of the Project.

B. Critical Path: The longest continuous chain of activities through the network schedule that establishes the minimum overall project duration.

C. Network Diagram: A graphic diagram of a network schedule, showing the activities and activity relationships.

D. Activity: A discrete part of a project that can be identified for planning, scheduling, monitoring, and controlling the construction project. Activities included in a construction schedule consume time and resources.

1. Critical activities are activities on the critical path.
2. Predecessor activity is an activity that must be completed before a given activity can be started.

E. Event: An event is the starting or ending point of an activity.

F. Milestone: A key or critical point in time for reference or measurement.

G. Float is the measure of leeway in activity performance. Accumulative float time belongs to the University.

1. Free float is the amount of time an activity can be delayed without adversely affecting the early start of the following activity.
2. Total float is the measure of leeway in starting or completing an activity without adversely affecting the planned project completion date.

1.5 QUALITY ASSURANCE

A. The Contractor's Consultant: Retain a consultant to provide planning, evaluating, and reporting by CPM scheduling.

B. The Consultant shall be a recognized specialist, acceptable to the University, who is an expert in CPM scheduling and reporting.

C. The Consultant shall have computer facilities that are capable of delivering detailed network diagrams within 48 hours of request.

D. In-House Option: The University may waive the requirement to retain a consultant if the Contractor can demonstrate that:

1. The Contractor has the computer equipment required to produce CPM network diagrams.
2. The Contractor employs skilled personnel with experience in CPM scheduling and reporting techniques.

E. Program: Use a computer software program for network analysis that has been developed specifically to manage CPM construction schedules and is acceptable to the University.

F. Standards: Comply with procedures contained in AGC's "Construction Planning & Scheduling."

1.6 RELIMINARY NETWORK DIAGRAM

A. Preliminary Network Diagram: Submit a preliminary network diagram within fourteen (14) days of the Notice to Proceed. The preliminary network diagram shall outline activities for the first sixty (60) days of construction. Include a skeleton diagram for the remainder of the Work with the preliminary diagram.

1. Include each significant construction activity. Coordinate each activity in the network with other activities. Schedule each construction activity in proper sequence.
2. Indicate completion of the Work on the date established for Substantial Completion, unless the University agrees otherwise.

B. Cash Requirement Prediction: With submittal of the preliminary network diagram, include a preliminary cash requirement prediction based on indicated activities.

C. Distribution: Distribute the preliminary network diagram to parties involved in construction activities that are scheduled early, including the University and the University.

1.7 CPM SCHEDULE

A. Prepare the Contractor's Construction Schedule using the network analysis diagram system known as the critical path method (CPM). Follow procedures outlined in AGC's "Construction Planning & Scheduling."

1. Proceed with preparation of the network diagram immediately following Notice to Proceed.
2. Follow the steps necessary to complete development of the network diagram in sufficient time to submit the CPM Schedule so it can be accepted for use no later than sixty (60) days after commencement of the Work.
3. Conduct educational workshops to train and inform key project personnel, including subcontractors' personnel, in proper methods of providing data and using CPM schedule information.
4. Establish procedures for monitoring and updating the CPM Schedule and for reporting progress. Coordinate procedures with progress meeting and payment request dates. Use "one working day" as the unit of time.

B. CPM Schedule Preparation: Prepare a list of all activities involved in the Project. Include a list of activities required to complete the Work. No single activity shall exceed fifteen (15) work days. Provide the best data available for generation of the network diagram and the CPM Schedule.

1. Indicate the estimated time duration, sequence requirements, and relationship of each activity in relation to other activities.
2. Indicate estimated times for the following activities to be performed:
   a. Preparation and processing of submittals.
   b. Purchase of materials.

c. Delivery.
d. Fabrication.
e. Installation.

3. Treat each story or separate area as a separate numbered activity for principal elements of the Work.
4. Using the preliminary network diagram, prepare a skeleton network to identify probable critical paths.

C. Processing: Enter prepared data on the processing system. Process data to produce output data or a computer-drawn, time-scaled network. Revise data, reorganize activity sequences, and reproduce as often as necessary to produce the CPM Schedule within the limitations of Contract Time.

D. Format: Display the full network on a single sheet of stable transparency, or other reproducible media, of sufficient width to show data clearly for the entire construction period.

1. Mark the critical path. Locate the critical path near the center of the network; locate paths with the most float near the edges.
2. Subnetworks on separate sheets are permissible for activities clearly off the critical path.

E. Initial Issue: Prepare the initial issue of the CPM Schedule network diagram from a listing of straight "early start-total float" sort. Identify critical activities. Prepare tabulated reports to show the following:

1. The Contractor or subcontractor and Work or activity.
2. Description of the activity.
3. Principal events of that activity.
4. Immediate preceding and succeeding activities.
5. Early and late start dates.
6. Early and late finish dates.
7. Activity duration in working days (maximum limit is fifteen (15) work days for construction activity).
8. Total float or slack time.
9. Average size of workforce.
10. Dollar value of activity (coordinated with the Schedule of Values).

F. Value Summaries: Prepare two (2) cumulative value listings, sorted by finish dates.

1. In first listing, tabulate the following:
   a. Activity number.
   b. Early finish date.
   c. Dollar value.
   d. Cumulative dollar value.

2. In second listing, tabulate the following:
   a. Activity number.
   b. Late finish date.
   c. Dollar value.
   d. Cumulative value.
3. In subsequent issues of both listings, substitute actual finish dates for activities completed as of listing date.
4. Prepare listing for ease of comparison with payment requests; coordinate timing with progress meetings.
   a. In both value summary listings, tabulate "actual percent complete," and "cumulative value completed" with total at bottom.
   b. Submit value summary printouts following each regularly scheduled progress meeting.

1.8 CPM SUBMITTALS

A. Submittal and Distribution: Submit three (3) copies of the initial issue of the tabulations and network to the University for acceptance. When authorized, distribute copies to the separate contractors, subcontractors and suppliers or fabricators, and others identified by the Contractor with a need-to-know schedule responsibility.

   1. Post copies in the Project meeting rooms and temporary field offices.
   2. When revisions are made, distribute updated schedules to the same parties and post in the same locations. Delete parties from distribution when they have completed their assigned portion of the Work and are no longer involved in performance of construction activities.
   3. Submit copies of each computer-produced report to the University.

B. Schedule Updating: Revise the schedule immediately after each meeting or other activity, where revisions have been recognized or made. Issue the updated schedule at each project meeting and submit with application for payment. Requests for payment will not be made without an updated CPM schedule.

1.9 SUBMITTAL SCHEDULE

A. After development and acceptance of the Contractor's CPM Schedule, prepare a complete schedule of submittals. Submit the schedule within ten (10) days of the date required for submittal of the Contractor's CPM Schedule.

   1. Coordinate Submittal Schedule with the list of subcontracts, Schedule of Values and the list of products as well as the Contractor's Construction Schedule.

B. Prepare the schedule in chronological order. Provide the following information:

   1. Scheduled date for the first submittal.

2. Related Section number.
3. Submittal category.
4. Name of the subcontractor.
5. Description of the part of the Work covered.
6. Latest scheduled date for the University's review/approval.

C. Distribution: Upon final approval of the University, print and distribute copies to the University, University, subcontractors, and other parties required to comply with submittal dates indicated.

1. Post copies in the Project meeting room and temporary field office.
2. When revisions are made, distribute to the same parties and post in the same locations. Delete parties from distribution when they have completed their assigned part of the Work and are no longer involved in construction activities.

D. Schedule Updating: Revise the schedule after each meeting or other activity where revisions have been recognized or made. Issue the updated schedule concurrently with the report of each meeting.

1.10 SCHEDULE OF INSPECTIONS AND TESTS

A. Prepare a schedule of inspections, tests, and similar services required by the Contract Documents. Submit the schedule within thirty (30) days of the date established for commencement of the Work.

B. Form: The schedule shall be in tabular form and shall include, but not be limited to, the following:

1. Specification Section number.
2. Description of the test.
3. Identification of applicable standards.
4. Identification of test methods.
5. Number of tests required.
6. Time schedule or time span for tests.
7. Entity responsible for performing tests.
8. Requirements for taking samples.
9. Unique characteristics of each service.

C. Distribution: Distribute the schedule to the University, and each party involved in performance of portions of the Work where inspections and tests are required.

D. Schedule Updating: Revise the schedule after each meeting or other activity where revisions have been recognized or made. Issue the updated schedule concurrently with the report of each meeting.

1.11 REPORTS

A. Daily Construction Reports: Prepare a daily construction report recording the following information concerning events at the site. Submit duplicate copies to the University at weekly intervals:

1. List of subcontractors at the site.
2. List of separate contractors at the site.
3. Approximate count of personnel at the site.
4. High and low temperatures, general weather conditions.
5. Accidents.
6. Meetings and significant decisions.
7. Unusual events (refer to special reports).
8. Stoppages, delays, shortages, and losses.
9. Meter readings and similar recordings.
10. Emergency procedures.
11. Orders and requests of governing authorities.
12. Change Orders received, implemented.
13. Services connected, disconnected.
14. Equipment or system tests and startups.
15. Partial Completions, occupancies.
16. Substantial Completions authorized.

B. Material Location Reports: At weekly intervals, prepare a comprehensive list of materials delivered to and stored at the site. The list shall be cumulative, showing materials previously reported plus items recently delivered. Include with the list a statement of progress on and delivery dates for materials or items of equipment fabricated or stored away from the site. Submit copies of the list to the University at weekly intervals.

1.12 SPECIAL REPORTS

A. General: Submit special reports directly to the University within one day of an occurrence. Submit a copy to other parties affected by the occurrence.

B. Reporting Unusual Events: When an event of an unusual and significant nature occurs at the site, prepare and submit a special report. List the chain of events, persons participating, response by the Contractor's personnel, an evaluation of the results or effects and similar pertinent information. Advise the University in advance when such events are anticipated or predictable.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 01311

SECTION 01380 - CONSTRUCTION PHOTOGRAPHS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes administrative and procedural requirements for construction photographs for the following types of projects:

1. New construction projects.
2. Campus renovation projects.

1.3 CM REQUIREMENTS

A. The CM shall make arrangements to have a series of construction photographs taken of the construction site utilizing their personnel with a digital camera.

B. The CM shall maintain an up-to-date electronic file of the photographs in numerical order per month in an XL spread sheet format as follows:

1. The XL spread sheet shall include a header with the UM Project Name and Project Number. Under the header include columns for "Photo #", "Date" "Location on Project Site", "View of the Photo" "Description" and "Photograph". For Example:

a. Photo #1
b. 6-5-12
c. Roof Level
d. Looking East
e. Roof Flashing at Stair Tower
f. Photograph

1.4 SUBMITTALS

A. Monthly: Submit construction photographs, electronically, in "pdf" file format to the University Project Manager (PM) monthly with the application for payment.

1. Organize the electronic "pdf" files as indicated in paragraph 1.3 above.
2. Pre-construction photographs shall be submitted with the first application for payment.

1.5 PHOTOGRAPHIC REQUIREMENTS

A. The CM shall take a series of construction photographs to document conditions at the project site and during various stages of construction as follows:

1. Pre-Construction Photographs: Prior to the start of construction take photographs of the project site and adjacent areas as follows:

a. New Projects: Take photographs in sufficient number to show existing conditions adjacent to the work areas before starting work. Where applicable, take photographs of existing buildings either on or adjoining the property in sufficient detail to record accurately the physical conditions at the start of construction.

b. Campus Renovation Projects: Take photographs in sufficient number to show existing conditions adjacent to the work areas, to indicate pre construction damage to existing walls, partitions, insulation, previous work that was not completed, and/or missing materials before starting work.

2. Construction Progress Photographs:

a. Take project photographs, in accordance with requirements indicated, to best show the status of construction and progress since taking previous photographs.

b. Frequency: Take photographs weekly.

c. Vantage Points: Comply with the University's directions concerning desired vantage points for shots.

3. Record Photograph Files:

a. At the end of the project submit a complete set of record photographs, organized in XL spread sheets on a CD-R in a full size jewel case to the University. Label the CD-R and the jewel case with the UM project, UM Project Number, contents on the CD, and the submission date.

4. Post Construction Photographs:

a. After the project has completed if the A/E, the CM, and/or other contractors would like to have a series of post construction photographs taken of the project site they must submit a written request to the University PM. The PM will contact the contact the appropriate University representatives to gain approval and the set up a time for the photographs to be taken. Post

construction photographs will not be allowed without the approval of the end usurer or their representative.

END OF SECTION 01380

SECTION 01400 - QUALITY CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes administrative and procedural requirements for quality-control services.

B. Quality-control services include inspections, tests, and related actions, including reports, performed by Contractor, by independent agencies, and by governing authorities. They do not include contract enforcement activities performed by the University.

C. Inspection and testing services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with Contract Document requirements.

1.3 RESPONSIBILITIES

A. Contractor Responsibilities: Unless otherwise indicated as the responsibility of another identified entity, Contractor shall provide inspections, tests, and other quality-control services specified elsewhere in the Contract Documents and required by authorities having jurisdiction. Costs for these services are included in the Contract Sum.

1. Where individual Sections specifically indicate that certain inspections, tests, and other quality-control services are the Contractor's responsibility, the Contractor may perform testing by its own workforce. Otherwise, and as indicated in individual Sections, the Contractor shall employ and pay a qualified independent testing agency to perform quality-control services. Costs for these services are included in the Contract Sum.
2. Where individual Sections specifically indicate that certain inspections, tests, and other quality-control services are the University's responsibility, the University will employ and pay a qualified independent testing agency to perform those services.

    a. Where the University has engaged a testing agency for testing and inspecting part of the Work, and the Contractor is also required to engage an entity for the same or related element, the Contractor shall not employ the entity engaged by the University, unless agreed to in writing by the University.

B. Retesting: The Contractor is responsible for retesting where results of inspections, tests, or other quality-control services prove unsatisfactory and indicate noncompliance with

Contract Document requirements, regardless of whether the original test was Contractor's responsibility.

1. The cost of retesting construction, revised or replaced by the Contractor, is the Contractor's responsibility where required tests performed on original construction indicated noncompliance with Contract Document requirements.

C. Associated Services: Cooperate with agencies performing required inspections, tests, and similar services, and provide reasonable auxiliary services as requested. Notify the agency sufficiently in advance of operations to permit assignment of personnel. Auxiliary services required include, but are not limited to, the following:

1. Provide access to the Work.
2. Furnish incidental labor and facilities necessary to facilitate inspections and tests.
3. Take adequate quantities of representative samples of materials that require testing or assist the agency in taking samples.
4. Provide facilities for storage and curing of test samples.
5. Deliver samples to testing laboratories.
6. Provide the agency with a preliminary design mix proposed for use for materials mixes that require control by the testing agency.
7. Provide security and protection of samples and test equipment at the Project Site.

D. Duties of the Testing Agency: The independent agency engaged to perform inspections, sampling, and testing of materials and construction specified in individual Sections shall cooperate with the University and the Contractor in performance of the agency's duties. The testing agency shall provide qualified personnel to perform required inspections and tests.

1. The agency shall notify the University and the Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
2. The agency is not authorized to release, revoke, alter, or enlarge requirements of the Contract Documents or approve or accept any portion of the Work.
3. The agency shall not perform any duties of the Contractor.

E. Coordination: Coordinate the sequence of activities to accommodate required services with a minimum of delay. Coordinate activities to avoid the necessity of removing and replacing construction to accommodate inspections and tests.

1. The Contractor is responsible for scheduling times for inspections, tests, taking samples, and similar activities.

1.4 SUBMITTALS

A. Unless the Contractor is responsible for this service, the independent testing agency shall submit a certified written report, in duplicate, of each inspection, test, or similar service to the University. If the Contractor is responsible for the service, submit a certified written report, in duplicate, of each inspection, test, or similar service through the Contractor.

1. Submit additional copies of each written report directly to the governing authority, when the authority so directs.
2. Report Data: Written reports of each inspection, test, or similar service include, but are not limited to, the following:
   a. Date of issue of report.
   b. Project title and number.
   c. Name, address, and telephone number of testing agency.
   d. Dates and locations of samples and tests or inspections.
   e. Names of individuals making the inspection or test.
   f. Designation of the Work and test method.
   g. Identification of product and Specification Section.
   h. Complete inspection or test data.
   i. Test results and an interpretation of test results.
   j. Ambient conditions at the time of sample taking and testing.
   k. Comments or professional opinion on whether inspected or tested Work complies with Contract Document requirements.
   l. Name and signature of laboratory inspector.
   m. Recommendations on retesting.

1.5 QUALITY ASSURANCE

A. Qualifications for Service Agencies: Engage inspection and testing service agencies, including independent testing laboratories, that are prequalified as complying with the American Council of Independent Laboratories' "Recommended Requirements for Independent Laboratory Qualification" and that specialize in the types of inspections and tests to be performed.

   1. Each independent inspection and testing agency engaged on the Project shall be authorized by authorities having jurisdiction to operate in the state where the Project is located.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 REPAIR AND PROTECTION

A. General: Upon completion of inspection, testing, sample taking and similar services, repair damaged construction and restore substrates and finishes. Comply with Contract Document requirements for Division 1 Section "Cutting and Patching."

B. Protect construction exposed by or for quality-control service activities, and protect repaired construction.

C. Repair and protection is Contractor's responsibility, regardless of the assignment of responsibility for inspection, testing, or similar services.

END OF SECTION 01400

SECTION 01500 - CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes requirements for construction facilities and temporary controls, including temporary utilities, support facilities, and security and protection.

Temporary utilities include, but are not limited to, the following:

1. Water service and distribution.
2. Temporary electric power and light.
3. Temporary heat.
4. Ventilation.
5. Telephone service.
6. Sanitary facilities, including drinking water.
7. Storm and sanitary sewer.

Support facilities include, but are not limited to, the following:

1. Field offices and storage sheds.
2. Dewatering facilities and drains.
3. Temporary enclosures.
4. Hoists and temporary elevator use.
5. Temporary project identification signs and bulletin boards.
6. Waste disposal services.
7. Rodent and pest control.
8. Construction aids and miscellaneous services and facilities.

Security and protection facilities include, but are not limited to, the following:

1. Barricades, warning signs, and lights.
2. Sidewalk bridge or enclosure fence for the site.
3. Environmental protection.

1.3 SUBMITTALS

A. Temporary Utilities: Submit reports of tests, inspections, meter readings, and similar procedures performed on temporary utilities.

B. Implementation and Termination Schedule: Within 15 days of the date established for commencement of the Work, submit a schedule indicating implementation and termination of each temporary utility.

1.4 QUALITY ASSURANCE

A. Regulations: Comply with industry standards and applicable laws and regulations of authorities having jurisdiction including, but not limited to, the following:

1. Building code requirements.
2. Health and safety regulations.
3. Utility company regulations.
4. Police, fire department, and rescue squad rules.
5. Environmental protection regulations.

B. Standards: Comply with NFPA 241 "Standard for Safeguarding Construction, Alterations, and Demolition Operations," ANSI A10 Series standards for "Safety Requirements for Construction and Demolition," and NECA Electrical Design Library "Temporary Electrical Facilities."

1. Electrical Service: Comply with NEMA, NECA, and UL standards and regulations for temporary electric service. Install service in compliance with NFPA 70 "National Electric Code."

C. Inspections: Arrange for authorities having jurisdiction to inspect and test each temporary utility before use. Obtain required certifications and permits.

1.5 PROJECT CONDITIONS

A. Temporary Utilities: Prepare a schedule indicating dates for implementation and termination of each temporary utility. At the earliest feasible time, when acceptable to the University, change over from use of temporary service to use of permanent service.

B. Conditions of Use: Keep temporary services and facilities clean and neat in appearance. Operate in a safe and efficient manner. Relocate temporary services and facilities as the Work progresses. Do not overload facilities or permit them to interfere with progress. Take necessary fire-prevention measures. Do not allow hazardous, dangerous, or unsanitary conditions, or public nuisances to develop or persist on-site.

PART 2 - PRODUCTS

2.1 MATERIALS

General: Provide new materials. If acceptable to the University, the Contractor may use undamaged, previously used materials in serviceable condition. Provide materials suitable for use intended.

A. Lumber and Plywood:
   1. For signs and directory boards, provide exterior-type, Grade B-B high-density concrete form overlay plywood of sizes and thicknesses indicated.
   2. For fences and vision barriers, provide minimum 3/8-inch- (9.5-mm-) thick exterior plywood.
   3. For safety barriers, sidewalk bridges, and similar uses, provide minimum 5/8-inch- (16-mm-) thick exterior plywood.

B. Paint:
   1. For sign panels and applying graphics, provide exterior-grade alkyd gloss enamel over exterior primer.

C. Tarpaulins: Provide waterproof, fire-resistant, UL-labeled tarpaulins with flame-spread rating of fifteen (15) or less. For temporary enclosures, provide translucent, nylon-reinforced, laminated polyethylene or polyvinyl chloride, fire-retardant tarpaulins.

D. Water: Provide potable water approved by local health authorities.

E. Open-Mesh Fencing: Provide 0.120-inch- (3-mm-) thick, galvanized 2 inch (50-mm) chain link fabric fencing six (6) feet (2 m) high with galvanized barbed-wire top strand and galvanized steel pipe posts, 1-1/2 inches (38 mm) I.D. for line posts and 2-1/2 inches (64 mm) I.D. for corner posts.

2.2 EQUIPMENT

A. General: Provide new equipment. If acceptable to the University, the Contractor may use undamaged, previously used equipment in serviceable condition. Provide equipment suitable for use intended.

B. Water Hoses: Provide 3/4-inch (19-mm), heavy-duty, abrasion-resistant, flexible rubber hoses one hundred (100) feet (30 m) long, with pressure rating greater than the maximum pressure of the water distribution system. Provide adjustable shutoff nozzles at hose discharge.

C. Electrical Outlets: Provide properly configured, NEMA-polarized outlets to prevent insertion of 110- to 120-Volt plugs into higher voltage outlets. Provide receptacle outlets equipped with ground-fault circuit interrupters, reset button, and pilot light for connection of power tools and equipment.

D. Electrical Power Cords: Provide grounded extension cords. Use hard-service cords where exposed to abrasion and traffic. Provide waterproof connectors to connect separate lengths

of electric cords if single lengths will not reach areas where construction activities are in progress. Do not exceed safe length-voltage ratio.

E. Lamps and Light Fixtures: Provide general service incandescent lamps of wattage required for adequate illumination. Provide guard cages or tempered-glass enclosures where exposed to breakage. Provide exterior fixtures where exposed to moisture.

F. Heating Units: Provide temporary heating units that have been tested and labeled by UL, FM, or another recognized trade association related to the type of fuel being consumed.

G. Temporary Offices: Provide prefabricated or mobile units or similar job-built construction with lockable entrances, operable windows, and serviceable finishes. Provide heated and air-conditioned units on foundations adequate for normal loading.

H. Temporary Toilet Units: Provide self-contained, single-occupant toilet units of the chemical, aerated recirculation, or combustion type. Provide units properly vented and fully enclosed with a glass-fiber-reinforced polyester shell or similar nonabsorbent material.

I. Fire Extinguishers: Provide hand-carried, portable, UL-rated, Class A fire extinguishers for temporary offices and similar spaces. In other locations, provide hand-carried, portable, UL-rated, Class ABC, dry-chemical extinguishers or a combination of extinguishers of NFPA-recommended classes for the exposures.

1. Comply with NFPA 10 and NFPA 241 for classification, extinguishing agent, and size required by location and class of fire exposure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Use qualified personnel for installation of temporary facilities. Locate facilities where they will serve the Project adequately and result in minimum interference with performance of the Work. Relocate and modify facilities as required.

B. Provide each facility ready for use when needed to avoid delay. Maintain and modify as required. Do not remove until facilities are no longer needed or are replaced by authorized use of completed permanent facilities.

3.2 TEMPORARY UTILITY INSTALLATION

A. General: Coordinate with the University Operations and Maintenance Personnel to install temporary service or connect to existing service. Provide all necessary labor, materials and equipment for connections.

1. Coordinate with the University for a time when service can be interrupted, if necessary, to make connections for temporary services.
2. Provide adequate capacity at each stage of construction. Prior to temporary utility availability, provide trucked-in services.
3. Obtain easements to bring temporary utilities to the site where the University's easements cannot be used for that purpose.
4. Use Charges: Cost or use charges for temporary facilities are not chargeable to the University. The University will not accept cost or use charges as a basis of claims for Change Orders.

B. Water Service: Install water service and distribution piping of sizes and pressures adequate for construction until permanent water service is in use.

1. Sterilization: Sterilize temporary water piping prior to use.

C. Temporary Electric Power Service: Provide weatherproof, grounded electric power service and distribution system of sufficient size, capacity, and power characteristics during construction period. Include meters, transformers, overload-protected disconnects, automatic ground-fault interrupters, and main distribution switch gear.

1. Install electric power service underground, except where overhead service must be used.
2. Power Distribution System: Install wiring overhead and rise vertically where least exposed to damage. Where permitted, wiring circuits not exceeding 125 Volts, ac 20 Ampere rating, and lighting circuits may be nonmetallic sheathed cable where overhead and exposed for surveillance.

D. Temporary Lighting: When overhead floor or roof deck has been installed, provide temporary lighting with local switching.

1. Install and operate temporary lighting that will fulfill security and protection requirements without operating the entire system. Provide temporary lighting that will provide adequate illumination for construction operations and traffic conditions.

E. Temporary Heat: Provide temporary heat required by construction activities for curing or drying of completed installations or for protection of installed construction from adverse effects of low temperatures or high humidity. Select safe equipment that will not have a harmful effect on completed installations or elements being installed. Coordinate ventilation requirements to produce the ambient condition required and minimize consumption of energy.

F. Heating Facilities: Except where the University authorizes use of the permanent system, provide vented, self-contained, LP-gas or fuel-oil heaters with individual space thermostatic control.

1. Use of gasoline-burning space heaters, open flame, or salamander heating units is prohibited.

G. Temporary Telephones: Provide temporary telephone service throughout the construction period for all personnel engaged in construction activities. Install telephone on a separate line for each temporary office and first-aid station.

1. Separate Telephone Lines: Provide additional telephone lines for the following:
   a. Where an office has more than two (2) occupants, install a telephone for each additional occupant or pair of occupants.
   b. Provide a dedicated telephone line for a fax machine in the field office.
   c. Provide a separate line for the University's use.
2. At each telephone, post a list of important telephone numbers.

H. Sanitary facilities include temporary toilets, wash facilities, and drinking-water fixtures. Comply with regulations and health codes for the type, number, location, operation, and maintenance of fixtures and facilities. Install where facilities will best serve the Project's needs.

1. Provide toilet tissue, paper towels, paper cups, and similar disposable materials for each facility. Provide covered waste containers for used material.

I. Toilets: Install self-contained toilet units. Shield toilets to ensure privacy. Use of pit-type privies will not be permitted.

1. Provide separate facilities for male and female personnel.

J. Sewers and Drainage: Provide temporary connections to remove effluent that can be discharged lawfully. If drainage facilities cannot be lawfully used for discharge of effluent, provide containers to remove and dispose of effluent off-site in a lawful manner.

1. Filter out excessive amounts of soil, construction debris, chemicals, oils, and similar contaminants that might clog sewers or pollute waterways before discharge.
2. Connect temporary sewers to the municipal system, as directed by Baltimore City sewer department officials.
3. Maintain temporary sewers and drainage facilities in a clean, sanitary condition. Following heavy use, restore normal conditions promptly.

K. Provide earthen embankments and similar barriers in and around excavations and subgrade construction, sufficient to prevent flooding by runoff of storm water from heavy rains.

3.3 SUPPORT FACILITIES INSTALLATION

A. Locate field offices, storage sheds, and other temporary construction and support facilities for easy access.

1. Maintain support facilities until near Substantial Completion. Remove prior to Substantial Completion. Personnel remaining after Substantial Completion will be permitted to use permanent facilities, under conditions acceptable to the University.

B. Field Offices: Provide insulated, weather tight temporary offices of sufficient size to accommodate required office personnel at the Project Site. Keep the office clean and orderly for use for small progress meetings. Furnish and equip offices as follows:

1. Furnish with a desk and chairs, a four (4) drawer file cabinet, plan table, plan rack, and a six (6) shelf bookcase.
2. Equip with a water cooler and include a table and chairs for progress meetings, private toilet complete with water closet, lavatory, and medicine cabinet unit with a mirror.

C. Storage and Fabrication Trailers: Install storage and fabrication trailers sized, furnished, and equipped to accommodate materials and equipment involved, including temporary utility service.

D. Dewatering Facilities and Drains: For temporary drainage and dewatering facilities and operations not directly associated with construction activities included under individual Sections, comply with dewatering requirements of applicable Division 2 Sections. Where feasible, utilize the same facilities. Maintain the site, excavations, and construction free of water.

E. Temporary Enclosures: Provide temporary enclosures for protection of construction, in progress and completed, from exposure, foul weather, other construction operations, and similar activities.

1. Where heat is needed and the permanent building enclosure is not complete, provide temporary enclosures where there is no other provision for containment of heat. Coordinate enclosure with ventilating and material drying or curing requirements to avoid dangerous conditions and effects.
2. Install tarpaulins securely, with incombustible wood framing and other materials. Close openings of twenty five (25) sq. ft. (2.3 sq. m) or less with plywood or similar materials.
3. Close openings through floor or roof decks and horizontal surfaces with load-bearing, wood-framed construction.

F. Project Identification and Temporary Signs: Prepare project identification and other signs of size indicated. Install signs where indicated to inform the public and persons seeking entrance to the Project. Support on posts or framing of preservative-treated wood or steel. Do not permit installation of unauthorized signs.

1. Project Identification Signs: Engage an experienced sign painter to apply graphics. Comply with details indicated.
2. Temporary Signs: Prepare signs to provide directional information to construction personnel and visitors.

G. Temporary Exterior Lighting: Install exterior yard and sign lights so signs are visible when Work is being performed.

H. Collection and Disposal of Waste: Collect waste from construction areas and elsewhere daily. Comply with requirements of NFPA 241 for removal of combustible waste material and debris. Enforce requirements strictly. Do not hold materials more than seven (7) days during normal weather or three (3) days when the temperature is expected to rise above 80^{o}F (27^{o}C). Handle hazardous, dangerous, or unsanitary waste materials separately from other waste by containerizing properly. Dispose of material lawfully.

I. Rodent and Pest Control: Before deep foundation work has been completed, retain a local exterminator or pest control company to recommend practices to minimize attraction and harboring of rodents, roaches, and other pests. Employ this service to perform extermination and control procedures at regular intervals so the Project will be free of pests and their residues at Substantial Completion. Perform control operations lawfully, using environmentally safe materials.

J. Stairs: Until permanent stairs are available, provide temporary stairs where ladders are not adequate. Cover finished, permanent stairs with a protective covering of plywood or similar material so finishes will be undamaged at the time of acceptance.

3.4 SECURITY AND PROTECTION FACILITIES INSTALLATION

A. Except for use of permanent fire protection as soon as available, do not change over from use of temporary security and protection facilities to permanent facilities until Substantial Completion, or longer, as requested by the University.

B. Temporary Fire Protection: Until fire-protection needs are supplied by permanent facilities, install and maintain temporary fire-protection facilities of the types needed to protect against reasonably predictable and controllable fire losses. Comply with NFPA 10 "Standard for Portable Fire Extinguishers" and NFPA 241 "Standard for Safeguarding Construction, Alterations, and Demolition Operations."

1. Locate fire extinguishers where convenient and effective for their intended purpose, but not less than one extinguisher on each floor at or near each usable stairwell. Store combustible materials in containers in fire-safe locations.
2. Maintain unobstructed access to fire extinguishers, fire hydrants, temporary fire-protection facilities, stairways, and other access routes for fighting fires. Smoking is not permitted anywhere on project sites.

3. Provide supervision of welding operations, combustion-type temporary heating units, and similar sources of fire ignition.

C. Permanent Fire Protection: At the earliest feasible date in each area of the Project, complete installation of the permanent fire-protection facility, including connected services, and place into operation and use. Instruct key personnel on use of facilities.

D. Barricades, Warning Signs, and Lights: Comply with standards and code requirements for erection of structurally adequate barricades. Paint with appropriate colors, graphics, and warning signs to inform personnel and the public of the hazard being protected against. Where appropriate and needed, provide lighting, including flashing red or amber lights.

E. Enclosure Fence: Before excavation begins, install an enclosure fence with lockable entrance gates. Locate where indicated, or enclose the entire site or the portion determined sufficient to accommodate construction operations. Install in a manner that will prevent people, dogs, and other animals from easily entering the site, except by the entrance gates.

1. Provide open-mesh, chainlink fencing with posts set in a compacted mixture of gravel and earth.

F. Security Enclosure and Lockup: Install substantial temporary enclosure of partially completed areas of construction. Provide locking entrances to prevent unauthorized entrance, vandalism, theft, and similar violations of security.

1. Storage: Where materials and equipment must be stored, and are of value or attractive for theft, provide a secure lockup. Enforce discipline in connection with the installation and release of material to minimize the opportunity for theft and vandalism.

G. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction in ways and by methods that comply with environmental regulations, and minimize the possibility that air, waterways, and subsoil might be contaminated or polluted or that other undesirable effects might result. Avoid use of tools and equipment that produce harmful noise. Restrict use of noise-making tools and equipment to hours that will minimize complaints from persons or firms near the site.

3.5 OPERATION, TERMINATION, AND REMOVAL

A. Supervision: Enforce strict discipline in use of temporary facilities. Limit availability of temporary facilities to essential and intended uses to minimize waste and abuse.

B. Maintenance: Maintain facilities in good operating condition until removal. Protect from damage by freezing temperatures and similar elements.

1. Maintain operation of temporary enclosures, heating, cooling, humidity control, ventilation, and similar facilities on a twenty four (24) hour basis where required to achieve indicated results and to avoid possibility of damage.
2. Protection: Prevent water-filled piping from freezing. Maintain markers for underground lines. Protect from damage during excavation operations.

C. Termination and Removal: Unless the University requests that it be maintained longer, remove each temporary facility when the need has ended, when replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with the temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.

1. Materials and facilities that constitute temporary facilities are the Contractor's property. The University reserves the right to take possession of project identification signs.
2. At Substantial Completion, clean and renovate permanent facilities used during the construction period including, but not limited to, the following:
   a. Replace air filters and clean inside of ductwork and housings.
   b. Replace significantly worn parts and parts subject to unusual operating conditions.
   c. Replace lamps burned out or noticeably dimmed by hours of use.

END OF SECTION 01500

SECTION 01600 - MATERIALS AND EQUIPMENT, DELIVERY, STORAGE, AND HANDLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes administrative and procedural requirements governing the Contractor's selection of products for use in the Project.

1.3 DEFINITIONS

A. Definitions used in this Article are not intended to change the meaning of other terms used in the Contract Documents, such as "specialties," "systems," "structure," "finishes," "accessories," and similar terms. Such terms are self-explanatory and have well-recognized meanings in the construction industry.

1. "Products" are items purchased for incorporation in the Work, whether purchased for the Project or taken from previously purchased stock. The term "product" includes the terms "material," "equipment," "system," and terms of similar intent.
    a. "Named Products" are items identified by the manufacturer's product name, including make or model number or other designation, shown or listed in the manufacturer's published product literature, that is current as of the date of the Contract Documents.
    b. "Foreign Products," as distinguished from "domestic products," are items substantially manufactured (50 percent or more of value) outside the United States and its possessions. Products produced or supplied by entities substantially owned (more than 50 percent) by persons who are not citizens of, nor living within, the United States and its possessions are also considered to be foreign products.
2. "Materials" are products substantially shaped, cut, worked, mixed, finished, refined or otherwise fabricated, processed, or installed to form a part of the Work.
3. "Equipment" is a product with operational parts, whether motorized or manually operated, that requires service connections, such as wiring or piping.

1.4 SUBMITTALS:

A. All submittals shall comply with the requirements in the “SUBMITTALS” section.

1.5 QUALITY ASSURANCE

A. Source Limitations: To the fullest extent possible, provide products of the same kind from a single source.

1. When specified products are available only from sources that do not, or cannot, produce a quantity adequate to complete project requirements in a timely manner, consult with the University to determine the most important product qualities before proceeding. Qualities may include attributes, such as visual appearance, strength, durability, or compatibility. When a determination has been made, select products from sources producing products that possess these qualities, to the fullest extent possible.

B. Compatibility of Options: When the Contractor is given the option of selecting between 2 or more products for use on the Project, the product selected shall be compatible with products previously selected, even if previously selected products were also options.

C. Foreign Product Limitations: Except under one or more of the following conditions, rovide domestic products, not foreign products, for inclusion in the Work:

1. No available domestic product complies with the Contract Documents.
2. Domestic products that comply with the Contract Documents are available only at prices or terms substantially higher than foreign products that comply with the Contract Documents.

D. Nameplates: Except for required labels and operating data, do not attach or imprint manufacturer's or producer's nameplates or trademarks on exposed surfaces of products that will be exposed to view in occupied spaces or on the exterior.

1. Labels: Locate required product labels and stamps on concealed surfaces or, where required for observation after installation, on accessible surfaces that are not conspicuous.
2. Equipment Nameplates: Provide a permanent nameplate on each item of service-connected or power-operated equipment. Locate on an easily accessible surface that is inconspicuous in occupied spaces. The nameplate shall contain the following information and other essential operating data:
   a. Name of product and manufacturer.
   b. Model and serial number.
   c. Capacity.
   d. Speed.
   e. Ratings.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products according to the manufacturer's recommendations, using means and methods that will prevent damage, deterioration, and loss, including theft.

1. Schedule delivery to minimize long-term storage at the site and to prevent overcrowding of construction spaces.
2. Coordinate delivery with installation time to assure minimum holding time for items that are flammable, hazardous, easily damaged, or sensitive to deterioration, theft, and other losses.
3. Deliver products to the site in an undamaged condition in the manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.
4. Inspect products upon delivery to ensure compliance with the Contract Documents and to ensure that products are undamaged and properly protected.
5. Store products at the site in a manner that will facilitate inspection and measurement of quantity or counting of units.
6. Store heavy materials away from the Project structure in a manner that will not endanger the supporting construction.
7. Store products subject to damage by the elements above ground, under cover in a weather tight enclosure, with ventilation adequate to prevent condensation. Maintain temperature and humidity within range required by manufacturer's instructions.

PART 2 - PRODUCTS

2.1 PRODUCT SELECTION

A. General Product Requirements: Provide products that comply with Contract Documents that are undamaged and new at time of installation.

1. Provide products complete with accessories, trim, finish, safety guards, and other devices and details needed for complete installation and intended use and effect.
2. Standard Products: Where available, provide standard products of types that have been produced and used successfully in similar situations on other projects.
3. Where products are accompanied by the term as selected, University will make selection.
4. Where products are accompanied by the term match sample, sample to be matched is University's.
5. Descriptive, performance, and reference standard requirements in the Specifications establish salient characteristics of products.

A. General Compliance Requirements: Compliance requirements for individual products, as indicated in Contract Documents, are multiple in nature and may include generic descriptions, performance requirements, compliance with reference standards, conformance with graphic details and other similar forms and methods of indicating requirements, all of which must be complied with.

B. Procedures for Selecting Products: Contractor's options for selecting products are limited by Contract Document requirements, and are not controlled by industry traditions or procedures experienced by Contractor on previous construction projects.

C. Products specified by Reference Standards, Codes and Regulations: Select from among products which can be shown to comply to referenced documents.

D. Products specified by Naming Products and Manufacturers: Select from among products listed.

E. Products specified by Naming One Manufacturer's Product as the Basis-of-Design with Reference to Other Manufacturers: Select either the specified Basis-of-Design product or an approved comparable product by one of the other named manufacturers.

1. Comply with provisions in Comparable Products Article to obtain approval for use of a comparable product by one of the named manufacturers.

F. Products specified by Naming One Manufacturer's Product and Indicating Option of Selecting Comparable Products by stating or Approved Equivalent or similar language: Select either the specified product or an approved comparable product.

1. Comply with provisions in Comparable Products Article to obtain approval for use of an unnamed comparable product by another manufacturer.

G. Visual Matching Specification: Where Specifications require matching an established Sample, select a product that complies with requirements and matches University's sample. University's decision will be final on whether proposed product matches satisfactorily.

H. Visual Selection Specification: Where Specifications include the phrase as selected from manufacturer's standard colors, patterns, textures or similar phrase, select a product that complies with other specified requirements. University will select color, pattern, and texture.

1. Standard Range: Where Specifications include the phrase standard range of colors, patterns, textures or similar phrase, University will select color, pattern, or texture from manufacturer's product line that does not include premium items.
2. Full Range: Where Specifications include the phrase full range of colors, patterns, textures or similar phrase, University will select color, pattern, or texture from manufacturer's product line that includes both standard and premium items.

2.2 COMPARABLE PRODUCTS

A. Where Basis-of-Design products are specified by name, submit the following, in addition to other required submittals, to obtain approval of a comparable product by one of the named manufacturers:

1. Evidence that the proposed product does not require extensive revisions to the Contract Documents that it is consistent with the Contract Documents and will

produce the indicated results, and that it is compatible with other portions of the Work.

2. Detailed comparison of significant qualities of proposed product with the Basis-of-Design product in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, serviceability, visual effect, and specific features and requirements indicated.
3. Evidence that proposed product provides specified warranty.
4. List of similar installations for completed projects with project names and addresses and names and addresses of Universities, if requested.
5. Samples, if requested.

PART 3 - EXECUTION

3.1 INSTALLATION OF PRODUCTS

A. Comply with manufacturer's instructions and recommendations for installation of products in the applications indicated. Anchor each product securely in place, accurately located and aligned with other Work.

1. Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.

B. Install products in accordance with the execution’s sections of the Project Manual.

END OF SECTION 01600

SECTION 01631 - SUBSTITUTIONS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes administrative and procedural requirements for handling requests for substitutions made after award of the Contract.

B. Contractor's submittal and University's acceptance of Shop Drawings, Product Data, or Samples not complying with Contract Documents do not constitute an acceptable or valid request for substitution, nor do they constitute approval. Substitutions not properly authorized may be considered defective.

1.3 DEFINITIONS

A. Definitions in this Article do not change or modify the meaning of other terms used in the Contract Documents.

B. Substitutions: Changes in products, materials, equipment, and methods of construction required by the Contract Documents proposed by the Contractor after award of the Contract are considered to be requests for substitutions. The following are not considered to be requests for substitutions:

1. Substitutions requested during the bidding period, and accepted by Addendum prior to award of the Contract, are included in the Contract Documents and are not subject to requirements specified in this Section for substitutions.
2. Revisions to the Contract Documents requested by the University or University.
3. Specified options of products and construction methods included in the Contract Documents.
4. The Contractor's determination of and compliance with governing regulations and orders issued by governing authorities.

1.4 SUBMITTALS

A. Substitution Request Submittal: The University will consider requests for substitution if received within sixty (60) days after issuance of Notice to Proceed. Requests received more than sixty (60) days after issuance of Notice to Proceed may be considered or rejected at the discretion of the University.

1. Submit three (3) copies of each request for substitution for consideration. Submit requests in the form and according to procedures required for change-order proposals.
2. Identify the product or the fabrication or installation method to be replaced in each request. Include related Specification Section and Drawing numbers.
3. Provide complete documentation showing compliance with the requirements for substitutions, and the following information, as appropriate:
    a. Coordination information, including a list of changes or modifications needed to other parts of the Work and to construction performed by the University and separate contractors, that will be necessary to accommodate the proposed substitution.
    b. A detailed comparison of significant qualities of the proposed substitution with those of the Work specified. Significant qualities may include elements, such as performance, weight, size, durability, and visual effect.
    c. Product Data, including Drawings and descriptions of products and fabrication and installation procedures.
    d. Samples, where applicable or requested.
    e. A statement indicating the substitution's effect on the Contractor's CPM Construction Schedule compared to the schedule without approval of the substitution. Indicate the effect of the proposed substitution on overall Contract Time.
    f. Cost information, including a proposal of the net change, if any in the Contract Sum.
    g. The Contractor's certification that the proposed substitution has been fully investigated and determined to be equal or superior in all respects to specified product.
    h. The Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of the failure of the substitution to perform adequately.
    i. Confirmation that the same warranty will be furnished for substitute product as for specified product.

1.5 UNIVERSITY'S ACTION

A. University will review and take appropriate action upon Contractor's request for substitutions.

1. University's action will be taken with reasonable promptness, while allowing sufficient time in University's professional judgement to permit adequate review.
2. University shall be entitled to rely upon adequacy, accuracy, and completeness of data, and certifications prepared by Contractor.
3. If necessary, University will request additional information or documentation for evaluation after initial review of receipt of request for substitution.

PART 2 – PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01631

SECTION 01700 - CONTRACT CLOSEOUT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes administrative and procedural requirements for contract closeout including, but not limited to, the following:

1. Inspection procedures.
2. Project record document submittal, including the following:
3. Marked-up copies of Contract Drawings.
4. Marked-up copies of Shop Drawings.
5. Newly prepared drawings.
6. Marked-up copies of Specifications, addenda, and Change Orders.
7. Marked-up Product Data submittals.
8. Record Samples.
9. Field records for variable and concealed conditions.
10. Record information on Work that is recorded only schematically.
11. Operation and maintenance manual submittal.
12. Preparing and submitting operation and maintenance manuals for building operating systems and equipment.
13. Preparing and submitting instruction manuals covering the care, preservation, and maintenance of University products and finishes.
14. Instruction of the University's operating personnel in the operation and maintenance of building systems and equipment.
15. Submittal of warranties.
16. Final cleaning.

B. Closeout requirements for specific construction activities are included in the appropriate Sections the specifications.

C. Environmental Requirements: Conduct cleaning and waste-disposal operations in compliance with local laws and ordinances. Comply fully with federal and local environmental and antipollution regulations.

1. Do not dispose of volatile wastes, such as mineral spirits, oil, or paint thinner, in storm or sanitary drains.
2. Burning or burying of debris, rubbish, or other waste material on the premises is not permitted.

D. Maintenance of Documents and Samples: Store record documents and Samples in the field office apart from the Contract Documents used for construction. Do not use Project Record Documents for construction purposes. Maintain record documents in good order and in a clean, dry, legible condition. Make documents and Samples available at all times for the University's inspections.

E. Disclaimers and Limitations: Manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the warranty on the Work that incorporates the products. Manufacturer's disclaimers and limitations on product warranties do not relieve suppliers, manufacturers, and subcontractors required to countersign special warranties with the Contractor.

1.3 DEFINITIONS

A. Standard product warranties are preprinted written warranties published by individual manufacturers for particular products and are specifically endorsed by the manufacturer to the University.

B. Special warranties are written warranties required by or incorporated in the Contract Documents, either to extend time limits provided by standard warranties or to provide greater rights for the University.

1.4 WARRANTY REQUIREMENTS

A. Related Damages and Losses: When correcting failed or damaged warranted construction, remove and replace construction that has been damaged as a result of such failure or must be removed and replaced to provide access for correction of warranted construction.

B. Reinstatement of Warranty: When Work covered by a warranty has failed and been corrected by replacement or rebuilding, reinstate the warranty by written endorsement. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.

C. Replacement Cost: Upon determination that Work covered by a warranty has failed, replace or rebuild the Work to an acceptable condition complying with requirements of the Contract Documents. The Contractor is responsible for the cost of replacing or rebuilding defective Work regardless of whether the University has benefited from use of the Work through a portion of its anticipated useful service life.

D. University's Recourse: Expressed warranties made to the University are in addition to implied warranties and shall not limit the duties, obligations, rights, and remedies otherwise available under the law. Expressed warranty periods shall not be interpreted as limitations on the time in which the University can enforce such other duties, obligations, rights, or remedies.

1. Rejection of Warranties: The University reserves the right to reject warranties and to limit selection to products with warranties not in conflict with requirements of the Contract Documents.

E. Where the Contract Documents require a special warranty, or similar commitment on the Work or part of the Work, the University reserves the right to refuse to accept the Work, until the Contractor presents evidence that entities required to countersign such commitments are willing to do so.

1.5 SUBSTANTIAL COMPLETION

A. Preliminary Procedures: Before requesting inspection for certification of Substantial Completion, complete the following. List exceptions in the request.

1. In the Application for Payment that coincides with, or first follows, the date Substantial Completion is claimed, show 100 percent completion for the portion of the Work claimed as substantially complete.
   a. Include supporting documentation for completion as indicated in these Contract Documents and a statement showing an accounting of changes to the Contract Sum.
   b. If 100 percent completion cannot be shown, include a list of incomplete items, the value of incomplete construction, and reasons the Work is not complete.
2. Advise the University of pending insurance changeover requirements.
3. Submit specific warranties, workmanship bonds, maintenance agreements, final certifications, and similar documents.
4. Obtain and submit releases enabling the University unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
5. Submit record drawings, maintenance manuals, final project photographs, damage or settlement surveys, property surveys, and similar final record information.
6. Deliver tools, spare parts, extra stock, and similar items, including inventory list.
7. Make final changeover of permanent locks and transmit keys to the University. Advise the University's personnel of changeover in security provisions.
8. Complete startup testing of systems and instruction of the University's operation and maintenance personnel. Discontinue and remove temporary facilities from the site, along with mockups, construction tools, and similar elements.
9. Complete final cleanup requirements, including touchup painting.
10. Touch up and otherwise repair and restore marred, exposed finishes.

B. Inspection Procedures: On receipt of a request for inspection, the University will either proceed with inspection or advise the Contractor of unfilled requirements. The University will prepare the Certificate of Substantial Completion following inspection or advise the Contractor of construction that must be completed or corrected before the certificate will be issued.

1. The University will repeat inspection when requested and assured that the Work is substantially complete.

2. Results of the completed inspection will form the basis of requirements for final acceptance.

1.6 FINAL ACCEPTANCE

A. Preliminary Procedures: Before requesting final inspection for certification of final acceptance and final payment, complete the following. List exceptions in the request.

1. Submit the final payment request with releases and supporting documentation not previously submitted and accepted. Include insurance certificates for products and completed operations where required.
2. Submit an updated final statement, accounting for final additional changes to the Contract Sum.
3. Submit a certified copy of the University's final punch list of items to be completed or corrected, endorsed and dated by the University. The certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance and will be endorsed and dated by the University.
4. Submit final meter readings for utilities, a measured record of stored fuel, and similar data as of the date of Substantial Completion or when the University took possession of and assumed responsibility for corresponding elements of the Work.
5. Submit consent of surety to final payment.
6. Submit a final liquidated damages settlement statement.
7. Submit evidence of final, continuing insurance coverage complying with insurance requirements.

B. Reinspection Procedure: The University will reinspect the Work upon receipt of notice that the Work, including inspection list items from earlier inspections, has been completed, except for items whose completion is delayed under circumstances acceptable to the University.

1. Upon completion of reinspection, the University will prepare a certificate of final acceptance. If the Work is incomplete, the University will advise the Contractor of Work that is incomplete or of obligations that have not been fulfilled but are required for final acceptance.

2. If necessary, reinspection will be repeated.

1.7 QUALITY ASSURANCE

A. Maintenance Manual Preparation: In preparation of maintenance manuals, use personnel thoroughly trained and experienced in operation and maintenance of equipment or system involved.

1. Where maintenance manuals require written instructions, use personnel skilled in technical writing where necessary for communication of essential data.
2. Where maintenance manuals require drawings or diagrams, use draftsmen capable of preparing drawings clearly in an understandable format.

B. Instructions for the University's Personnel: Use experienced instructors thoroughly trained and experienced in operation and maintenance of equipment or system involved to instruct the University's operation and maintenance personnel.

1.8 RECORD DOCUMENT SUBMITTALS

A. General: Do not use record documents for construction purposes. Protect record documents from deterioration and loss in a secure, fire-resistant location. Provide access to record documents for the University's reference during normal working hours.

B. Record Drawings (As-Builts):

1. Markup Procedure: During construction, maintain a set of blue- or black-line white prints of Contract Drawings and Shop Drawings for Project Record Document (As-Built) purposes.
   a. Mark these Drawings to show the actual installation where the installation varies from the installation shown originally. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later. Items required to be marked include, but are not limited to, the following:
      1) Dimensional changes to the Drawings.
      2) Revisions to details shown on the Drawings.
      3) Depths of foundations below the first floor.
      4) Locations and depths of underground utilities.
      5) Revisions to routing of piping and conduits.
      6) Revisions to electrical circuitry.
      7) Actual equipment locations.
      8) Duct size and routing.
      9) Locations of concealed internal utilities.
      10) Changes made by change order.
      11) Changes made following the University's written orders.
      12) Details not on original Contract Drawings.
   b. Mark record prints of Contract Drawings or Shop Drawings, whichever is most capable of showing actual physical conditions, completely and

accurately. Where Shop Drawings are marked, show cross-reference on Contract Drawings location.

c. Mark record sets with red erasable colored pencil. Use other colors to distinguish between changes for different categories of the Work at the same location.

d. Mark important additional information that was either shown schematically or omitted from original Drawings.

e. Note change-order numbers, and similar identification.

2. Responsibility for Markup: The individual or entity who obtained record data, whether the individual or entity is the Installer, subcontractor, or similar entity, shall prepare the markup on record drawings.

a. Accurately record information in an understandable drawing technique.

b. Record data as soon as possible after obtaining it. Record and check the markup prior to enclosing concealed installations.

c. At time of Substantial Completion, submit record drawings to the University for the University's records. Organize into sets and bind and label sets for the University's continued use.

C. Record Specifications

1. During the construction period, maintain one copy of the Project Specifications, including addenda and modifications issued, for Project Record Document purposes.

a. Mark the Specifications to indicate the actual installation where the installation varies from that indicated in Specifications and modifications issued. Note related project record drawing information, where applicable. Give particular attention to substitutions, selection of product options, and information on concealed installations that would be difficult to identify or measure and record later.

1) In each Specification Section where products, materials, or units of equipment are specified or scheduled, mark the copy with the proprietary name and model number of the product furnished.

2) Record the name of the manufacturer, supplier, installer, and other information necessary to provide a record of selections made and to document coordination with record Product Data submittals and maintenance manuals.

3) Note related record Product Data, where applicable. For each principal product specified, indicate whether record Product Data has been submitted in maintenance manual instead of submitted as record Product Data.

b. Upon completion of markup, submit record Specifications to the University.

D. Record Product Data: Maintain one copy of each Product Data submittal. Note related Change Orders and markup of record drawings and Specifications.

1. Mark these documents to show significant variations in actual Work performed in comparison with information submitted. Include variations in products delivered to the site and from the manufacturer's installation instructions and recommendations.

2. Give particular attention to concealed products and portions of the Work that cannot otherwise be readily discerned later by direct observation.
3. Upon completion of markup, submit three complete sets of record Product Data to the University for the University's records.

E. Record Sample Submitted: Immediately prior to Substantial Completion, the Contractor shall meet with the University and the University's personnel at the Project Site to determine which Samples are to be transmitted to the University for record purposes. Comply with the University's instructions regarding delivery to the University's Sample storage area. Dispose of other samples in a manner specified for disposing surplus and waste materials.

F. Miscellaneous Record Submittals:

1. Refer to other Specification Sections for miscellaneous record-keeping requirements and submittals in connection with various construction activities. Immediately prior to Substantial Completion, complete miscellaneous records and place in good order, properly identified and bound or filed, ready for use and reference. Submit to the University for the University's records.
    a. Categories of requirements resulting in miscellaneous records include, but are not limited to, the following:
        1) Field records on excavations and foundations.
        2) Field records on underground construction and similar work.
        3) Survey showing locations and elevations of underground lines.
        4) Invert elevations of drainage piping.
        5) Surveys establishing building lines and levels.
        6) Records of plant treatment.
        7) Ambient and substrate condition tests.
        8) Certifications received in lieu of labels on bulk products.
        9) Batch mixing and bulk delivery records.
        10) Testing and qualification of tradesmen.
        11) Documented qualification of installation firms.
        12) Load and performance testing.
        13) Inspections and certifications by governing authorities.
        14) Leakage and water-penetration tests.
        15) Fire-resistance and flame-spread test results.
        16) Final inspection and correction procedures.
        17) Pipe leakage test reports.
        18) Duct leakage test reports.
        19) Air and water balance reports.

G. Operation and Maintenance Manuals:

1. General Submission Requirements: The University of Maryland (UM) requires operation and maintenance manuals (O&MM) to be submitted in electronic "pdf" file format, by the CM, before substantial completion to the A/E and the University for review.

2. Product Data: All product data and shop drawing "pdf" files submitted during the shop drawing review phase must be complete per the requirements of the bid documents. These files can be either scanned as a "pdf" file or the files can be converted to "pdf" format provided the "pdf" files are clear and readable when either viewed on a computer monitor or printed on 8.5 x 11 or 11 x 17 paper. UM has examples of prints from electronic submittal files that are either acceptable or unacceptable and are available upon request. Contact the University project manager for file examples, if necessary.

3. General File Description: The following description outlines the organization of one (1) electronic O&MM file for each discipline such as, Architectural, Structural, Civil, Mechanical, and Electrical including the minimum documentation that shall be included in each O&MM file for each discipline. Each File shall be arranged as a stack file with bookmarks and a tree structure.

4. Arrangement: Arrange each O&MM file in a similar manner as a hard bound copy would be set up and submitted. For each discipline O&MM file include:

    a. Cover: Include the University Project Title, University Project Number, and Date.

    b. Table of Contents: Numeric List of each page with page 1 being the Cover Sheet, then each product submittal and shop drawing.

    c. Subcontractor List: List each subcontractor by company name, address, contact name and phone number for each approved product data submittal and/or approved shop drawing included in the file.

    d. Supplier List: List each manufacturer's company name, address, contact name and phone number for each approved product data submittal and/or approved shop drawing included in the file.

    e. Contractor Warranty Statement: Warranty statement in letter for the project warranty on the letter head of the mechanical contractor.

    f. Maintenance Chart: Include a maintenance chart for each piece of equipment or type of material that requires periodic maintenance. List the equipment and parts requiring the maintenance and the time interval.

g. Warranty and Instruction Information: Include any warranty information and/or manufacturers operating and maintenance instructions including replacement part's list with each product. Each product data submittal, shop drawing, warranty data, instructions shall be an individual "pdf" file for said data. Include Approved submittal data only.

5. General File Structure Example: Each discipline file structure shall be arranged using the structure example as follows:

   a. Table of Contents: Include the following:
      1) Cover Sheet
      2) Subcontractors List
      3) Suppliers List
      4) Contractor Warranty
      5) Maintenance Charts
      6) Discipline Specific Main Folders and Subfolders Content

6. Discipline O&MM Files: Each discipline O&MM files shall be arranged as follows:
   a. Architectural O&MM file include:
      1) Exterior: Include all submittals related to the Exterior.
      2) Interior: Include all submittals related to the Interior.
      3) Furnishings: Include all submittals related to the Furnishings.
      4) Equipment: Include all submittals related to the Equipment.
      5) Signage: Include all submittals related to the Signage.

   b. Structural O&MM file includes:
      1) Include all submittals related to Structural

   c. Civil O&MM file includes:
      1) Include all submittals related to Civil

   d. Mechanical O&MM file includes:
      1) Plumbing: Include all submittals related to Plumbing.
      2) HVAC: Include all submittals related to HVAC.
      3) Fire Protection: Include all submittals related to Fire Protection plus the complete fire protection drawings in "dwg" file format on a CD.

   e. Electrical O&MM file includes:
      1) Lighting: Include all submittals related to Lighting
      2) Power: Include all submittals related to Power

3) Fire Alarm: Include all submittals related to the Fire Alarm System plus the complete fire alarm drawings in "dwg" file format on a
4) Security: Include all submittals related to Security plus the complete security drawings in "dwg" file format on a CD.
5) Telecomm: Include all submittals related to telecomm plus the complete telecomm drawings in "dwg" file format on a CD.
6) Audio/visual: Include all submittals related to A/V plus the complete A/V drawings in "dwg" file format on a CD.

7. Discipline System File Name and "pdf" Tree Structure: Each Discipline System fie name and "pdf" tree structure including main folders and sub folders shall be arranged as follows:
   a. File Name: Architectural O&MM
      1) "PDF" Tree Structure – Main Folders
      a) Π Cover Sheet
      b) Π Table of Contents
      c) Π Subcontractor List
      d) Π Suppliers List
      e) Π Contractor Warranty
      f) Π Maintenance Charts
      g) Π Exterior
      h) Π Interior
      i) Π Furnishings
      j) Π Equipment
      k) Π Signage

   b. "PDF" Tree Structure – Main Topic - Sub Folders Example
      a) Π Furnishings
         (1) Π Laboratory Case Work
            (a) Π Approved Product Submittal File Product Data
            (b) Π Case Work Drawings
            (c) Π Manufacturers Warranty
            (d) Π Repeat Above sub folders for each approved product submittal

   c. File Name: Mechanical O&MM
      1) "PDF" Tree Structure – Main Folders
         a) Π Cover Sheet
         b) Π Table of Contents
         c) Π Subcontractor List
         d) Π Suppliers List
         e) Π Contractor Warranty

f) Π Maintenance Charts
g) Π Plumbing
h) Π HVAC
i) Π Fire Protection

2) "PDF" Tree Structure – Main Topic - Sub Folders Example
a) Π Plumbing
(1) Π Domestic Water Booster Pump
(a) Π Approved Product Submittal File
(b) Π Manufacturers Maintenance Data
(c) Π Manufacturers Warranty
b) Π Repeat Above sub folders for each approved product submittal

d. File Name: Electrical O&MM
1) "PDF" Tree Structure – Main Folders
a) Π Cover Sheet
b) Π Table of Contents
c) Π Subcontractor List
d) Π Suppliers List
e) Π Contractor Warranty
f) Π Maintenance Charts
g) Π Lighting
h) Π Power
i) Π Security
j) Π Fire Alarm
k) Π Telecomm
l) Π Audio Visual

2) "PDF" Tree Structure – Main Topic - Sub Folders Example
a) Π Lighting
(1) Π 2x4 Light Fixtures
(2) Π Approved Product Submittal File Product Data
(3) Π Manufacturers Maintenance Data
(4) Π Manufacturers Warranty
b) Π Repeat Above sub folders for each approved product submittal

1.9 INSTRUCTIONS FOR THE UNIVERSITY'S PERSONNEL

A. Prior to final inspection, instruct the University's personnel in operation, adjustment, and maintenance of products, equipment, and systems. Provide instruction at mutually agreed upon times.

1. For equipment that requires seasonal operation, provide similar instruction during other seasons.
2. Use operation and maintenance manuals for each piece of equipment or system as the basis of instruction. Review contents in detail to explain all aspects of operation and maintenance.

2.1 MATERIALS

A. Cleaning Agents: Use cleaning materials and agents recommended by the manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.

PART 2 - EXECUTION

3.1 CLOSEOUT PROCEDURES

A. Operation and Maintenance Instructions: Arrange for each Installer of equipment that requires regular maintenance to meet with the University's personnel to provide instruction in proper operation and maintenance. Provide instruction by manufacturer's representatives if installers are not experienced in operation and maintenance procedures. Include a detailed review of the following items:
   1. Maintenance manuals.
   2. Record documents.
   3. Spare parts and materials.
   4. Tools.
   5. Lubricants.
   6. Fuels.
   7. Identification systems.
   8. Control sequences.
   9. Hazards.
   10. Cleaning.
   11. Warranties and bonds.
   12. Maintenance agreements and similar continuing commitments.

B. As part of instruction for operating equipment, demonstrate the following procedures:
   1. Startup.
   2. Shutdown.
   3. Emergency operations.
   4. Noise and vibration adjustments.
   5. Safety procedures.
   6. Economy and efficiency adjustments.
   7. Effective energy utilization.

3.2 FINAL CLEANING

A. General: The General Conditions require general cleaning during construction. Regular site cleaning is included in Division 1 Section "Construction Facilities and Temporary Controls."
B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to the condition expected in a normal, commercial building cleaning and maintenance program. Comply with manufacturer's instructions.

1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion.
    a. Clean the Project Site, yard and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and foreign substances.
    b. Sweep paved areas broom clean. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
    c. Remove petrochemical spills, stains, and other foreign deposits.
    d. Remove tools, construction equipment, machinery, and surplus material from the site.
    e. Remove snow and ice to provide safe access to the building.
    f. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
    g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
    h. Broom clean concrete floors in unoccupied spaces.
    i. Vacuum clean carpet and similar soft surfaces, removing debris and excess nap. Shampoo, if required.
    j. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other substances that are noticeable vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials. Polish mirrors and glass, taking care not to scratch surfaces.
    k. Remove labels that are not permanent labels.
    l. Touch up and otherwise repair and restore marred, exposed finishes and surfaces. Replace finishes and surfaces that cannot be satisfactorily repaired or restored or that already show evidence of repair or restoration.
        1) Do not paint over "UL" and similar labels, including mechanical and electrical nameplates.
    m. Wipe surfaces of mechanical and electrical equipment, elevator equipment, and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
    n. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
    o. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.

p. Clean ducts, blowers, and coils if units were operated without filters during construction.
q. Clean food-service equipment to a sanitary condition, ready and acceptable for its intended use.
r. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency. Replace burned-out bulbs and defective and noisy starters in fluorescent and mercury vapor fixtures.
s. Leave the Project clean and ready for occupancy.

C. Removal of Protection: Remove temporary protection and facilities installed for protection of the Work during construction.

D. Compliance: Comply with regulations of authorities having jurisdiction and safety standards for cleaning. Do not burn waste materials. Do not bury debris or excess materials on the University's property. Do not discharge volatile, harmful, or dangerous materials into drainage systems. Remove waste materials from the site and dispose of lawfully.

1. Where extra materials of value remain after completion of associated Work, they become the University's property. Dispose of these materials as directed by the University.

END OF SECTION 01700

SECTION 019113 – GENERAL COMMISSIONING REQUIREMENTS
PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the administrative requirements related to commissioning and includes the following:

1. Definitions
2. Coordination
3. Quality control
4. Submittals
5. Design review and documentation
6. Test equipment
7. Commissioning process
8. Commissioning scope meetings
9. Commissioning plans
10. Submittal review
11. Commissioning controls coordination meeting
12. Startup/Pre functional check lists
13. Functional performance testing
14. Issue log
15. Operations and maintenance training
16. Final commissioning report
17. Deferred seasonal testing
18. Team responsibilities

B. The Owner, Architect/Engineer, and Commissioning Agent are not responsible for construction means, methods, job safety, or management function related to commissioning on the job site.

1. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

2. The mention of a subcontractor is not meant to usurp the Contractor's responsibility to assign the work.

C. Related Sections:

1. 014000 Quality Requirements
2. 017700 Closeout Procedures
3. 017900 Demonstration and Training
4. 260000 General Requirements Electrical Systems
5. 260800 Commissioning Electrical System

1.2 DEFINITONS

A. Basis of Design (BOD): The Basis of Design document is a specific Commissioning document that describes the systems, components, conditions and methods chosen by the design engineer to meet the requirements of the project. Some reiteration of the Owner's Project Requirements may be included.

B. Commissioning (Cx): Commissioning is a comprehensive and systematic process to verify that the building systems perform as designed to meet the Owner's requirements. Commissioning during the construction, acceptance and warranty phases is intended to achieve the following specific objectives:

1. Verify and document that the equipment is installed and started per manufacturer's recommendations, industry accepted minimum standards, and the Contract Documents.

2. Verify and document that the equipment and systems receive complete operational checkout by installing contractors.

3. Verify and document equipment and system performance.

4. Verify the completeness of the Operations and Maintenance materials.

5. Ensure that the Owner's operating personnel are adequately trained on the operation and maintenance of building equipment.

6. The commissioning process does not take away from or reduce the responsibility of the systems designers or installing contractors to provide a finished and fully functioning product.

C. Commissioning Agent (CxA): The commissioning agent develops the functional test procedures in a sequential written form, coordinates, oversees, and documents the actual testing, which is usually performed by the installing contractor or vendor. Functional Performance Tests are performed after pre-functional checklists and startup is complete.

D. Commissioning Plan: The commissioning plan is an overall plan that provides the structure, schedule, and coordination planning for the commissioning process.

E. Deficiency: A deficiency is a condition in the installation or function of a component, piece of equipment, or system that is not in compliance with the Contract Documents, does not perform properly, or is not complying with the Owner's Project Requirements.

F. Owner's Project Requirements (OPR): The OPR is a specific Commissioning document that is updated throughout the project that provides the explanation of the ideas, concepts,

and criteria that are considered to be very important to the Owner. It is initially the outcome of the programming and conceptual design process.

G. Functional Performance Test (FPT): The FPT is a test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g. the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failure, unoccupied, varying outside air temperatures, fire alarm power failure, and any other operational sequence included in the system design. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not functional testing, in the commissioning sense of the word. TAB's primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The CxA develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is usually performed by the installing contractor or vendor. Functional Performance Tests are performed after prefunctional checklists and startup is complete.

H. Prefunctional Checklist: The pre-functional check list is a list of items to inspect and elementary component test to conduct to verify proper installation of equipment, provided by the CxA to the contractor. Prefunctional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g. belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated). However, some prefunctional checklist items entail system testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three-phase pump motor of a chiller system). The word "prefunctional" refers to before functional testing. Prefunctional checklists augment and are combined with the manufacturer's start-up checklist.

I. Warranty Period: The warranty period is for the entire project, including equipment components. Warranty begins at Substantial Completion and extends for two years, unless specifically noted otherwise in the Contract Documents and accepted submittals.

J. Abbreviations: The following are common abbreviations used in the Commissioning Specification:

1. A/E - Architect and Engineers
2. CxA - Commissioning Agent
3. CC - Controls Contractor
4. Cx Plan - Commissioning Plan document
5. FPT - Functional Performance Test

6. GC - General Contractor
7. MEP – Mechanical, Electrical, Plumbing
8. PM - Project Manager (University)
9. Subs - Subcontractors to the General Contractor
10. TAB - Test and Balance Contractor

1.3 COORDINATION

A. The owner will hire a third-party Commissioning Agent (CxA). The contractor and the contractor's team shall be responsible for assisting the CxA in commissioning activities.

B. Commissioning Agent (CxA) shall provide overall coordination and management of the commissioning program as specified herein.

C. Commissioning Team: The commissioning process will require the cooperation of the Contractor, subcontractors, vendors, Architect/Engineer, Commissioning Agent, and Owner. The commissioning team shall be comprised of the following. Team member responsibilities are listed in Part 3 of this section.

1. Commissioning Agent:

    a. Project Manager
    b. Project Technicians

2. Contractor and Sub-contractors as required.

3. Owner Representative(s)

4. Architect/Engineer:

    a. Architect
    b. MEP Engineers
    c. Specialty Consultant(s)

D. Progress Meetings: Attend construction job-site meetings, as necessary, to monitor construction and commissioning progress. Coordinate with contractor to address coordination, deficiency resolution, and planning issues.

1. Plan and coordinate additional meetings as needed based on work progress.

E. Site Observations: Perform site visits as necessary to observe component and system installations.

F. Functional Testing Coordination:

1. Equipment shall not be "temporarily" started for commissioning.
2. Functional performance testing shall not begin until pre-functional check, start-up, and TAB are completed for a given system.
3. The controls system and equipment controls shall not be functionally tested until all points have been calibrated and pre-functional checklists are complete.

1.4 QUALITY CONTROL

A. Engage commissioning service personnel that specialize in the types of inspections and tests to be performed.

B. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems of the systems to be commissioned.

1.5 SUBMITTALS

A. Cx Meeting Minutes:

1. CxA shall be responsible for preparing meeting minutes and provide to Owner's PM for distribution.

B. Commissioning Plan:

1. Contractor shall be responsible for reviewing the Commissioning plan, provided by the CxA, and incorporating into project schedule.

C. Pre-Functional Checklists:

1. Contractor shall be responsible for completing pre-functional checklists (prepared by CxA). The contractor shall allow five days for review of completed PFC's before FPT's are scheduled to begin.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The contractor will make available standard testing equipment required to perform startup, initial checkout and functional performance testing as well as any special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents.

B. Data Logging equipment and software required to test equipment shall be provided by the Contractor, but shall not become property of the Owner.

C. Instrumentation shall meet the following standards:

1. Be of sufficient quality and accuracy to test and measure system performance within the tolerances required to determine adequate performance.
2. Be calibrated on the manufacturer's recommended intervals with calibration tags permanently affixed to the instrument being used.
3. Be maintained and in good repair and operational condition throughout the duration of use on this project.

D. Test Equipment Calibration Requirements: Contractors shall comply with test equipment manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired after being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

PART 3 - EXECUTION

3.1 COMMISSIONING PROCESS

A. The following activities outline the commissioning tasks and the general order in which they occur. The CxA shall coordinate all activities.

1. Design Review and Documentation:
    a. Basis of Design and Owner's Project Requirements Review
    b. Design Document Review
    c. Controls Coordination Review Meeting
    d. Construction Document Review
2. Commissioning Scoping Meetings
3. Commissioning Plan
4. Submittal Review:
    a. General systems to be Commissioned
    b. Controls Submittal Review
5. Commissioning Controls Coordination Meeting
6. Start-Up / Pre-functional Checklists
7. Functional Performance Testing
8. Issues Log
9. Operations and Maintenance Training
10. Final Commissioning Report
11. Deferred and Seasonal Testing

3.2 COMMISSIONING SCOPE MEETINGS

A. Commissioning Scope Meeting – Design Phase:

1. Attend a scope meeting during the design phase prior to the first design review.
2. Cx Team members who have been hired during the design phase shall be in attendance.

3. Review the Cx process with special attention on the design phase requirements.

B. Commissioning Scope Meeting – Construction Phase:

1. Attend a scoping meeting at the start of construction after the subcontractors have been selected.
2. All Cx Team members shall be in attendance.
3. Review the Cx process with special attention on the construction phase requirements.

3.3 COMMISSIONING CONTROLS COORDINATION MEETING

A. Meeting Attendees:

1. CxA
2. Controls Contractor
3. Engineer of Record
4. Owner's Representatives
5. Contractor
6. Architect

B. After the first controls submittal review is complete, schedule, coordinate and facilitate the Commissioning Controls Coordination Meeting.

C. Review all submittal review comments with the group and, as a group, determine the required resolution for each comment. Controls resubmittal shall be submitted within two (2) weeks of this meeting.

3.4 START-UP / PRE-FUNCTIONAL CHECKLISTS

A. Start-up/Pre-Functional Checklists: Coordinate start-up plans and documentation formats, including providing contractor with pre-functional checklists to be completed during the start-up process.

1. Manufacturer's start-up checklists and other technical documentation guidelines may be used as the basis for pre-functional checklists. CxA will coordinate with the Contractor to obtain manufacturer data as needed.

B. Start-up/Pre-Functional Checklists are used to verify that the systems are complete and operational before functional testing is scheduled.

3.5 FUNCTIONAL PERFORMANCE TESTING

A. Functional Performance Tests (FPT): Test procedures shall fully describe system configuration and steps required for each test; appropriately documented so that the test can be repeated with virtually identical results.

1. Test Methods: Functional performance testing and verification may be achieved using a combination of the following methods to test the complete sequence of operation. The CxA shall determine which method, or combination, is most appropriate:

    a. Direct manipulation of system inputs (i.e. applying heat or cold to sensors).
    b. Manipulation of system inputs with the building automation software (i.e. software override of sensor inputs)
    c. Direct observation of equipment readouts, gauges, and actuators.
    d. Trend logs of system inputs and outputs using the building automation system
    e. Short-term monitoring of system inputs and outputs using stand alone data loggers.

2. Setup: Setup each test procedure to be performed under conditions that simulate normal operating conditions as closely as possible. Where equipment requires integral safety devices to stop/prevent equipment operation unless minimum safety standards or conditions are met, functional performance test procedures shall demonstrate the actual performance of safety shutoffs in a real or closely-simulated condition of failure.

3. Sampling: Multiple identical pieces of non-life-safety or non-critical equipment may be functionally tested using a sampling strategy. The sampling strategy shall be developed by the CxA. If, after three attempts at testing the specified sample percentage, failures are still present, then all remaining units shall be tested at the contractor's expense. Sampling may only be used as agreed upon in the Cx contract.

4. Trending: Identify conditions where trend data from the building automation system or data loggers can be used to verify sequence of operation performance. Include trend log requirements in FPT documentation.

B. Assist CxA in completing FPT's as directed by the CxA.

3.6 ISSUES LOG

A. Issues are items of non-compliance in materials, installation, or operation observed by the CxA.

B. The CxA shall notify responsible parties upon observation of deficiencies or issues of non-compliance. CxA shall recommend corrective actions as appropriate. Issues that are not immediately resolved shall be placed on the Issues Log.

C. The CxA shall update the Issues Log and submit it to the PM for distribution to all members of the Cx Team when changes are made.

D. Those identified as "Responsible" for a specific issue shall respond within three (3) days of receiving an updated Issues Log with the planned resolution.

1. "Responsible" indicates the party who is responsible for responding to the open issue, it does not imply responsibility for creating the issue. For example, if the issue relates to a temperature set-point, the Owner may be listed as the responsible party for providing the desired value.

2. Any member of the design and construction team may be identified to respond to Cx Issues. Team members are responsible for responding to design and construction questions raised during commissioning work.

3.7 TEAM RESPONSIBILITIES

A. Owner's Responsibilities:

1. Owner will hire the third party CxA.

2. Provide the OPR documentation to the CxA and Contractors for use in developing the Cx Plan, testing plans, and checklists.

3. Provide the Basis of Design documents, prepared by the architect and approved by the Owner, for use in developing the Commissioning Plan; testing plans and checklists.

4. Assign operation and maintenance personnel and schedule them to participate in Commissioning Team activities including, but not limited to, the following:

a. Commissioning meetings.
b. Construction phase coordination meetings.
c. Piping and ductwork testing and flushing verification meetings.
d. Procedures meeting for testing, adjusting and balancing.
e. Testing and demonstration of systems, subsystems and equipment.
f. Training in operation and maintenance of systems, subsystems and equipment.
g. Final review and acceptance meetings.
h. Provide utility services required for the commissioning process.
i. Review and approve the commissioning plan.
j. Coordinate any seasonal or deferred testing.
k. Ensure that any seasonal, deferred testing and/or deficiency issues are addressed.

B. Architect / Engineer's Responsibilities:

1. Attend the Commissioning Scoping Meetings, Controls Coordination Meetings, and selected team meetings.

2. Perform submittal review, construction observation, as-built drawing preparation, and other items as contracted.

3. Provide the Basis of Design Document. The design engineers shall assist in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

4. Participate in the resolution of system deficiencies and issues identified during the commissioning, according to the contract documents.

5. Insure that the CxA's submittal comments are incorporated into the Design Professional's submittal comments prior to sending to CM for distribution.

6. Participate in resolution of design non-conformance and design deficiencies identified during the warranty-period commissioning process.

C. Contractor, and Subcontractor Responsibilities:

1. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following brief overview:

   a. Facilitate the coordination of commissioning and incorporate commissioning activities into the overall project.
   b. Provide copies of all applicable submittals as required in the specifications including all changes.
   c. Provide detailed startup procedures.
   d. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, perform corrective actions.
   e. Cooperate with the CxA for resolution of issues recorded in the Issues Log.
   f. Attend commissioning team meetings held on a scheduled basis.
   g. Make available a copy of all construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CxA.
   h. Integrate and coordinate commissioning process activities with construction schedule.
   i. Review construction checklists provided by the CxA.

j. Review commissioning process test procedures provided by the CxA.
k. Complete commissioning process test procedures.
l. Submit training plan for approval, coordinate training and provide qualified instructors for training of Owner personnel.
m. Assist the CxA as necessary in the seasonal testing, deferred testing and deficiency resolution.
n. Ensure that subcontractors correct deficiencies and make necessary adjustments to submittals, O&M manuals and red-lined drawings for applicable issues identified during testing.
o. Provide as-built controls drawings and sequences of operation for all equipment.
p. Provide a written list of all user adjustable set-points and reset schedules with a brief discussion of the purpose of each and the range of reasonable adjustments with energy implications.

2. Equipment Supplier Responsibilities:

a. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
b. Assist in equipment testing per agreements with subcontractors.
c. Provide information requested by the CxA regarding equipment sequence of operation and testing procedures.

3. Commissioning Agent Responsibilities:

a. Roles and Responsibilities:

1) The CxA is not responsible for the design concept, the design criteria, compliance with codes, design or general construction scheduling, cost estimating or construction management.
2) The CxA may assist with problem solving and non-conformance items or deficiencies, but the CxA is not the Engineer of Record, and the commissioning process does not preclude the Engineer of Record of responsibilities for system evaluations, adequacy of systems to meet the OPR, capacities of systems, quality control checks, or any of the other elements and recommended final acceptance of systems to the Owner.
3) The primary role of the CxA is to coordinate and direct the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultants with all necessary parties, frequently updated timelines and schedules and technical expertise.

b. Commissioning Plan:

1) The CxA shall develop a Commissioning Plan at the start of the project.
2) At the end of the Project, the CxA shall provide the Owner with the Final Commissioning Plan for the Owner's use.

c. Document Review:

1) Review the Owner's Project Requirements and Basis of Design developed by the design professionals.
2) Perform two (2) focused reviews of the drawings and specification during design phase.
3) Develop full commissioning specifications for all systems and equipment to be commissioned. The commissioning specifications will be subject to approval of the design team and included in the final construction specifications.
4) Review submittals applicable to systems being commissioned for compliance for commissioning needs, concurrent with the AE's reviews.

d. Cx Team Meetings:

1) Lead Cx Meetings during design and construction.

e. Coordination and Scheduling:

1) Coordinate and direct commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications, and consultations with all necessary parties.
2) Coordinate commissioning work with the CM to ensure that commissioning activities are being scheduled into the master project schedule.

f. Commissioning Progress:

1) Perform site visits, as necessary, to observe component and system installations.
2) Attend selected planning and jobsite meetings to obtain information on construction progress.
3) Review construction meeting minutes for revisions/substitutions relating to the commissioning process.

g. Pre-Functional Checks:

1) Verify proper installation of components, equipment, systems and assemblies.

h. Equipment and System Startup and Verification:

1) Review system startup reports and conduct selected site observation.
2) Perform TAB verification per contract requirements, and review the TAB report prior to functional testing.
3) Functional Performance Testing
4) With assistance from the Contractor, write Functional Performance Test procedures for all components, equipment or systems to be commissioned.
5) With the assistance of the Contractors, coordinate Functional Performance Testing. Witness and approve Functional Performance Testing performed by the Contractors.

i. With the assistance of the Contractors, coordinate retesting as necessary until satisfactory performance is achieved.
j. Witness seasonal or deferred Functional Performance Testing as necessary.

4. Issue/Deficiency Logs:

a. Prepare a formal, ongoing, online record of deficiencies, problems and concerns – and their resolution – raised by members of the Commissioning Team during the Commissioning Process.
b. Issues will be recorded in the Issues Log. The AE, CM/GC and Contractors will resolve all issues to the satisfaction of the Owner. Issues will be added by the CxA. Team members are required to respond to issues pertaining to their work. Team members are required to respond to issues added to the list within five (5) working days of issue of an update to the Issues Log.
c. When issues are resolved, they will be closed on the Issues Log by the CxA.

5. Operation and Maintenance Data:

a. The CxA shall review of the documentation submitted by the Contractor as required by the Specifications for completeness and accuracy. This commissioning review supplements, but does not replace, the Architect/Engineer's review.
b. Review equipment warranties to ensure that the Owner's responsibilities are clearly defined.

6. Training:

   a. The CM/GC and Contractors will provide all documentation and qualified training personnel for training.
   b. The CxA will verify through the Contractor's plan and schedule, training agendas, and attendance documentation that proper training procedures were followed on all commissioned systems.
   c. See specifications for training requirements.

7. Commissioning Final Report:

   a. The CxA shall provide a final report following the completion of all Functional Performance Testing.

END OF SECTION 019100

SECTION 033000 - CAST-IN-PLACE CONCRETE

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 cast-in-place concrete, including formwork, reinforcement, concrete materials, mixture design, placement procedures, and finishes.

B. Related Requirements:

1. Section 033300 "Architectural Concrete" for general building applications of specially finished formed concrete.

2. Section 033816 “Unbonded Post-Tensioned Concrete” for post-tensioned floor construction.
3. Section 312000 "Earth Moving" for drainage fill under slabs-on-grade.
4. Section 321313 "Concrete Paving" for concrete pavement and walks.
5. Section 321316 "Decorative Concrete Paving" for decorative concrete pavement and walks.

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of the following: blended hydraulic cement, fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.

B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Before submitting design mixtures, review concrete design mixture and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:

a. Contractor's superintendent.
b. Independent testing agency responsible for concrete design mixtures.
c. Ready-mix concrete manufacturer.
d. Concrete Subcontractor.

2. Review special inspection and testing and inspecting agency procedures for field quality control, concrete finishes and finishing, cold- and hot-weather concreting procedures, curing procedures, construction contraction and isolation joints, and joint-filler strips, forms and form removal limitations, vapor-retarder installation, anchor rod and anchorage device installation tolerances, steel reinforcement installation, methods for achieving specified floor and slab flatness and levelness floor and slab flatness and levelness measurement, concrete repair procedures, and concrete protection.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
2. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.
3. Laboratory Test Reports: For liquid floor treatments and curing and sealing compounds, indicating compliance with requirements for low-emitting materials.

C. Design Mixtures: For each concrete mixture. Submit alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1. Indicate amounts of mixing water to be withheld for later addition at Project site.

D. Steel Reinforcement Shop Drawings: Placing Drawings that detail fabrication, bending, and placement. Include bar sizes, lengths, material, grade, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, splices and laps, mechanical connections, tie spacing, hoop spacing, and supports for concrete reinforcement.

E. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.

1. Location of construction joints is subject to approval of the Architect.

F. Samples: For waterstops and vapor retarder.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

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

1. Cementitious materials.
2. Admixtures.
3. Form materials and form-release agents.
4. Steel reinforcement and accessories.
5. Fiber reinforcement.
6. Waterstops.
7. Curing compounds.
8. Floor and slab treatments.
9. Bonding agents.
10. Adhesives.
11. Vapor retarders.
12. Semirigid joint filler.
13. Joint-filler strips.
14. Repair materials.

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

1. Aggregates: Include service record data indicating absence of deleterious expansion of concrete due to alkali aggregate reactivity.

D. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer, detailing fabrication, assembly, and support of formwork.

1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and reshoring installation and removal.

E. Floor surface flatness and levelness measurements indicating compliance with specified tolerances.

F. Field quality-control reports.

G. Minutes of preinstallation conference.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.

B. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

C. Testing Agency Qualifications: An independent agency, qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
2. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician, Grade I. Testing agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician, Grade II.

D. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M.

1.8 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on concrete mixtures.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement.

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

1.10 FIELD CONDITIONS

A. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When average high and low temperature is expected to fall below 40 deg F for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.

2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

B. Hot-Weather Placement: Comply with ACI 301 and as follows:

1. Maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with the following unless modified by requirements in the Contract Documents:

1. ACI 301.
2. ACI 117.

2.2 FORM-FACING MATERIALS

A. Smooth-Formed Finished Concrete: Form-facing panels that provide continuous, true, and smooth concrete surfaces. Furnish in largest practicable sizes to minimize number of joints.

1. Plywood, metal, or other approved panel materials.
2. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:

    a. High-density overlay, Class 1 or better.
    b. Medium-density overlay, Class 1 or better; mill-release agent treated and edge sealed.
    c. Structural 1, B-B or better; mill oiled and edge sealed.
    d. B-B (Concrete Form), Class 1 or better; mill oiled and edge sealed.

3. Overlaid Finnish birch plywood.

B. Rough-Formed Finished Concrete: Plywood, lumber, metal, or another approved material. Provide lumber dressed on at least two edges and one side for tight fit.

C. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that produce surfaces with gradual or abrupt irregularities not exceeding specified formwork surface class. Provide units with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.

D. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to resist plastic concrete loads without detrimental deformation.

E. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

F. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.

G. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.

H. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.

I. Form Ties: Factory-fabricated, removable or snap-off glass-fiber-reinforced plastic or metal form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.

1. Furnish units that leave no corrodible metal closer than 1 inch to the plane of exposed concrete surface.
2. Furnish ties that, when removed, leave holes no larger than 1 inch in diameter in concrete surface.
3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

2.3 STEEL REINFORCEMENT

A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 60 percent.

B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed.

C. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.

D. Galvanized Reinforcing Bars: ASTM A 615/A 615M, Grade 60, deformed bars, ASTM A 767/A 767M, Class II zinc coated after fabrication and bending.

E. Epoxy-Coated Reinforcing Bars: ASTM A 615/A 615M, Grade 60 deformed bars, ASTM A 775/A 775M, epoxy coated, with less than 2 percent damaged coating in each 12-inch bar length.

F. Stainless-Steel Reinforcing Bars: ASTM A 955/A 955M, Grade 60, Type 316L, deformed.

G. Steel Bar Mats: ASTM A 184/A 184M, fabricated from ASTM A 615/A 615M, Grade 60, deformed bars, assembled with clips.

H. Plain-Steel Wire: ASTM A 1064/A 1064M, as drawn.

I. Deformed-Steel Wire: ASTM A 1064/A 1064M.

J. Epoxy-Coated Wire: ASTM A 884/A 884M, Class A, Type 1 coated, as-drawn, plain - steel wire, with less than 2 percent damaged coating in each 12-inch wire length.

K. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, plain, fabricated from as-drawn steel wire into flat sheets.

L. Deformed-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, flat sheet.

M. Galvanized-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, plain, fabricated from galvanized-steel wire into flat sheets.

N. Epoxy-Coated Welded-Wire Reinforcement: ASTM A 884/A 884M, Class A coated, Type 1, plain steel.

2.4 REINFORCEMENT ACCESSORIES

A. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.

B. Epoxy-Coated Joint Dowel Bars: ASTM A 615/A 615M, Grade 60, plain-steel bars, ASTM A 775/A 775M epoxy coated.

C. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating; compatible with epoxy coating on reinforcement and complying with ASTM A 775/A 775M.

D. Zinc Repair Material: ASTM A 780/A 780M.

E. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place. Manufacture bar supports from steel wire, plastic, or precast concrete according to CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

1. For concrete surfaces exposed to view, where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire or CRSI Class 2 stainless-steel bar supports.
2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
3. For zinc-coated reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.

2.5 CONCRETE MATERIALS

A. Regional Materials: Concrete shall be manufactured within 500 miles of Project site from aggregates and cementitious materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.

B. Regional Materials: Concrete shall be manufactured within 500 miles of Project site.

C. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.

D. Cementitious Materials:

1. Portland Cement: ASTM C 150/C 150M, Type I, Type II, Type I/II, or Type III; gray.
2. Fly Ash: ASTM C 618, Class F or C.
3. Slag Cement: ASTM C 989/C 989M, Grade 100 or 120.
4. Silica Fume: ASTM C 1240, amorphous silica.

E. Normal-Weight Aggregates: ASTM C 33/C 33M, Class 4S for exterior, Class 4M for interior, coarse aggregate or better, graded. Provide aggregates from a single source.

1. Maximum Coarse-Aggregate Size: 1 inch nominal.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

F. Lightweight Aggregate: ASTM C 330/C 330M, 3/4-inch nominal maximum aggregate size.

G. Air-Entraining Admixture: ASTM C 260/C 260M.

H. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.

3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

I. Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete and complying with ASTM C 494/C 494M, Type C.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to the following:

a. BASF Corporation-Construction Systems; MasterLife CI 30 (Pre-2014: Rheocrete CNI).
b. Euclid Chemical Company (The); an RPM company; EUCON CIA.
c. Grace Construction Products; W.R. Grace & Co. -- Conn.; DCI.
d. Sika Corporation; Sika CNI.

J. Non-Set-Accelerating Corrosion-Inhibiting Admixture: Commercially formulated, non-set-accelerating, anodic inhibitor or mixed cathodic and anodic inhibitor; capable of forming a protective barrier and minimizing chloride reactions with steel reinforcement in concrete.

1. Products: Subject to compliance with requirements, provide one of the following:

a. BASF Corporation-Construction Systems; MasterLife CI 222 (Pre-2014: Rheocrete 222+).
b. Cortec Corporation; MCI- 2005NS.
c. Grace Construction Products; W.R. Grace & Co. -- Conn.; DCI-S.
d. Sika Corporation; FerroGard 901.

K. Water: ASTM C 94/C 94M and potable.

2.6 FIBER REINFORCEMENT

A. Synthetic Micro-Fiber: Fibrillated polypropylene micro-fibers engineered and designed for use in concrete, complying with ASTM C 1116/C 1116M, Type III, 1/2 to 1-1/2 incheslong.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Euclid Chemical Company (The); an RPM company; PSI Fiberstrand F.
b. FORTA Corporation; FORTA Econo-Net, FORTA Super-Net, FORTA Ultra-net.

c. Grace Construction Products; W.R. Grace & Co. -- Conn.; Grace Fibers.
d. Nycon, Inc.; ProCon-F -–E, [ProConF.
e. Propex; Fibermesh 300.
f. Sika Corporation; Sika Fiber PPF.

2.7 WATERSTOPS

A. Flexible Rubber Waterstops: CE CRD-C 513,[with factory-installed metal eyelets,] for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.

1. Products: Subject to compliance with requirements, provide the following:

a. Williams Products, Inc; <Insert product designation>.

2. Profile: [Flat dumbbell with center bulb] [Flat dumbbell without center bulb] [Ribbed with center bulb] [Ribbed without center bulb] [As indicated] <Insert profile>.
3. Dimensions: [4 inches by 3/16 inch thick] [6 inches by 3/8 inch thick] [9 inches by 3/8 inch thick] <Insert dimensions>; nontapered.

B. Chemically Resistant Flexible Waterstops: Thermoplastic elastomer rubber waterstops[with factory-installed metal eyelets], for embedding in concrete to prevent passage of fluids through joints; resistant to oils, solvents, and chemicals. Factory fabricate corners, intersections, and directional changes.

1. Products: Subject to compliance with requirements, provide one of the following:

a. JP Specialties, Inc.; Earth Shield TPV.
b. Sika Corporation; WESTEC Envirostop.

2. Profile: [Flat dumbbell with center bulb] [Flat dumbbell without center bulb] [Ribbed with center bulb] [Ribbed without center bulb] [As indicated] <Insert profile>.
3. Dimensions: [4 inches by 3/16 inch thick] [6 inches by 3/16 inch thick] [6 inches by 3/8 inch thick] [9 inches by 3/16 inch thick] [9 inches by 3/8 inch thick] <Insert dimensions>; nontapered.

C. Flexible PVC Waterstops: CE CRD-C 572,[with factory-installed metal eyelets,] for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.

1. Products: Subject to compliance with requirements, provide one of the following:

a. BoMetals, Inc; <Insert product designation>.
b. Paul Murphy Plastics Company; <Insert product designation>.

c. Sika Greenstreak; Sika Greenstreak PVC Waterstop.
d. Vinylex Waterstop & Accessories; <Insert product designation>.

2. Profile: [Flat dumbbell with center bulb] [Flat dumbbell without center bulb] [Ribbed with center bulb] [Ribbed without center bulb] [As indicated] <Insert profile>.
3. Dimensions: [4 inches by 3/16 inch thick] [6 inches by 3/8 inch thick] [9 inches by 3/8 inch thick] <Insert dimensions>; nontapered.

D. Self-Expanding Butyl Strip Waterstops: Manufactured rectangular or trapezoidal strip, butyl rubber with sodium bentonite or other hydrophilic polymers, for adhesive bonding to concrete, 3/4 by 1 inch.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Carlisle Coatings & Waterproofing Inc; MiraSTOP.
b. CETCO, a Minerals Technologies company; [Waterstop-RX-101] [Waterstop-RX-101T] [Waterstop-RX-102].
c. Concrete Sealants Inc.; Conseal CS-231.
d. Henry Company, Sealants Division; Hydro-Flex.
e. JP Specialties, Inc.; Earth Shield Type 20.
f. Sika Greenstreak; Swellstop.

E. Self-Expanding Rubber Strip Waterstops: Manufactured rectangular or trapezoidal strip, bentonite-free hydrophilic polymer-modified chloroprene rubber, for adhesive bonding to concrete, 3/8 by 3/4 inch.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Adeka Ultra Seal/OCM, Inc.; [Adeka Ultra Seal MC-2005T] [Adeka Ultra Seal MC-2010MN].
b. CETCO, a Minerals Technologies company; Akwastop.
c. Grace Construction Products; W.R. Grace & Co. -- Conn.; Adcor ES.
d. Sika Greenstreak; Hydrotite.

2.8 VAPOR RETARDERS

A. Sheet Vapor Retarder: ASTM E 1745, Class A[, except with maximum water-vapor permeance of <Insert rating>]. Include manufacturer's recommended adhesive or pressure-sensitive tape.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Fortifiber Building Systems Group; [Moistop Ultra 10] [Moistop Ultra 15].
b. Grace Construction Products; W.R. Grace & Co. -- Conn.; Florprufe 120.

c. Insulation Solutions, Inc.; [Viper VaporCheck II 10-mil] [Viper VaporCheck II 15-mil].
d. Poly-America, L.P.; [Husky Yellow Guard Vapor Barrier 15 Mil ASTM E-1745 Class A] [Husky Yellow Guard Vapor Retarder 10 Mil ASTM E-1745 Class A].
e. Raven Industries, Inc; [Vapor Block 10] [Vapor Block 15] [Vapor Block VB10] [Vapor Block VB15].
f. Reef Industries, Inc; [Griffolyn 10 mil Green] [Griffolyn 15 mil Green] [Griffolyn Type-105] [Griffolyn Type-65G].
g. Stego Industries, LLC; [Stego Wrap 10 mil Class A] [Stego Wrap 15 mil Class A].
h. Tex-Trude, Inc.; [Xtreme 10 Mil Underslab Vapor Barrier] [Xtreme 15 mil Vapor Barrier] [Xtreme 20 mil Vapor Barrier].
i. W.R. Meadows, Inc; [Perminator 10 mil] [Perminator 15 mil].

B. Sheet Vapor Retarder: ASTM E 1745, Class B[, except with maximum water-vapor permeance of <Insert rating>]. Include manufacturer's recommended adhesive or pressure-sensitive tape.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Fortifiber Building Systems Group; Moistop Ultra 6.
b. Reef Industries, Inc; [Griffolyn 10 mil Green] [Griffolyn Type-85] [Griffolyn Vaporguard].

C. Sheet Vapor Retarder: ASTM E 1745, Class C[, except with maximum water-vapor permeance of <Insert rating>]. Include manufacturer's recommended adhesive or pressure-sensitive joint tape.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Insulation Solutions, Inc.; [Viper VaporCheck II 10 mil] [Viper VaporCheck II 6-mil].
b. Raven Industries, Inc; Vapor Block VB6.
c. Reef Industries, Inc; Griffolyn Type-65.
d. Stego Industries, LLC; Stego Wrap, 10 mil Class C.
e. Tex-Trude, Inc.; Xtreme 10 mil Class C.

D. Sheet Vapor Retarder: Polyethylene sheet, ASTM D 4397, not less than 10 mils thick.

E. Bituminous Vapor Retarder: 110-mil- thick, semiflexible, seven-ply sheet membrane consisting of reinforced core and carrier sheet with fortified asphalt layers, protective weathercoating, and removable plastic release liner. Furnish manufacturer's accessories, including bonding asphalt, pointing mastics, and self-adhering joint tape.

1. Products: Subject to compliance with requirements, provide the following:

a. W.R. Meadows, Inc; Premoulded Membrane Vapor Seal.

2. Water-Vapor Permeance: 0.0011 grains/h x sq. ft. x inches Hg; ASTM E 154.

3. Tensile Strength: 140 lbf/inch; ASTM E 154.
4. Puncture Resistance: 90 lbf; ASTM E 154.

2.9 FLOOR AND SLAB TREATMENTS

A. Slip-Resistive Emery Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive, crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials with 100 percent passing [3/8-inch] [No. 4] [No. 8] <Insert size or gradation> sieve.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Anti-Hydro International, Inc; A-H Emery Non-Slip.
b. Dayton Superior; [Emery Non-Slip][Emery Tuff Top].
c. L&M Construction Chemicals, Inc; Grip It.
d. Lambert Corporation; EMAG-20.
e. Metalcrete Industries; Met-Top E.

B. Slip-Resistive Aluminum Granule Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of not less than 95 percent fused aluminum-oxide granules.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Anti-Hydro International, Inc; A-H Alox.
b. BASF Corporation-Construction Systems; MasterTop 120 SR (Pre-2014: Frictex NS).
c. L&M Construction Chemicals, Inc; Grip It AO.

C. Emery Dry-Shake Floor Hardener: [Pigmented] [Unpigmented], factory-packaged, dry combination of portland cement, graded emery aggregate, and plasticizing admixture; with emery aggregate consisting of no less than 60 percent of total aggregate content.

1. Color: [As indicated by manufacturer's designation] [Match Architect's sample] [As selected by Architect from manufacturer's full range].

D. Metallic Dry-Shake Floor Hardener: [Pigmented] [Unpigmented], factory-packaged, dry combination of portland cement, graded metallic aggregate, rust inhibitors, and

plasticizing admixture; with metallic aggregate consisting of no less than 65 percent of total aggregate content.

1. Color: [As indicated by manufacturer's designation] [Match Architect's sample] [As selected by Architect from manufacturer's full range].

E. Unpigmented Mineral Dry-Shake Floor Hardener: Factory-packaged dry combination of portland cement, graded quartz aggregate, and plasticizing admixture.

1. Products: Subject to compliance with requirements, provide one of the following:

a. BASF Corporation-Construction Systems; Maximent HD.
b. Dayton Superior; Quartz Tuff.
c. Euclid Chemical Company (The); an RPM company; Surflex.
d. Kaufman Products, Inc; Tycron.
e. L&M Construction Chemicals, Inc; Quartzplate FF.
f. Lambert Corporation; Colorhard.
g. Metalcrete Industries; Floor Quartz.
h. Scofield, L. M. Company; Lithochrome Color Hardener.
i. SpecChem, LLC; Quartz Hardener.

F. Pigmented Mineral Dry-Shake Floor Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Anti-Hydro International, Inc; A-H S-Q Hardener.
b. BASF Corporation-Construction Systems; MasterTop 100 (Pre-2014: Mastercron).
c. Bon Tool Co.; BonWay Concrete Color Hardener.
d. Brickform; a division of Solomon Colors; CH-Color Hardener.
e. Butterfield Color; Perma-Cast Shake-On Color Hardener.
f. Dayton Superior; Quartz Tuff.
g. Decosup Inc.; HardBright Color Hardener.
h. Dynamic Color Solutions, Inc; Dynamicast Color Hardener.
i. Euclid Chemical Company (The); an RPM company; Surflex.
j. H&C Concrete Care Products; Dry-Shake Color Hardener.
k. Kaufman Products, Inc; Tycron.
l. L&M Construction Chemicals, Inc; Quartz Plate FF.
m. Lambert Corporation; Colorhard.
n. Metalcrete Industries; Floor Quartz.
o. Proline Concrete Tools, Inc.; Dura-Color Hardener.
p. QC Construction Products; [QC Color Hardener] [QC Heavy-Duty Color Hardener].

q. Scofield, L. M. Company; Lithochrome Color Hardener.
r. SpecChem, LLC; Quartz Hardener - Colored.
s. Specialty Concrete Products, Inc; CHROME-HARD Color Hardener.
t. Stampcrete International, Ltd; Color Hardener.
u. SuperStone, Inc; Color Hardener.
v. SureCrete Design Products; Color Hardener.

2. Color: [As indicated by manufacturer's designation] [Match Architect's sample] [As selected by Architect from manufacturer's full range].

2.10 LIQUID FLOOR TREATMENTS

A. Penetrating Liquid Floor Treatment: Clear, chemically reactive, waterborne solution of inorganic silicate or siliconate materials and proprietary components; odorless; that penetrates, hardens, and densifies concrete surfaces.

1. Products: Subject to compliance with requirements, provide one of the following:

a. AWRC Corporation; AMERI-SHIELD Shield-Proof.
b. ChemMasters, Inc; Chemisil Plus.
c. ChemTec Int'l; ChemTec One.
d. Curecrete Distribution Inc.; Ashford Formula.
e. Dayton Superior; [Pentra-Hard Densifier] [Pentra-Hard Finish] [Pentra-Hard Guard] [Sure Hard Densifier J17].
f. Euclid Chemical Company (The); an RPM company; Euco Diamond Hard.
g. Kaufman Products, Inc; SureHard.
h. L&M Construction Chemicals, Inc; Seal Hard.
i. Metalcrete Industries; Floorsaver.
j. Nox-Crete Products Group; Duro-Nox.
k. PROSOCO, Inc; Consolideck LS by PROSOCO.
l. SpecChem, LLC; SpecHard.
m. US SPEC, Division of US MIX Company; US SPEC Industraseal.
n. Vexcon Chemicals Inc.; Vexcon StarSeal PS Clear.
o. W.R. Meadows, Inc; LIQUI-HARD.

2. Products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.11 CURING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. BASF Corporation-Construction Systems; Confilm.
    b. Bon Tool Co.; 32-301-B7 BonWay Evaporation Retarder.
    c. Brickform; a division of Solomon Colors; Evaporation Retarder.
    d. ChemMasters, Inc; Spray-Film.
    e. Dayton Superior; AquaFilm Concentrate J74 or AquaFilm J74RTU.
    f. Euclid Chemical Company (The); an RPM company; Eucobar.
    g. Kaufman Products, Inc; VaporAid.
    h. L&M Construction Chemicals, Inc; E-CON.
    i. Lambert Corporation; LAMBCO Skin.
    j. Metalcrete Industries; Waterhold.
    k. Nox-Crete Products Group; MONOFILM.
    l. Sika Corporation; Caltexol CIMFILM or SikaFilm.
    m. SpecChem, LLC; Spec Film.
    n. TK Products; TK-2120 TRI-FILM.
    o. Vexcon Chemicals Inc.; Certi-Vex EnvioAssist.
    p. W.R. Meadows, Inc; EVAPRE.

B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.

C. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

D. Water: Potable.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, 18 to 25 percent solids, nondissipating, certified by curing compound manufacturer to not interfere with bonding of floor covering.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. AWRC Corporation; AMERI-SHIELD Shield-Sheen WB 20.
    b. BASF Corporation-Construction Systems; MasterKure CC 200 WB (Pre-2014: Kure-N-Seal W).
    c. ChemMasters, Inc; Polyseal WB.
    d. Dayton Superior; Cure & Seal 1315 J22 WB.
    e. Euclid Chemical Company (The); an RPM company; Diamond Clear VOX.
    f. L&M Construction Chemicals, Inc; Dress & Seal WB.
    g. Lambert Corporation; Glazecote Sealer-20.
    h. Metalcrete Industries; Metcure 0800.
    i. Nox-Crete Products Group; Cure & Seal 200E or Cure & Seal 250 E.
    j. SpecChem, LLC; Cure & Seal WB 25.
    k. Vexcon Chemicals Inc.; Starseal 0800.
    l. W.R. Meadows, Inc; Vocomp-20.

2.12 RELATED MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork.

B. Semirigid Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Type A shore durometer hardness of 80 or aromatic polyurea with a Type A shore durometer hardness range of 90 to 95 according to ASTM D 2240.

C. Bonding Agent: ASTM C 1059/C 1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.

D. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:

1. Types I and II at nonload bearing conditions, Types IV and V at load bearing conditions, for bonding hardened or freshly mixed concrete to hardened concrete.

E. Reglets: Fabricate reglets of not less than 0.022-inch- thick, galvanized-steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.

F. Dovetail Anchor Slots: Hot-dip galvanized-steel sheet, not less than 0.034 inch thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.

2.13 REPAIR MATERIALS

A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.

1. Cement Binder: ASTM C 150/C 150M, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by underlayment manufacturer.
4. Compressive Strength: Not less than 4100 psi at 28 days when tested according to ASTM C 109/C 109M.

B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch and that can be filled in over a scarified surface to match adjacent floor elevations.

1. Cement Binder: ASTM C 150/C 150M, portland cement or hydraulic or blended hydraulic cement as defined in ASTM C 219.
2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand as recommended by topping manufacturer.
4. Compressive Strength: Not less than 5000 psi at 28 days when tested according to ASTM C 109/C 109M.

2.14 CONCRETE MIXTURES, GENERAL

A. Prepare design mixtures for each type and strength of concrete as indicated on drawings, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.

1. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash: 25 percent.
2. Combined Fly Ash and Pozzolan: 25 percent.
3. Slag Cement: 50 percent.
4. Combined Fly Ash or Pozzolan and Slag Cement: 50 percent portland cement minimum, with fly ash or pozzolan not exceeding 25 percent.
5. Silica Fume: 10 percent.
6. Combined Fly Ash, Pozzolans, and Silica Fume: 35 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent.
7. Combined Fly Ash or Pozzolans, Slag Cement, and Silica Fume: 50 percent with fly ash or pozzolans not exceeding 25 percent and silica fume not exceeding 10 percent.

C. Limit water-soluble, chloride-ion content in hardened concrete to the following by percent by weight of cement:

1. Prestressed and Post-Tensioned concrete: 0.06
2. Reinforced concrete exposed to chloride: 0.15
3. Reinforced concrete that is not dry or protected from moisture: 0.30
4. Reinforced concrete that is dry or protected from moisture: 1.00

D. Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water-reducing, high-range water-reducing, or plasticizing admixture in concrete, as required, for placement and workability.

2. Use water-reducing and -retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
3. Use water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs and parking structure slabs, concrete required to be watertight, and concrete with a w/c ratio below 0.50.
4. Use corrosion-inhibiting admixture in concrete mixtures where indicated.

E. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.15 FABRICATING REINFORCEMENT

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

2.16 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.

1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For mixer capacity of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For mixer capacity larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixture time, quantity, and amount of water added. Record approximate location of final deposit in structure.

PART 3 - EXECUTION

3.1 FORMWORK INSTALLATION

A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.

B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.

C. Limit concrete surface irregularities, designated by ACI 347 as abrupt or gradual, as follows:

1. Class A, 1/8 inch for smooth-formed finished surfaces.
2. Class B, 1/4 inch for rough-formed finished surfaces.

D. Construct forms tight enough to prevent loss of concrete mortar.

E. Construct forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast-concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.

1. Install keyways, reglets, recesses, and the like, for easy removal.
2. Do not use rust-stained steel form-facing material.

F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.

G. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar. Locate temporary openings in forms at inconspicuous locations.

H. Chamfer exterior corners and edges of permanently exposed concrete, unless otherwise noted.

I. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.

J. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

K. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

L. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.2 EMBEDDED ITEM INSTALLATION

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

1. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC 303.
2. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.
3. Install dovetail anchor slots in concrete structures as indicated.

3.3 REMOVING AND REUSING FORMS

A. General: Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations, and curing and protection operations need to be maintained.

1. Leave formwork for beam soffits, joists, slabs, and other structural elements that support weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.
2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.

B. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material are not acceptable for exposed surfaces. Apply new form-release agent.

C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.4 SHORING AND RESHORING INSTALLATION

A. Comply with ACI 318 and ACI 301 for design, installation, and removal of shoring and reshoring.

1. Do not remove shoring or reshoring until measurement of slab tolerances is complete.

B. In multistory construction, extend shoring or reshoring over a sufficient number of stories to distribute loads in such a manner that no floor or member will be excessively loaded or will induce tensile stress in concrete members without sufficient steel reinforcement.

C. Plan sequence of removal of shores and reshore to avoid damage to concrete. Locate and provide adequate reshoring to support construction without excessive stress or deflection.

3.5 VAPOR-RETARDER INSTALLATION

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.

1. Lap joints 6 inches and seal with manufacturer's recommended tape.

B. Bituminous Vapor Retarders: Place, protect, and repair bituminous vapor retarder according to manufacturer's written instructions.

3.6 STEEL REINFORCEMENT INSTALLATION

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

1. Do not cut or puncture vapor retarder. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that reduce bond to concrete.

C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.

1. Weld reinforcing bars according to AWS D1.4/D 1.4M, where indicated.

D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

E. Install welded-wire reinforcement in longest practicable lengths on bar supports spaced to minimize sagging. Lap edges and ends of adjoining sheets at least one mesh spacing. Offset laps of adjoining sheet widths to prevent continuous laps in either direction. Lace overlaps with wire.

F. Epoxy-Coated Reinforcement: Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M. Use epoxy-coated steel wire ties to fasten epoxy-coated steel reinforcement.

G. Zinc-Coated Reinforcement: Repair cut and damaged zinc coatings with zinc repair material according to ASTM A 780/A 780M. Use galvanized-steel wire ties to fasten zinc-coated steel reinforcement.

3.7 JOINTS

A. General: Construct joints true to line with faces perpendicular to surface plane of concrete.

B. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

1. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of strip placements of floors and slabs.
2. Form keyed joints as indicated. Embed keys at least 1-1/2 inches into concrete.
3. Locate joints for beams, slabs, joists, and girders in the middle third of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
4. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
5. Space vertical joints in walls as indicated. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
6. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
7. Use epoxy-bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of concrete thickness as follows:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.

2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random contraction cracks.

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

1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated.
2. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface where joint sealants, specified in Section 079200 "Joint Sealants," are indicated.
3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

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

3.8 WATERSTOP INSTALLATION

A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm. Install in longest lengths practicable. Support and protect exposed waterstops during progress of the Work. Field fabricate joints in waterstops according to manufacturer's written instructions.

B. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated, according to manufacturer's written instructions, adhesive bonding, mechanically fastening, and firmly pressing into place. Install in longest lengths practicable.

3.9 CONCRETE PLACEMENT

A. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections are completed.

B. Do not add water to concrete during delivery, at Project site, or during placement unless approved by Architect.

C. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301.

1. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

D. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.

1. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.
2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.
3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

E. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Consolidate concrete during placement operations, so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
2. Maintain reinforcement in position on chairs during concrete placement.
3. Screed slab surfaces with a straightedge and strike off to correct elevations.
4. Slope surfaces uniformly to drains where required.
5. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface. Do not further disturb slab surfaces before starting finishing operations.

3.10 FINISHING FORMED SURFACES

A. Rough-Formed Finish: As-cast concrete texture imparted by form-facing material with tie holes and defects repaired and patched. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces not exposed to public view.

B. Smooth-Formed Finish: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams. Repair and patch tie holes and defects. Remove fins and other projections that exceed specified limits on formed-surface irregularities.

1. Apply to concrete surfaces exposed to public view, to receive a rubbed finish, or to be covered with a coating or covering material applied directly to concrete.

C. Rubbed Finish: Apply the following to smooth-formed-finished as-cast concrete where indicated:

1. Smooth-Rubbed Finish: Not later than one day after form removal, moisten concrete surfaces and rub with carborundum brick or another abrasive until producing a uniform color and texture. Do not apply cement grout other than that created by the rubbing process.
2. Grout-Cleaned Finish: Wet concrete surfaces and apply grout of a consistency of thick paint to coat surfaces and fill small holes. Mix 1 part portland cement to 1-1/2 parts fine sand with a 1:1 mixture of bonding admixture and water. Add white portland cement in amounts determined by trial patches, so color of dry grout matches adjacent surfaces. Scrub grout into voids and remove excess grout. When grout whitens, rub surface with clean burlap and keep surface damp by fog spray for at least 36 hours.
3. Cork-Floated Finish: Wet concrete surfaces and apply a stiff grout. Mix 1 part portland cement and 1 part fine sand with a 1:1 mixture of bonding agent and water. Add white portland cement in amounts determined by trial patches, so color of dry grout matches adjacent surfaces. Compress grout into voids by grinding surface. In a swirling motion, finish surface with a cork float.

D. Related Unformed Surfaces: At tops of walls, horizontal offsets, and similar unformed surfaces adjacent to formed surfaces, strike off smooth and finish with a texture matching adjacent formed surfaces. Continue final surface treatment of formed surfaces uniformly across adjacent unformed surfaces unless otherwise indicated.

3.11 FINISHING FLOORS AND SLABS

A. General: Comply with ACI 302.1R recommendations for screeding, restraightening, and finishing operations for concrete surfaces. Do not wet concrete surfaces.

B. Scratch Finish: While still plastic, texture concrete surface that has been screeded and bull-floated or darbied. Use stiff brushes, brooms, or rakes to produce a profile amplitude of 1/4 inch in one direction.

1. Apply scratch finish to surfaces to receive concrete floor toppings or mortar setting beds for bonded cementitious floor finishes.

C. Float Finish: Consolidate surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats. Restraighten, cut down high spots, and fill low spots. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture.

1. Apply float finish to surfaces to receive trowel finish or to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo.

D. Trowel Finish: After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.

1. Apply a trowel finish to surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
2. Finish surfaces to the following tolerances, according to ASTM E 1155, for a randomly trafficked floor surface:

    a. Specified overall values of flatness, F(F) 25; and of levelness, F(L) 20; with minimum local values of flatness, F(F) 17; and of levelness, F(L) 15.

3. Finish and measure surface, so gap at any point between concrete surface and an unleveled, freestanding, 10-ft.- long straightedge resting on two high spots and placed anywhere on the surface does not exceed 1/4 inch.

E. Trowel and Fine-Broom Finish: Apply a first trowel finish to surfaces where ceramic or quarry tile is to be installed by either thickset or thinset method. While concrete is still plastic, slightly scarify surface with a fine broom.

1. Comply with flatness and levelness tolerances for trowel-finished floor surfaces.

F. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and elsewhere as indicated.

1. Immediately after float finishing, slightly roughen trafficked surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with Architect before application.

G. Slip-Resistive Finish: Before final floating, apply slip-resistive aggregate finish where indicated and to concrete stair treads, platforms, and ramps. Apply according to manufacturer's written instructions and as follows:

1. Uniformly spread 25 lb/100 sq. ft. of dampened slip-resistive aggregate over surface in one or two applications. Tamp aggregate flush with surface, but do not force below surface.
2. After broadcasting and tamping, apply float finish.
3. After curing, lightly work surface with a steel wire brush or an abrasive stone and water to expose slip-resistive aggregate.

H. Dry-Shake Floor Hardener Finish: After initial floating, apply dry-shake floor hardener to surfaces according to manufacturer's written instructions and as follows:

1. Uniformly apply dry-shake floor hardener at a rate of 100 lb/100 sq. ft. unless greater amount is recommended by manufacturer.
2. Uniformly distribute approximately two-thirds of dry-shake floor hardener over surface by hand or with mechanical spreader, and embed by power floating. Follow power floating with a second dry-shake floor hardener application, uniformly distributing remainder of material, and embed by power floating.
3. After final floating, apply a trowel finish. Cure concrete with curing compound recommended by dry-shake floor hardener manufacturer and apply immediately after final finishing.

3.12 MISCELLANEOUS CONCRETE ITEM INSTALLATION

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

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

C. Equipment Bases and Foundations:

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct concrete bases 4 inches high unless otherwise indicated, and extend base not less than 6 inches in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated or unless required for seismic anchor support.
3. Minimum Compressive Strength: 3000 psi at 28 days.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete substrate.
6. Prior to pouring concrete, place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Cast anchor-bolt insert into bases. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads, landings, and associated items. Cast-in inserts and accessories as shown on Drawings. Screed, tamp, and trowel finish concrete surfaces.

3.13 CONCRETE PROTECTING AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during curing.

B. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

C. Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure after loosening forms. If removing forms before end of curing period, continue curing for remainder of curing period.

D. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.

E. Cure concrete according to ACI 308.1, by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

    a. Water.
    b. Continuous water-fog spray.
    c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Cure for not less than seven days. Immediately repair any holes or tears during curing period, using cover material and waterproof tape.

    a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.
    b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.

c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies does not interfere with bonding of floor covering used on Project.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer unless manufacturer certifies curing compound does not interfere with bonding of floor covering used on Project.

4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

3.14 LIQUID FLOOR TREATMENT APPLICATION

A. Penetrating Liquid Floor Treatment: Prepare, apply, and finish penetrating liquid floor treatment according to manufacturer's written instructions.

1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
2. Do not apply to concrete that is less than 28 days' old.
3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous.

B. Sealing Coat: Uniformly apply a continuous sealing coat of curing and sealing compound to hardened concrete by power spray or roller according to manufacturer's written instructions.

3.15 JOINT FILLING

A. Prepare, clean, and install joint filler according to manufacturer's written instructions.

1. Defer joint filling until concrete has aged at least six month(s). Do not fill joints until construction traffic has permanently ceased.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.

C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints. Overfill joint and trim joint filler flush with top of joint after hardening.

3.16 CONCRETE SURFACE REPAIRS

A. Defective Concrete: Repair and patch defective areas when approved by Architect. Remove and replace concrete that cannot be repaired and patched to Architect's approval.

B. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.

C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.

1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch in any dimension to solid concrete. Limit cut depth to 3/4 inch. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement so that, when dry, patching mortar matches surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Architect.

D. Repairing Unformed Surfaces: Test unformed surfaces, such as floors and slabs, for finish and verify surface tolerances specified for each surface. Correct low and high areas. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

1. Repair finished surfaces containing defects. Surface defects include spalls, popouts, honeycombs, rock pockets, crazing and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width, and other objectionable conditions.
2. After concrete has cured at least 14 days, correct high areas by grinding.

3. Correct localized low areas during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete.
4. Correct other low areas scheduled to receive floor coverings with a repair underlayment. Prepare, mix, and apply repair underlayment and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface. Feather edges to match adjacent floor elevations.
5. Correct other low areas scheduled to remain exposed with a repair topping. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations. Prepare, mix, and apply repair topping and primer according to manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
6. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose steel reinforcement with at least a 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
7. Repair random cracks and single holes 1 inch or less in diameter with patching mortar. Groove top of cracks and cut out holes to sound concrete and clean off dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding agent. Place patching mortar before bonding agent has dried. Compact patching mortar and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.17 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a special inspector and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports in accordance with IBC – Chapter 17 and applicable referenced standards.

B. Inspections:

1. Steel reinforcement placement.
2. Steel reinforcement welding.
3. Headed bolts and studs.
4. Verification of use of required design mixture.

5. Concrete placement, including conveying and depositing.
6. Curing procedures and maintenance of curing temperature.
7. Verification of concrete strength before removal of shores and forms from beams and slabs.

C. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172/C 172M shall be performed according to the following requirements:

1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. or fraction thereof.
2. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.

    a. When frequency of testing provides fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

3. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
4. Air Content: ASTM C 231/C 231M, pressure method, for normal-weight concrete; ASTM C 173/C 173M, volumetric method, for structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
5. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below or 80 deg F and above, and one test for each composite sample.
6. Unit Weight: ASTM C 567/C 567M, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
7. Compression Test Specimens: ASTM C 31/C 31M.

    a. Cast and laboratory cure a minimum of three sets of two standard cylinder specimens for each composite sample.
    b. Cast and field cure a minimum of three sets of two standard cylinder specimens for each composite sample.

8. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days. If 28 day tests do not meet specified compressive-strength requirements, hold remaining set of two laboratory-cured specimens for 56 day tests.

    a. Test one set of two field-cured specimens at 7 days and one set of two specimens at 28 days. If 28 day tests do not meet specified compressive-

strength requirements, hold remaining set of two field-cured specimens for 56 day tests.

b. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.

9. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
10. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
11. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for 7-, 28-, and 56-day tests.
12. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect as a correlation guide, but will not be used as sole basis for approval or rejection of concrete.
13. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42/C 42M or by other methods as directed by Architect.
14. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
15. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.

D. Measure floor and slab flatness and levelness according to ASTM E 1155 within 24 hours of finishing.

3.18 PROTECTION OF LIQUID FLOOR TREATMENTS

A. Protect liquid floor treatment from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by liquid floor treatments installer.

END OF SECTION 03300

SECTION 078413 - PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Penetrations in fire-resistance-rated walls.
2. Penetrations in horizontal assemblies.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: For each penetration firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing and inspecting agency.

1.3 INFORMATIONAL SUBMITTALS

A. Product test reports.

1.4 CLOSEOUT SUBMITTALS

A. Installer Certificates: From Installer indicating that penetration firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FM Global according to FM Global 4991, "Approval of Firestop Contractors," or been evaluated by UL and found to comply with its "Qualified Firestop Contractor Program Requirements."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics:

1. Perform penetration firestopping system tests by a qualified testing agency acceptable to authorities having jurisdiction.

2. Test per testing standards referenced in "Penetration Firestopping Systems" Article. Provide rated systems complying with the following requirements:

    a. Penetration firestopping systems shall bear classification marking of a qualified testing agency.

2.2 PENETRATION FIRESTOPPING SYSTEMS

A. Penetration Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.

B. Penetrations in Fire-Resistance-Rated Walls: Penetration firestopping systems with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.

1. F-Rating: Not less than the fire-resistance rating of constructions penetrated.

C. Penetrations in Horizontal Assemblies: Penetration firestopping systems with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.

1. F-Rating: At least one hour, but not less than the fire-resistance rating of constructions penetrated.
2. T-Rating: At least one hour, but not less than the fire-resistance rating of constructions penetrated except for floor penetrations within the cavity of a wall.
3. W-Rating: Provide penetration firestopping systems showing no evidence of water leakage when tested according to UL 1479.

D. Exposed Penetration Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, per ASTM E 84.

E. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping system manufacturer and approved by qualified testing and inspecting agency for conditions indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.

B. General: Install penetration firestopping systems to comply with manufacturer's written installation instructions and published drawings for products and applications.

C. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings.

1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not forming permanent components of firestopping.

D. Install fill materials by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories and penetrating items to achieve required fire-resistance ratings.
2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.2 FIELD QUALITY CONTROL

A. Owner will engage a qualified testing agency to perform tests and inspections according to ASTM E 2174.

B. Where deficiencies are found or penetration firestopping system is damaged or removed because of testing, repair or replace penetration firestopping system to comply with requirements.

C. Proceed with enclosing penetration firestopping systems with other construction only after inspection reports are issued and installations comply with requirements.

END OF SECTION 078413

SECTION 230000 – BASIC MECHANICAL REQUIREMENTS – HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements, as well as the following basic mechanical materials and methods:

1. Codes, organizations, standards, and abbreviations
2. Responsibility
3. Site visit
4. Outages
5. Submittals
6. Variances
7. Performance requirements
8. Material and equipment
9. Coordination, sequencing and scheduling
10. Demolition
11. Fire safe materials
12. UL requirements
13. Coordination drawings
14. Construction record documents.
15. Operation and maintenance manuals
16. Warranty / Guarantee
17. Listed manufacturers
18. Approved equal equipment layouts
19. General requirements - execution
20. Existing HVAC Systems
21. Equipment roughins
22. Mechanical installation - HVAC
23. Cutting and patching
24. Cutting, welding and burning
25. Painting and finishing
26. Erection of metal supports and anchorage
27. Demolition
28. Penetration of water proof construction
29. Cleaning and Finishes

30. Electrical requirements
31. Provisions for access
32. Operation of equipment
33. Temporary service and equipment use
34. Demonstration and instructions
35. Lubrication
36. Wall and floor penetrations
37. Equipment provided under another division and by others
38. Construction record drawings
39. Closeout procedures
40. Clean up
41. Project punchout

1.3 CODES, ORGANIZATIONS, STANDARDS AND ABBRIVIATIONS

A. Codes: All material and equipment provided and installed as part of these construction documents shall be in compliance with the latest edition of the following codes as adapted by the State of Maryland for the following:

1. International Building Code (IBC)
2. International Mechanical Code (IMC)
3. PHCC National Standard Plumbing Code Illustrated
4. National Electric Code (NEC)
5. Maryland State Health Department
6. Underwriters Laboratories (UL)
7. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilation Systems
8. NFPA 90B: Standard for the Installation of Warm Air Heating and Air Conditioning Systems
9. NFPA 101: Life Safety Code

B. Organizations and Standards: The following list of organizations and standards are referenced in the HVAC Specification Sections and are included here for reference:

1. AABC: Associated Air Balance Council
2. ADC: Air Diffusion Council
3. AEC: Architecture, Engineering and Construction
4. AGA: American Gas Association
5. AHRI: Air Conditioning, Heating and Refrigeration Institute
6. AMCA: Air Moving and Conditioning Association
7. ANSI: American National Standards Institute
8. API: American Petroleum Institute
9. ARI: Air Conditioning and Refrigeration Institute
10. ASCE: American Society of Civil Engineers
11. ASCE-SEI: American Society of Civil Engineers - Structural Engineering Institute

12. ASHRAE- American Society of Heating, Refrigerating and Air Conditioning Engineers
13. ASME: American Society of Mechanical Engineers
14. ASTM: American Society for Testing and Materials
15. AWS: American Welding Society
16. BAS: Building Automation System
17. CFR: Code of Federal Regulations
18. CGA: Compressed Gas Association
19. CS: Commercial Standard
20. EPA: Environmental Protection Agency
21. FM: Facilities Management
22. FMG: Factory Mutual Global
23. IAPMO: International Association of Plumbing and Mechanical Officials
24. ICC: International Code Council
25. IEEE: Institute of Electrical and Electronics Engineers
26. ISO: International Organization for Standardization
27. MOSHA- Maryland Occupational Safety and Health Administration
28. MSS: Manufacturers Standardization Society
29. MSSP: Manufacturers Standards Society of the Valve and Fittings Industry
30. MSS SP: Manufacturers Standardization Society Standard Practice
31. NADCA: National Air Duct Cleaners Association
32. NAIMA: North American Insulation Manufacturers Association.
33. NAIMA – AH: North American Insulation Manufacturers Association – Air Handling
34. NEBB: National Environmental Balancing Bureau
35. NEC: National Electric Code
36. NEMA: National Electrical Manufacturers Association
37. NEMA – ICS: National Electrical Manufacturers Association – Industrial Control and Systems
38. NEMA – MG: National Electrical Manufacturers Association – Motors & Generators
39. NFPA: National Fire Protection Association
40. NICET: National Institute for Certification in Engineering Technologies
41. NIOSH: National Institute for Occupational Safety and Health
42. OSHA - Occupational Safety and Health Administration
43. SMACNA- Sheet Metal and Air Conditioning Contractors National Association
44. TEMA: Tubular Exchanger Manufacturers Association
45. UL: Underwriters' Laboratories
46. UMB: University of Maryland, Baltimore
47. UMB-A/E: University of Maryland, Baltimore – Architect/Engineer
48. UMB-FM: University of Maryland, Baltimore – Facilities Management
49. UMB-PM: University of Maryland, Baltimore – Project Manager

C. Abbreviations: The following list of abbreviations are referenced in the HVAC Specification Sections and are included here for reference:

1. A/C: Air Conditioning
2. ADA: American Disability Act
3. ASJ: All Service Jacket
4. ATC: Automatic temperature Control
5. BACnet: Building Automation and Control Networks
6. BACnet IP: Internet Protocol
7. BACnet MSTP: Master Slave Token Passing
8. BACnet TCP: Transmission Control Protocol
9. BAS: Building Automation System
10. BMS: Building Management System
11. BTU: British Thermal Unit
12. CAD: Computer Aided Design
13. CD-ROM: Compact Disk – Read Only Material
14. CFC: Chlorofluorocarbon
15. CFM: Cubic Feet per Minute
16. CM: Construction Manager
17. Corp: Corporation
18. CV: Coefficient of Variation, Constant Volume
19. CWP: Cold Working Pressure
20. ^{o}C: Degree Celsius
21. ^{o}F: Degree Fahrenheit
22. DDC: Direct Digital Control
23. DIA: Diameter
24. DOC: Document
25. DOP: Dispersed Oil Particle
26. DP: Differential Pressure
27. Dwg: Drawing
28. EMT: Electrical Metallic Tubing
29. EDPM: Ethylene Propylene Diene Terpolymer Rubber
30. FCU: Fan Coil Unit
31. FLN: Floor Local Network
32. FNPT: Female National Pipe Thread
33. FPM: Feet Per Minute
34. FRP: Fiberglass Reinforced Pipe
35. FSK: Foil Scrim Kraft
36. FTU: Fin Tube
37. Ft.^{2}: Square Feet
38. GAL: Gallon(s)
39. GFI: Ground Fault Interrupter
40. GPM: Gallons Per Minute
41. HCFC: Hydrochlorofluorocarbons
42. HEPA: High Efficiency Particulate Absorption
43. Hr: Hour
44. H_g: Mercury
45. HP: Horse Power

46. HVAC: Heating Ventilation and Air Conditioning
47. H_z: Hertz
48. IBC: International Building Code
49. IEQ: Indoor Environmental Quality
50. Inc: Incorporated
51. ID: Inside Diameter
52. IN: Inches
53. Khz: Kilohertz
54. KVA: Kilo Volt Ampere
55. KVAR: Kilo Volt Amperes, Reactive
56. KVARH: Kilo Volt Amps Reactive Hours
57. kW: Kilowatt
58. LAN: Local Area Network
59. Lb: Pound
60. Lbf/inch: Pound Force per Inch
61. Lbs: Pounds
62. LCD: Liquid Crystal Display
63. LED: Light Emitting Diode
64. mA: Milli Ampere
65. mL: Milli Liter
66. MAX: Maximum
67. MERV: Minimum Efficiency Rating Value
68. MIN: Minimum
69. MPa: Megapascal
70. N/A: Not Applicable
71. NBR: Nitrile Butadiene Rubber
72. NEC: National Electric Code
73. NG: Natural Gas
74. NMEJ: Non-Metallic Expansion Joint
75. No.: Number
76. NOM: Nominal
77. NPS: Nominal Pipe Size
78. NPT: National Pipe Thread
79. NRC: Noise Reduction Coefficient
80. OC: On Center
81. OD: Outside Diameter
82. ODP: Open Drip Proof
83. OZ: Ounce
84. PD: Pressure Drop
85. Pdf: Portable Document Format
86. pH: Potassium Hydrogen
87. PPM: Parts per Million
88. PSI: Pounds per Square Inch
89. PSIG: Pounds per Square Inch Gage
90. P/T: Pressure/Temperature

91. PTFE: Polytetraflouroethylene
92. PVC: Polyvinyl Chloride
93. RPM: Revolutions per Minute
94. RPTFE: Reinforced PolyTetraFluoroEthylene
95. S/S: Stainless Steel
96. Sq.yd.: Square Yard
97. TAB: Testing, Adjusting, and Balancing
98. TEAO: Totally Enclosed Air Over Enclosure
99. TEC: Terminal Equipment Controller
100. TENV: Totally Enclosed Non Ventilating Enclosure
101. TSS: Total Suspended Solids
102. UH: Unit Heater
103. US: United States
104. USA: United States of America
105. USB: Universal Serial Bus
106. UPS: Uninterrupted Power Supply
107. UV: Ultraviolet
108. V: Volt
109. VOC: Volatile Organic Compounds
110. VSD: Variable Speed Drive
111. WG: Water Gage

1.4 RESPONSIBILITY

A. The Construction Manager/General Contractor (CM/GC) shall be responsible for all work included in Division 23. The delegation of work to the contractors shall not relieve him of this responsibility. Contractors who perform work under this Division shall be responsible to the CM/GC.

1.5 SITE VISIT

A. Prior to preparing the bid, the HVAC mechanical subcontractor shall visit the site and become familiar with all existing conditions. Make all necessary investigations as to locations of utilities and all other matters which can affect the work. No additional compensation will be made to the contractor as a result of his failure to familiarize himself with the existing conditions under which the work must be performed.

1.6 OUTAGES

A. For all work requiring an outage, the HVAC mechanical subcontractor shall submit an outage request to the UMB Project Manager, using the UMB Standard Request for Outage Form which is available through the UMB Design and Construction Web Site at http://www.umaryland.edu/designandconstruction/, under the Documents Link. The existing HVAC system shall remain operational unless turned off by University personnel during the construction of the project.

B. Unless otherwise specified, outages of any services required for the performance of this contract and affecting areas other than the immediate work area shall be scheduled at least ten business days (10) days in advance with the UMB Design and Construction Department. Outages shall be performed during normal duty hours. If necessary some outage work may be performed outside normal hours if approved by UMB.

C. All HVAC outages which will interfere with the normal use of the building in any manner shall be done at such times as shall be mutually agreed upon by the contractor and the UMB Design and Construction Department.

D. The HVAC contractor shall include in his price the cost of all premium time required for outages and other work which interferes with the normal use of the building, which will be performed, in most cases, during other than normal work time and at the convenience of the University.

E. The operation of HVAC valves or switches; required to achieve an outage must be operated by University personnel only. Unauthorized operation of HVAC valves, power switches, by contractors and their personnel will result in extremely serious consequences for which the contractor will be held accountable.

1.7 SUBMITTALS

A. General: For general requirements see Specification Division 01 Section "Submittals".

B. HVAC Submittals: Provide submittals for all material, equipment and/or supports as specified in Division 23 and where indicated on the drawings and details. For material and product data submission requirements see Division 23 Specification Sections. At a minimum the following submittals shall be provided as required by the project:

1. Pipe, fittings, valves, and accessories for refrigerant systems.
2. Insulation (pipe, duct and equipment).
3. Hangers and supports.
4. Switchgear Room AC Units
5. Air Devices (as required).
6. Building automation system.
7. Identification (labels, tags valve schedule).
8. Equipment supports.
9. Coordinated drawings.
10. Exhaust fans.

C. Submittal File Format: File formats for each submittal shall be electronically as follows:

1. Product Data File: “pdf” file format.
2. Drawings: “pdf” and “dwg” formats.
3. Coordinated Drawings: “pdf” or “dwg” file formats.
4. Schedules: “xl” file format.

1.8 VARIANCES

A. Where variances occur between the drawings and specifications or within either document itself, the item or arrangement of better quality, greater quantity or higher cost shall be included in the contract price. The Engineer shall decide on the item and manner in which the work shall be provided.

1.9 PERFORMANCE REQUIREMENTS

A. Contract drawings are generally diagrammatic and do not indicate all offsets, fittings, transitions, access panels and other specialties required.

B. Arrange HVAC piping, ductwork, equipment and other work generally as shown on the contract drawings, providing proper clearances and access.

C. Where departures are proposed because of field conditions or other causes, prepare and submit detailed shop drawing submittal for approval in accordance with Submittals specified below.

D. The Engineer may make reasonable changes in location of equipment piping and ductwork up to the time of rough-in or fabrication.

1.10 MATERIALS AND EQUIPMENT

A. The contract drawings and system performances have been designed on the basis of using the particular manufacturer's products specified or scheduled on the contract drawings.

B. Products of other manufacturer's listed in the specification shall be permitted provided as follows:

1. Products meet all of the requirements of the specifications.
2. Make, without additional cost to the Owner, all adjustments for deviations, such that the final installation is complete and functions as the basis of design product is intended.

C. Products with dimensions or other characteristics different from the basis of design product that render their use impractical or cause functional fit, access, or connection problems, shall not be acceptable.

1.11 COORDINATION, SEQUENCING AND SCHEDULING

A. Coordinate HVAC systems, equipment, and materials installation with other building components.

B. Sequencing: Sequence, coordinate, and integrate installations of HVAC materials and equipment for efficient flow of the Work. Give particular attention to large equipment

requiring positioning prior to closing in the building.

C. Electrical Services: Coordinate connection of electrical services.

D. Scheduling: Schedule and coordinate the delivery of material and equipment with other trades to avoid delivery conflicts.

1.12 DEMOLITION

A. HVAC Demolition:

1. Cut, remove and legally dispose of selected HVAC equipment, components, and materials as indicated, including but not limited to removal of HVAC piping, HVAC equipment, ductwork, and other HVAC items made obsolete by the new work.

1.13 FIRE SAFE MATERIALS

A. Unless otherwise indicated, materials shall conform to UL, NFPA or ASTM standards for fire safety with smoke and fire hazard rating not exceeding flame spread of twenty five (25) and smoke developed of fifty (50).

1.14 UNDERWRITER'S LABORATORY (UL) REQUIREMENTS

A. All equipment containing electrical components and provided as part of the mechanical specifications shall bear the Underwriter's Laboratory (UL) label, as a complete packaged system.

1. Equipment not provided with a UL label shall be tested in the field, certified and provided with a UL label at the installer's expense.
2. Field testing shall be performed by a testing agency approved by the authority having jurisdiction.

1.15 COORDINATION DRAWINGS

A. General: When required participate in the preparation of the coordinated drawing effort for the project. See Specification Division 01 for General Requirements.

B. Coordination Drawings: In addition to the requirements of the Specification Division 01 prepare the HVAC part for the coordination drawing effort. Work with the other trades to ensure the material and equipment installed as part on the HVAC system will not be in conflict with the installation of material and equipment by the other trade contractors. Unless otherwise indicated the coordination drawings, including plans, sections, and elevations shall be prepared at a scale of not less than 1/4 inch = 1 foot- 0 inches. At a minimum, prepare coordination drawings for all mechanical rooms, electrical rooms and substation rooms.

C. File Format: Coordination drawings shall be in a layered structure form as CAD Files or PDF Files for each floor with searchable text as follows:

1. File Structure: The "pdf" or "dwg" files shall have separate layered structure for:

a. Building Elements: Indicate each building element on separate layers, such as walls, steel, and columns.
b. Systems and Sub Systems: Indicate each system or sub system as warranted by congestion or complexity on separate layers such as HVAC equipment, air distribution systems, and electrical equipment and conduit:

2. The layered electronic files shall allow building elements, building systems and sub systems to be viewed in isolation or in combinations that are user selectable when the drawing files are being displayed.

D. Coordination Effort: This coordination effort shall include detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the work.

1.16 CONSTRUCTION RECORD DOCUMENTS

A. The mechanical contractor shall maintain a set of construction record documents during the construction period in accordance with Specification Division 01 Section "Project Closeout".

1.17 OPERATION AND MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Specification Division 01 Section "Project Closeout."

1.18 WARRANTY/GUARANTEE

A. All materials, equipment, etc. provided by the general contractor and/or his subcontractors shall be warranted and guaranteed to be free from defects in workmanship and materials for a period of two (2) years from the date of substantial completion and acceptance of work by UMB. Any defects in workmanship, materials, or performance which appear within the guarantee period shall be corrected by the contractor without cost to the owner, within a reasonable time, to be specified by UMB. In default thereof, owner may have such work done and charge the cost of same to the contractor. In addition to the above statement the Warranty/Guarantee Period shall also include all labor cost related to all warranty work. For compressorized equipment include an additional three (3) year Warranty/Guarantee Period.

PART 2 - PRODUCTS

2.1 LISTED MANUFACTURERS

A. Listed Manufacturers: The listed manufacturers indicated in Part 2 of each specification section as the basis of design represents the minimum level of quality for materials and equipment that is acceptable to UMB. Unless otherwise indicated in each specification section, contractors may submit material and equipment by non listed manufacturers provided said submittals meet all of the requirements of these specifications. All submitted materials and equipment are subject to approval by the A/E and UMB.

2.2 APPROVED EQUAL EQUIPMENT LAYOUTS

A. Approved Equal Equipment Layouts: The equipment layouts and the related mechanical and electrical service connections, access space and supports indicated on the construction documents represent equipment provided by the specified basis of design manufacturer and model number. When the successful bidder chooses to provide "or approved equal" equipment by one (1) of the other listed manufacturers in the specifications, the bidder shall be responsible for providing all adjustments and modifications to the services necessary to make connections to the equipment, the bidder shall be responsible for installing the equipment such that all required clear access space is maintained, and the bidder shall be responsible for providing all adjustments and modifications to the equipment mounting and supports. All adjustments and modifications shall be provided by the bidder and appropriate subcontractors at no additional cost to the project.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS – EXECUTION

A. All construction work that creates excessive noise will not be permitted during normal business hours. See Division 01 Specification Section "Cutting and Patching" for requirements.

3.2 EXISTING HVAC SYSTEMS

A. Building: In no case shall the buildings HVAC systems be placed out of service for any period of time unless it is in an emergency condition as directed by the University.

B. Project Area: The sections of the HVAC systems serving the project area can be placed out of service for the construction period as approved by UMB. When the construction is completed the section of the HVAC system serving the project area shall be placed back in service.

3.3 EQUIPMENT ROUGH INS

A. Verify final locations for rough ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications included in the mechanical and electrical specifications for equipment rough in requirements.

3.4 MECHANICAL INSTALLATIONS - HVAC

A. Verify all dimensions by field measurements.

B. Where HVAC systems, materials and equipment are intended for overhead installation, and where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible. Notify UMB - PM prior to installation of HVAC components when headroom is less than 7'-6" and/or where existing system components will be below the new finished ceiling height. Notification shall be through the “RFI” process.

C. Install HVAC systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, identify the conflict and submit and “RFI” for each conflict to the Engineer.

D. Install HVAC systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.

E. Install HVAC equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

F. Install HVAC systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.5 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Specification Division 01 Section "Cutting and Patching" In addition to the requirements specified in Specification Division 01, the following requirements apply:

1. Patch Materials: Patch finished surfaces and building components using new materials specified for the original installation and using experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

3.6 CUTTING, WELDING, BURNING

A. Before the contractor and/or any sub-contractor commences any cutting, welding, burning, brazing (pipe sweating), the contractor shall obtain a hot work permit from the

UMB Fire Marshal at extension 1-410-706-3490 or 1-410-706-7055.

B. The hot work permit copy shall remain on the job site at the hot work location until such work is completed at which time the permit shall be returned to the UMB Fire Marshal.

3.7 PAINTING AND FINISHING

A. Damage and Touch Up: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

B. Do not paint manufacturer's labels or tags.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS D1.1 "Structural Welding Code Steel."

3.9 DEMOLITION

A. Disconnect, demolish, and remove work specified as part of the HVAC specifications and as indicated. Remove pipes and ducts back to the active pipe and duct to remain and cap.

B. Where pipe, ductwork, insulation, or equipment to remain is damaged or disturbed, remove damaged portions and install new products of equal capacity and quality.

C. Accessible Work: Remove indicated exposed pipe and ductwork in its entirety.

D. Abandoned Work: Cut and remove buried pipe abandoned in place, two (2) inches beyond the face of adjacent construction. Cap and patch surface to match existing finish.

E. Removal: Remove indicated equipment from the Project site.

F. Temporary Disconnection: Remove, store, clean, reinstall, reconnect, and make operational equipment indicated for relocation.

3.10 PENETRATION OF WATERPROOF CONSTRUCTION

A. Coordinate the work to minimize penetration of waterproof construction, including roofs, exterior walls and interior waterproof construction.

B. Furnish and install drains, curbs, vent assemblies, sleeves, flashing, etc. specifically designed for application to the particular construction. Install system in accordance with the roofing manufacturer's instructions.

3.11 CLEANING AND FINISHES

A. Clean surfaces prior to application of insulation, adhesives, coating, and paint.

B. Provide factory applied finish where specified.

C. Protect all finishes, and restore all finishes to their original condition if damaged as a result of work installed as part of the mechanical specifications.

D. Remove all construction marking and writing from exposed equipment, ductwork, piping and building surfaces.

3.12 ELECTRICAL REQUIREMENTS

A. Unless otherwise indicated, furnish and install control and interlock wiring for the equipment furnished under this division. In general, power wiring and motor starting equipment will be provided as specified in the electrical specifications.

1. Where the electrical requirements of the equipment furnished differ from the provisions made in the electrical specifications, make the necessary allowances as part of the mechanical specifications.
2. Where no electrical provisions are included in the electrical specifications, include all necessary electrical work as part of the mechanical specifications.

B. All electrical work performed as part of the mechanical specifications shall be provided in accordance with the electrical specifications.

3.13 PROVISIONS FOR ACCESS

A. Furnish and install adequate access to all HVAC components. The following list shall be used as a guide only:

1. Equipment
2. Valves
3. Dampers and operators
4. Filters
5. Heating and air conditioning units
6. Controls
7. ATC panels
8. Heating and cooling coils
9. Low point drains

B. Access shall be adequate as determined by the Engineer.

C. Refer to contract drawings where access panels have been specifically located.

D. Provide additional access panels for adequate access as indicated in paragraph ‘A’ above.

3.14 OPERATION OF EQUIPMENT

A. Clean all systems and equipment prior to initial operation for testing and balancing.

B. Do not operate equipment unless all proper safety devices or controls are operational.

C. Provide all maintenance and service for equipment which is operated during construction.

D. Where specified and otherwise required, provide the services of a manufacturer's factory trained service organization to start the equipment.

3.15 TEMPORARY SERVICE AND EQUIPMENT USE

A. Temporary Service: Unless temporary services are required as part of the project, do not use HVAC systems for temporary services during construction unless authorized in writing by the Engineer and/or UMB.

B. Equipment Use: Where such authorization is granted, temporary use of new and or existing equipment shall not limit or otherwise affect warranties or guarantees covering new equipment. Where equipment is used by the contractor the contractor shall perform all required preventive maintenance on the equipment during the construction period. Upon completion of work, clean and restore all new and/or existing equipment to new condition and replace all filters as necessary.

3.16 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate operation and maintenance of equipment and systems to Owner’s personnel a minimum two (2) weeks prior to date of final inspection.

1. For equipment requiring seasonal operation, perform instructions for other seasons at the same time.
2. Training period shall be performed within one (1), two (2) week period.

B. Use operation and maintenance manuals and video as basis of instruction. Review contents of manual and video with personnel in detail to explain all aspects of operation and maintenance.

C. Demonstrate the following:

1. Start up.
2. Operation.
3. Control.
4. Adjustment.
5. Trouble shooting.
6. Servicing.
7. Maintenance.
8. Shutdown.

D. Provide at least forty (40) hours straight time instruction to the operating personnel.

1. This instruction period shall consist of not less than five (5) eight (8) hour days.
2. Time of instruction shall be designated by the Owner.
3. This instruction shall be in addition to instructional requirements of specific equipment specified elsewhere in the mechanical specifications.

3.17 LUBRICATION

A. All bearings, motors and all equipment requiring lubrication shall be provided with accessible fittings.

B. Before turning over the equipment to the Owner, the Installer shall provide the following:

1. Fully lubricate each item of equipment.
2. Provide one (1) year's supply of lubricant for each type of lubricant.
3. Provide complete written lubricating instructions, together with diagram locating the points requiring lubrication.

C. Motors and equipment shall be provided with grease lubricated roller or ball bearings with Alemite or equal extended grease fittings and drain plugs.

3.18 WALL AND FLOOR PENETRATIONS

A. All penetrations of partitions, walls and floors by ducts, piping or conduit under Specification Division 23 shall be sealed and caulked.

3.19 EQUIPMENT PROVIDED UNDER ANOTHER DIVISION AND BY OTHERS

A. The Installer of products under Specification Division 23 shall make all system connections required to equipment furnished and installed under another division and by others.

B. It shall be the responsibility of the Installer to obtain all necessary data from the equipment supplied under other Divisions.

3.20 CONSTRUCTION RECORD DRAWINGS

A. As the work progresses, the contractor shall record on one (1) set of prints, the installed locations, sizes, and depths of pipes, services, equipment, etc. which may differ from the approved contract drawings.

B. Upon completion of the HVAC installations, the installer shall deliver to the Engineer construction manager one (1) complete set of marked-up blueprints of the HVAC contract drawings. The construction manager shall compile the mark up prints into a composite set and transmit the set the Engineer who shall incorporate the mark ups into the record drawing electronic file.

1. The mark-ups shall be legibly marked in red pencil to show all changes and

departures of the installation as compared with the original design.

C. At a minimum include the following installed conditions:

1. Location of all valves with assigned valve tag numbers.
2. Show the location of equipment such as air conditioning units and rooftop condensers.

3.21 CLOSEOUT PROCEDURES

A. Operating and Maintenance Instructions: Submit Complete Package At Least one (1) Month Prior To Substantial Completion. Arrange for each installer of equipment that requires regular maintenance to meet with the Owner's personnel to provide instruction in proper operation and maintenance. If installers are not experienced in procedures, provide instruction by manufacturer's representatives. Include a detailed review of the following items:

1. Maintenance manuals, including a customized list of preventive maintenance items and annual schedule for maintenance.
2. Record documents.
3. Complete inventory of spare parts and materials.
4. Tools.
5. Lubricants.
6. Fuels.
7. Identification systems.
8. Control sequences.
9. Hazards.
10. Cleaning.
11. Warranties and bonds.
12. Maintenance agreements and similar continuing commitments.

B. As part of instruction for operating equipment, demonstrate the following procedures:

1. Start up.
2. Shut down.
3. Emergency operations.
4. Noise and vibration adjustments.
5. Safety procedures.
6. Economy and efficiency adjustments.
7. Effective energy utilization.

3.22 CLEAN UP

A. Excessive debris and dirt, such as occurs from cutting through masonry or plaster walls shall be cleaned up from the equipment and removed immediately after the work of cutting through the walls.

B. Debris shall be removed from UMB property.

C. All areas shall be left broom-clean at the end of the work period.

D. Remove all mechanical clipping, wiring, nuts, bolts, etc. left on top of ceilings and ceiling tiles.

3.23 PROJECT PUNCH OUT

A. Engineer will perform punch out reviews and will provide the Contractor with a list of punch list items to be completed before contract close out. Each and every punch list item shall be initialed and dated by the Contractor when the work is complete. The Engineer will not perform any punch list verification until all items have been completed, initialed, dated and the list returned to the Engineer. If any items have been initialed as being completed by the Contractor and the Engineer determines that the work is not complete, the Engineer shall be reimbursed by the Contractor at his regular hourly rate for any and all items requiring revisiting of the site by the Engineer. Reimbursement shall be made by deducting the Engineer fee from the Contractor's final payment.

END OF SECTION 230000

SECTION 230513 – MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the general requirements for single (1) phase and three (3) phase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 70, "National Electrical Code."

1. National Recognized Testing Laboratory (NRTL) Listing: Provide NRTL listed motors.

    a. Term "Listed": As defined in "National Electrical Code," Article 100.
    b. Listing Agency Qualifications NRTL as defined in OSHA Regulation 1910.7.

2. Comply with NEMA MG 1, "Motors and Generators."
3. Motors shall be UL listed.

1.4 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

1.5 WARRANTY/GUARANTEE

A. See Division 23 Specification Section "Basic Mechanical Requirements – HVAC" for warranty and guarantee requirements.

PART 2 - PRODUCTS

A. GENERAL PRODUCT REQUIREMENTS

1. Equipment Design and Selection: Motors shall be designed and selected, for the intended use, in accordance with the scheduled capacities on the drawings and the requirements of this specification.

2.2 MOTOR REQUIREMENTS

A. Compliance: Comply with NEMA MG 1 unless otherwise indicated.

B. Motor Requirements: Requirements below apply to motors covered by this Section except as otherwise indicated.

1. Motors 1 / 2 HP and Larger: Three phase.
2. Motors smaller than 1/2 HP: Single phase.
3. Frequency Rating: 60 Hz.
4. Voltage Rating: Determined by voltage of circuit to which motor is connected for the following motor voltage ratings (utilization voltages):

    a. 120 V Circuit: 115 V - motor rating.
    b. 208 V Circuit: 200 V - motor rating.
    c. 240 V Circuit: 230 V - motor rating.
    d. 480 V Circuit: 460 V - motor rating.

5. Minimum service factor shall be 15% and shall apply at frequency and utilization voltage at which motor is connected. Provide motors which will not operate in service factor range when supply voltage is within 10% of motor voltage rating.
6. Capacity: Sufficient to start and operate connected loads at designated speeds in indicated environment, and with indicated operating sequence, without exceeding nameplate ratings. Provide motors rated for continuous duty at 100% of rated capacity.
7. Temperature Rise: Based on 40ºC ambient except as otherwise indicated.
8. Enclosure: Open drip proof, unless otherwise specified. Provide screen over slots, where slots will permit passage of human extremities.
9. Provide adjustable motor slide base for belt driven equipment. Include adjusting bolts and locknuts.

2.3 MOTOR CHARACTERISTICS

A. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.4 THREE PHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Minimum motor efficiencies shall be as follows:

HP	Percent Efficiency, Minimum
1 and less	82.5
1½	84.0
2	84.0
3	87.5
5	87.5
7½	89.5
10	89.5
15	91.0
20	91.0
25	92.4
30	92.4
40	93.0
50	93.0
60	93.6
75 and larger	94.1

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Motor Frames: Motor frames constructed of aluminum will not be permitted. Motor frame sizes 184T and larger shall be constructed of cast iron. Motor frames sizes smaller than 184T shall be constructed of rolled steel.

2.5 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Motor ratings, characteristics, and features shall be coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.6 SINGLE PHASE MOTORS

A. Motors larger than 1/20 hp shall be one (1) of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION

3.1 FIELD INSTALLED MOTORS

A. General: The following requirements apply to field-installed motors.

1. Install motors in accordance with manufacturer's published instructions and the following:

    a. Direct Drive Motors: Mount securely in accurate alignment. Connect to driven equipment with coupler of appropriate type and material for the given duty. Coupler shall be selected for high and range of motor application.
    b. Belt Drive Motors: Use adjustable motor mounting bases. Align pulleys and install belts. Use belts identified by the manufacturer and tension belts in accordance with manufacturer recommendations.

END OF SECTION 230513

SECTION 230529 – HANGERS AND SUPPORTS FOR HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the requirements for hangers and supports for HVAC piping and equipment as follows:

1. Metal pipe angers and supports.
2. Trapeze pipe hangers.
3. Fastener systems.
4. Pipe stands.
5. Pipe supports and curbs – roof level.
6. Miscellaneous materials.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Support for all conditions of operation, including variations in installed and operating weight of equipment, piping and ductwork, to prevent excess stress and allow for proper expansion and contraction.

C. Support materials shall be steel or stainless steel unless specifically indicated.

D. Support devices shall be factory fabricated by manufacturers and have published load ratings.

E. Unless otherwise indicated, design structural support members and support devices, including couplings, rods, trapeze supports and strut systems, with safety factor in accordance with AISC Manual of Steel Construction, but not less than 2.0.

F. Unless otherwise indicated, hangers, support devices and hardware shall be steel and shall have factory standard black, primed, galvanized or electroplated finish for indoor application, and hot-dipped galvanized finish for outdoor application and corrosive atmospheres. Coat cut edges, welds or any damaged finish with galvanized paint.

G. Material in contact with pipe shall be compatible with piping material so that neither shall have deteriorating action on the other. If materials such as copper, stainless steel or other materials are not compatible, provide nonmetallic separation between uninsulated piping and metal supports. Plastic coated steel supports are acceptable.

H. Unless otherwise indicated, steel support devices exposed to ventilation air stream shall be stainless steel or steel with either galvanized finish or paint finish.

I. Fiberglass piping system supports shall meet the more stringent of (a) the requirements of these specifications and (b) the piping manufacturer's recommendations.

J. Contractor is responsible for proper placement and sizing of supporting devices to accommodate insulation thickness and pitching of pipe. Coordinate with Contractor performing work specified in Section "Insulation for HVAC Pipe and Duct Systems".

K. Where piping can be conveniently grouped to allow trapeze type supports, supporting steel shall be by means of standard structural shapes.

L. Hangers and rods shall be plumb when pipelines are at their normal operating temperatures.

M. Unless otherwise indicated, continuous insert channels are not allowed.

N. Punching, drilling, or welding of building structural steel is not allowed unless approved by Structural Engineer.

O. Application of concrete inserts and concrete anchors shall be reviewed and approved by Structural Engineer prior to installation.

P. Lateral bracing for piping and equipment shall be reviewed and approved by Structural Engineer prior to installation. Lateral braces shall be designed and detailed to apply loads as directly as possible to structural floor slabs, roof decks, or other building lateral elements. Braces shall not be applied to bottom flanges of steel beams or bottom chords of steel joists.

Q. Any proposed weld attachments to building structure shall be reviewed by Structural Engineer prior to execution of work. This review may result in use of other welding codes or standards, which may apply to "structural work". Execution of this work may

be assigned to General Trades responsible for building structural steel. Cost for this work, however, will remain the responsibility of this Contractor.

R. Fasteners including concrete anchors for seismic application shall have ICC Evaluation Service Report (ESR) and meet requirements of local authorities.

1.4 ACTION SUBMITTALS

A. Product Data: For each specified product, include manufacturers cut sheets, dimensional data, performance data, installation instructions, wirings diagrams, power requirements, specified options, and warranty information.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Include a copy of each approved submittal along with any applicable maintenance data in the project operation and maintenance manual.

1.7 QUALITY ASSURANCE

A. Materials and application of pipe hangers and supports shall conform to latest requirements of ANSI/ASME B31 Code for Pressure Piping and MSS Standard Practice SP-58 (Materials, design and Manufacture), SP-69 (Selection and Application), and SP-89 (Fabrication and Installation Practices), except as supplemented or modified herein.

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

C. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.8 WARRANTY/GUARANTEE

A. See Division 23 Specification Section “Basic Mechanical Requirements – HVAC” for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Design and Selection: Hangers and supports shall be designed and selected, for the intended use, in accordance with the requirements of this specification.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide comparable product by one (1) of the following:

1. Metal Pipe Hangers and Supports:

a. B-Line.
b. Fee and Mason.
c. Anvil.
d. Michigan Hanger.

2. Metal Framing Support System:

a. Unistrut,
b. B-Line Strut Systems
c. Anvil-Strut
d. Kindorf
e. Hilti

3. Pipe and Equipment Supports - Roof Level:

a. Pate Company.
b. Roof Products and Systems (RPS).
c. Tybar Corporation.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Insulated Horizontal Piping Hangers (refrigerant piping):

1. Two (2) inch and smaller: Figure No. B3108 with metal shield, Figure No. B3151.
2. Two and one-half (2-1/2) inch and larger: Figure No. B3108 with metal shield, Figure No. B3151.

B. Insulated and non-insulated vertical piping hangers:

1. Figure No B3373

C. Insulated and non-insulated vertical piping hangers:

1. Hangers Copper: B3373F.

2.3 TRAPEZE PIPE AND EQUIPMENT HANGERS

A. Description: Direct mounting hangers:

1. Anvil Figure No. 46.
2. Piping: Use straps, slides or rollers as specified below for Flat Surface (Trapeze,

Rack Type) support system.

3. Suspended Equipment: Contractor shall support suspended equipment with any combination of trapeze supports, or miscellaneous steel angles or channels properly sized for the weight and hung from the structure with spring isolation hangers.

2.4 FLAT SURFACES (TRAPEZE, RACK TYPE)

A. Description: Use structural steel members such as struts, angles, channels and beams to support pipes as required. Select members properly for pipe support types and loading conditions. Submit support details with type of members selected and load calculations. Provide straps, clamps, rollers or slides indicated below at each support point.

B. Insulated Horizontal Piping: (refrigerant piping):

1. Eight (8) inch and smaller: U-Bolt, B-Line, Figure No. B3188.

2.5 INSULATION PROTECTION SHIELDS

A. B-Line Figure No. 3151 constructed of galvanized carbon steel. Per the latest edition of Standard MSS SP-58, select shield to accommodate outer diameter of insulation. Shield length and gauge for insulation compression strength not less than 15 psi.

B. Minimum 18 gauge thick and 12” long for piping up to 4”, 16 gauge thick and 18” long for piping 5” through 6”, 14 gauge thick and 24” long for piping 8” through 14” and 12 gauge thick and 24” long for piping 16” and larger.

C. Shields and saddles for fiberglass piping shall be provided as recommended by the piping system manufacturer.

2.6 INSULATION PROTECTION SADDLES

A. B-Line Figure No. 3160 through 3165 constructed of carbon steel or alloy steel plate. Select saddles to accommodate insulation thickness specified.

2.7 PIPE STANDS

A. For support of pipe where axial movement is encountered: Figure No. B33117Sl where no vertical adjustments is required; and Figure B3118SL where vertical adjustments is required.

B. Compact Pipe Stand: One (1) piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe

supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two (2) or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

2.8 PIPE SEALS, SUPPORTS AND CURBS - ROOF LEVEL

A. General: Where piping systems and conduits for power and controls serve HVAC equipment located above the roof level where indicated on the drawings and as specified.

B. Pipe Seal Assembly: Model PPS by Pate, for a single pipe application, shall be a one piece spun aluminum base with full five (5) inch sloped roof surface flange, graduated step PVC boot and adjustable stainless steel clamp.

2.9 EQUIPMENT SUPPORTS – ROOF LEVEL

A. General: Where HVAC equipment such as exhaust fan assemblies, condensing units, dry coolers are located above the roof level provide equipment supports as manufactured by The Pate Company or approved equal.

B. Equipment Supports: Provide steel support beams per mechanical drawings.

2.10 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5,000-psi, twenty eight (28) day compressive strength.
3. Water: Potable
4. Packaging: Premixed and factory-packaged.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Vertical Piping Riser Clamps:

1. Copper Pipe: Figure No. B3373CT.
2. Steel Pipe: Figure No. B3136 and B3137.

E. Beam Clamps and Attachments:

1. For bolt-on locations to structure, Figure Nos. B3291, B3036, B3050.
2. Welded beam attachments, Figure No. B3083.

F. Brackets:

1. For equipment and piping adjacent to walls or steel columns, Figure Nos. B3066, B3063 and B3067 depending on weight to be supported.

G. Pipe Rests:

1. For pipes close to floor where no expansion provision is required, Figure No. B3088T base stand with B3093 adjustable pipe saddles support.

H. Hanger Rods:

1. Hanger rod, Figure No. B3205.
2. Continuous threaded rod, Figure No. ATR.
3. Eye rods, Figure No. B3210 or B3211, depending on load supported.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Install supports to allow for free expansion of piping. Support piping from building structural members using concrete inserts, beam clamps, ceiling plates, wall brackets, or floor stands. At no time shall hangers and supports overload building structural members. Fasten ceiling plates and wall brackets securely to structure and test to demonstrate adequacy of fastening.

B. Select and size building attachments properly in accordance with MSS Standards and manufacturer's published load rating information.

C. Coordinate hanger and support installation to properly group piping of all trades.

D. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.

E. Piping and ductwork shall be supported independently from other piping or ductwork.

F. Pipe hangers and supports shall not penetrate vapor barrier of pipe insulation.

G. Do not support equipment, piping or ductwork from metal roof decking or ceiling grid.

H. Install adequate supports so as not to over stress either piping or equipment to which piping is connected.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install

hangers, supports, clamps, and attachments as required to properly supported piping from the building structure.

1. Horizontal Piping: Support horizontal piping within twelve (12) inches of each fitting and coupling.
2. Base of Vertical Piping: Provide MSS Type 52, spring hangers.
3. Vertical Pipe Supports: Install supports for vertical steel pipe and copper tubing at each floor level and at the roof level.
4. Individual, Straight, Horizontal Piping Runs:
5.
6. One hundred (100) Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
7. Longer than One Hundred (100) Feet: MSS Type 43, adjustable, roller hangers.
8. Longer than One hundred (100) Feet if Indicated: MSS Type 49, spring cushion rolls.
9. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
10. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
11. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
3. Multiple, Straight, Horizontal Piping Runs One hundred (100) Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

D. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb.

E. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Upper attachments to structures shall have an allowable load not exceeding one quarter (1/4) of the failure (proof test) load but are not limited to the specific methods indicated.

M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

N. Insulated Piping:

1. Attach clamps and spacers to piping.
2. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
3. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
4. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
5. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
6. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
7. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
8. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
9. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: Twelve (12) inches long and 0.048 inch thick.

b. NPS 4: Twelve (12) inches long and 0.06 inch thick.
c. NPS 5 and NPS 6: Eighteen (18) inches long and 0.06 inch thick.
d. NPS 8 to NPS 14: Twenty four (24) inches long and 0.075 inch thick.
e. NPS 16 to NPS 24: Twenty four (24) inches long and 0.105 inch thick.

O. Conform to the table below for maximum spacing of supports and rod sizes:

1. Steel and Copper Pipe:

Nom. Pipe Size - In.	Steel Pipe Max. Span - Ft. (In.)	Copper Tube Max. Span - Ft. (In.)	Min. Rod Dia. – In.
Up to 3/4	7 (84)	5 (60)	3/8
1	7 (84)	6 (72)	3/8
1-1/4	7 (84)	7 (84)	3/8
1-1/2	9 (108)	8 (96)	3/8
2	10 (120)	8 (96)	3/8
2-1/2	11 (132)	9 (108)	1/2
3	12 (144)	10 (120)	1/2
3-1/2	13 (156)	11 (132)	1/2
4	14 (168)	12 (144)	5/8 (1/2 for copper)
5	16 (192)	13 (156)	5/8 (1/2 for copper)
6	17 (204)	14 (168)	3/4 (5/8 for copper)
8	19 (228)	16 (192)	7/8 (3/4 for copper)
10	22 (264)	18 (216)	7/8 (3/4 for copper)
12	23 (276)	19 (228)	7/8 (3/4 for copper)

a. Support vertical steel pipe and copper tube at each floor level.
b. Rod diameter may be reduced one (1) size for double-rod hangers, with three eights (3/8) inch minimum rods.

3.3 PIPE SUPPORTS - ROOF LEVEL

A. Install pipe supports at the roof level where indicated on the drawings, and/or details according to the manufacturer's recommendations.

B. Contractor shall provide galvanized insulation shields to protect the pipe insulation at each support point.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that

cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and 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. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to one and one half (1-1/2) inches.

3.6 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 a minimum dry film thickness of 2.0 mils.

B. Touchup: Clean and touchup paint 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 230529

SECTION 230553 – IDENTIFICATION FOR HVAC SYSTEMS AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the requirements for identification of HVAC piping and equipment using the following:

1. Equipment labels.
2. HVAC pipe system labels.
3. Warning tags

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Samples: For color, letter style, and graphic representation required for each identification material and device.
2. Data: Installation details, material descriptions, dimensions of individual components for each type tag and sign.
3. Equipment Label Schedule: Submit a sample equipment label schedule for each fire protection system. Include a list of all equipment to be labeled, the proposed content for each label and the location in an “xl” file format.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Include a copy of the final approved submittal for each product in the operation and maintenance manuals.

1.5 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Names, Abbreviations and Designations: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper

identification and operation/maintenance of mechanical systems and equipment.

1.6 WARRANTY/GUARANTEE

A. See Division 23, Specification Section "Basic Mechanical Requirements – HVAC" for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Labels, Signs and Tags: All labels, signs and tags shall conform to ANSI/OSHA requirements for letter/color combinations.

B. Basis of Design: The basis of design shall be mechanical identifications materials manufactured by the Seton Name Plate Corporation as follows:

1. Equipment Labels – Style M4562 – M4565
2. HVAC Pipe Labels – Size 8SM - 32
3. Duct System Labels – Custom Stencils

C. Other Acceptable Manufacturers: Subject to compliance with requirements, provide mechanical identifications materials from one (1) of the following:

1. Brady (Wilt.) Co. Singmark Division.
2. Industrial Safety Supply Co., Inc.

2.2 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, one eighth (1/8) inch thick, and having predrilled holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than two and one half (2-1/2) inch by three quarter (3/4) inch.
3. Minimum Letter Size: One quarter (1/4) inch for name of units if viewing distance is less than twenty four (24) inches, one half (1/2) inch for viewing distances up to seventy two (72) inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two thirds (2/3) to three fourths (3/4) the size of principal lettering.
4. Fasteners: Self tapping stainless steel screws, screws, except contact type permanent adhesive where screws cannot or should not penetrate the substrate.
5. Adhesive: Contact type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's label as indicated on the construction documents.

C. Equipment Label Schedule: Provide a schedule for all equipment labels.

2.3 HVAC PIPE SYSTEMS LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

1. Small Pipes: For external diameters less than six (6) inches (including insulation if any, provide full band pipe markers, extending 360 degrees around pipe at each location, fastened by one (1) of the following methods:

a. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
b. Adhesive lap joint in pipe marker overlap.
c. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than three quarter (3/4) inch wide; full circle at both ends of pipe marker, tape lapped one and one half (1-1/2) inches.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Pipe label contents shall comply with the following:

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least one and one half (1-1/2) inches high.
3. Label Designation and Colors: See chart below.

HVAC SERVICE DESIGNATION	LABEL DESIGNATION	FIELD/LETTER COLOR
AC Condensate Drain	Same as Service Designation	Yellow / Black
Refrigerant Gas	Same as Service Designation	Yellow / Black
Refrigerant Liquid	Same as Service Designation	Yellow / Black

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Per schedule.

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
2. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
3. Near major equipment items and other points of origination and termination.
4. Spaced at maximum intervals of fifty (50) feet along each run. Reduce intervals to twenty five (25) feet in areas of congested piping and equipment.

C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

3.5 ADJUSTING AND CLEANING

A. Adjusting: Relocate any mechanical identification device which has become visually blocked by work of this division or other divisions.

B. Cleaning: Clean face of identification devices.

END OF SECTION 230553

SECTION 230593 – TESTING, ADJUSTING, AND BALANCING HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the requirements for testing, adjusting and balancing the following systems:

1. Balancing Air Systems:

a. Supply air distribution systems.

2. Testing, Adjusting, and Balancing Equipment:

a. Floor mounted air conditioning units.
b. Fans.

3. Testing, adjusting, and balancing existing systems and equipment:

a. Limited to renovation projects. See drawings for locations of existing HVAC equipment.

1.3 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of fourteen (14) days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.4 ACTION SUBMITTALS

A. Agency Data: within thirty (30) days of award of contract submit proof that proposed testing, adjusting, and balancing agency meets the qualifications specified.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within thirty (30) days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within ninety (90) days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within sixty (60) days of Contractor's Notice to Proceed, submit TAB strategies and step by step procedures as specified in "Preparation" Article.

D. System Readiness Checklists: Within ninety (90) days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Final TAB Report Submittal: Within thirty (30) days after all fieldwork has been completed, submit a final TAB report as detailed in Part 3 of this Section to assure design objectives are met and to assist Owner in future maintenance.

1.6 CLOSEOUT SUBMITTAL

A. Operation and Maintenance Data: Include a copy of the final approved TAB Report in the operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. General: Employ services of an independent testing, adjusting, and balancing agency to be the single source of responsibility to test, adjust, and balance the HVAC systems indicated on the drawings serving the project area. Services shall include checking installations for conformity to design, measurement and establishment of fluid quantities of mechanical systems as required to meet the requirements of the design documents, and record and report the results.

B. Certification: Certified by Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project, and having at least one (1) Professional Engineer registered in State in which services are to be performed, certified by AABC as Test and Balance Engineer. NEBB certified balancing companies will not be permitted.

C. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

G. Work shall be accomplished in accordance with specifications. Procedures specified shall be followed and, if not specifically described herein, in general, shall be in accordance with Associated Air Balance Council's National Standards.

H. Design Review: Review all design drawings and specifications.

1. Review shall include:

a. Fans in duct systems.
b. Equipment layout.
c. Indicate additional balancing devices required for proper balancing.
d. Specifications on all devices required for balancing.
e. Note any potential noise problems.

2. Within ninety (90) days of award of contract, meet with the CM, Owner, A/E, Mechanical Contractor, and Building Automation System Contractor to review procedures and agenda and comments on design documents as to potential problem areas.

I. Shop Drawing Review: Review the Building Automation System (BAS) shop drawing submittals noting any potential balancing problems. Note comments on submittal, sign, stamp and return to General Contractor. All BAS submittals must be reviewed by balancing agency prior to review by the engineer.

J. Pre Balancing Conference: Prior to beginning of testing, adjusting, and balancing procedures, schedule and conduct conference with the CM, Owner, and representatives of installers of mechanical systems. Objective of conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.

K. During construction, balancing agency shall inspect the installation of HVAC systems, sheet metal work, temperature controls, and other component parts of heating, ventilating, and air conditioning systems. Inspections shall be performed periodically as work progresses. Minimum of two (2) inspections are required as follows:

1. One (1) when 50% of equipment is installed;
2. Two (2) when 90% of equipment is installed.
3. Balancing agency shall submit brief written report of each inspection to Owner and engineer.

1.8 STANDARDS

A. Associated Air Balance Council (AABC) Publication: National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems, Latest Edition.

B. American Society of Heating, Refrigeration and air Conditioning Engineers (ASHRAE) Publications:

1. "ASHRAE Research Report No. 1162, "Air Flow Measurements at Intake and Discharge Openings and Grilles," ASHVE Transactions, Volume 46.
2. ASHRAE Handbook of Fundamentals, Latest Edition.

C. American National Standards Institute (ANSI) Publications:

1. ANSI/AIHA Z9.5 American National Standard for Laboratory Ventilation, Latest Edition.
2. S1.4 General - Purpose Sound Level Meters, Specifications for,

D. Sheet Metal and Air Conditioning Contractors National Association Inc. (SMACNA) - Air Duct Leakage Test Manual, Latest Edition.

1.9 FIELD CONDITIONS

A. Renovation Projects: During the renovation to the project area, adjacent areas of the building outside of the project area are occupied by University personnel. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.10 WARRANTY/GUARANTEE

A. See Division 23 Specification Section “Basic Mechanical Requirements – HVAC” for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

A. Provide all required instrumentation to obtain proper measurements. Application of instruments and accuracy of instruments and measurements shall be in accordance with requirements of AABC.

B. Instruments used for measurements shall be accurate, and calibration histories for each instrument to be available for examination by A/E upon request. Calibration and maintenance of instruments shall be in accordance with requirements of AABC.

2.2 INSTRUMENT TEST HOLE PLUGS

A. Center-pull plugs similar to Alliance Plastics CP Series. Plug material shall be Grade 1 virgin polyethylene.

B. Do not drill test holes in welded ducts serving containment areas.

PART 3 - EXECUTION

3.1 GENERAL PROCEDURES

A. General: Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" and in this Section to obtain air quantities indicated and required for proper operation of the systems.

B. System Operation: During all tests, it shall be demonstrated that all systems shall be free from leaks and all parts of each system are operating correctly. If not, report deficiencies to the CM/GC and the UMB – PM. Balancing Firm shall make final adjustments to equipment as may be required for proper operation, maintaining correct temperatures in all parts of the building. Controls shall be adjusted by BAS technicians in conjunction with Balancing Firm. Coordinate set points and adjustments with BAS.

C. Air Systems: Balance each air circulation system, installed under this contract to achieve air quantities, pressure and temperature drops and static pressures in all equipment and parts of system as indicated on the plans, in specifications, and on the approved shop drawings.

D. Noise: Study and report on excessive noise conditions which may develop during system balancing. Report shall be sent to CM and UMB – PM in a form of a “pdf” file.

E. TAB Field Markings: Field mark equipment and balancing devices, including damper control positions, valve position indicators, fan speed control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

F. Traverse Test Probes: Where insulation on ductwork and/or plenums needs to be removed to perform traverse measurements cut and remove insulation as necessary to complete the TAB work. When the work has been completed plug each opening with a properly sized rubber grommet to seal the holes air tight. Coordinate with the mechanical contractor to have the duct insulation repaired to match its previous condition.

G. Acceptable System Tolerance: Unless otherwise specified, the maximum acceptable tolerances for the air flow rates shall be +/- 10% of the flow rates as indicated on the drawings and approved submittals.

3.2 TAB REPORT

A. TAB Report: The TAB report shall include the following:

1. Certification form signed and dated by a TAB professional engineer who represents the TAB Company.
2. Table of contents with separate sections for air system balance and hydronic system balance.
3. List of abbreviations used in the report.
4. List of instruments used with instrument type, manufacturer, serial number, range, and calibration date.
5. Job notes.
6. Completed TAB Data Forms as specified.

B. Units of Measurement: Units of measurements shall be in inch/pound (IP) units.

C. Equipment Labels: Includes all major equipment and devices in each system. Include the following:

1. Equipment tag from the drawings.
2. Equipment name.
3. Manufacturer.
4. Model number.
5. Serial number.
6. Location.

D. TAB Data Forms: For each component that requires a TAB procedure provide a TAB data form with the design data from the construction documents and/or approved submittals and the actual measured data that represents the operation of each system and components as follows:

1. Air Systems and Equipment: Air handling units, energy recovery units and fans:

a. Total air volume in CFM.
b. Return air volume in CFM.
c. Outside air volume in CFM.
d. Static pressure (TSP/ESP) in inches wg.
e. Suction pressure in inches wg.
f. Discharge pressure in inches wg.
g. Air side pressure drop in inches water gauge (wg).
h. Air temperature entering in °F.
i. Air temperature leaving in °F.
j. Air side temperature difference in °F between EAT/LAT.
k. Damper positions % open/closed.

2. Motors: For fans and pumps:

a. Motor HP.

b. Motor BHP.
c. Motor volts and phase.
d. Motor amps.
e. Motor RPM.
f. Fan RPM.
g. Fan sheave.
h. Motor sheave.
i. Belts.
j. Motor efficiency.

3. Air Devices: Diffusers and grilles:

a. Outlet number.
b. Outlet size
c. Outlet type.
d. Min/max air volume in CFM.

E. Instrument Calibration Reports: Instrument calibration reports shall include the following data:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

3.3 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

F. Examine system and equipment installations and verify that field quality control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

I. Examine heat transfer coils for correct piping connections and for clean and straight fins.

J. Examine operating safety interlocks and controls on HVAC equipment.

K. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.4 PREPARATION

A. Perform system readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Air Side:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Volume, smoke, and fire dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature control systems are operational.
h. Suitable access to balancing devices and equipment is provided.

3.5 PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain approved submittals and manufacturer's outlet factors and recommended testing procedures. Cross check the summation of required outlet volumes with required fan design flow rates.

B. In conjunction with the BAS, fans and equipment shall be started and operated per design/approved sequence of operation.

C. With the supply and exhaust fans set for the respective design air flow volumes, system static pressures, fan rpm, motor rpm and power, and with system dampers set to handle normal minimum outdoor air perform and record the following test:

1. Air Handling Equipment:

a. Test for Total Air

1) Sum of discharge, exhaust air, return air and outside air ducts.
2) Number and locations of velocity readings taken.
3) Duct average velocity.
4) Total airflow.

b. After completion of tests, adjustments, and balancing under minimum outdoor air conditions, set system for 100% outdoor air. Repeat the total airflow tests to check field versus design conditions. Result's under the outdoor air cycle shall agree with conditions found under "minimum fresh air operation" before system is considered to be in balance. Adjustments of proper dampers shall be made to achieve balance.

c. If airflow is not within 10% of design capacity at rated speed, review system conditions, procedures, and recorded data. Check and record pressure drops across filters, compensate for clean versus dirty filters, coils, sound traps, airflow sensors, etc., to indicate excessive pressure loss or leakage. Resolve problems with appropriate contractor. If systems are properly operating, and airflow is still unacceptable, adjust fan drive in accordance with manufacturer's recommendations to obtain proper airflow and static pressure. Systems shall be balanced and operated at lowest feasible static pressure with allowance for filter loading. Record fan suction pressure, fan discharge pressure, amperage and airflow measurement. Correct fan curves to indicate new points of balance. Fan motor shall not be overloaded.

2. Air Duct Mains and Branches:

a. Design and actual airflow.
b. Adjust, measure and record airflow, static pressure of duct mains and branch ducts to provide required pressure and airflow at terminal devices.

3. Air Outlets (supply, return and exhaust registers diffusers and grilles):

a. Design and actual airflow.
b. Adjust outlets to obtain design airflow within ±5%.

c. Adjust direction of throw as required to match final installation location to prevent drafts.
d. With supply, return and exhaust balanced to design airflow, report room pressurization, (positive or negative). Record pressure readings relative to adjacent spaces and submit them to the Owner and Engineer.

D. Sheaves and Belts: Should the air balance fall short of or exceed the specified tolerances, change and replace sheaves and belts to achieve the acceptable air balance. Replacement of sheaves and belts shall be provided at no additional cost.

E. Verify that air duct system is sealed as specified. Balancing contractor shall witness leakage tests required of sheet metal construction.

F. Balancing contractor shall witness leakage tests required of sheet metal contractor.

3.6 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal protection element rating.
8. Service factor and frame size.

B. Motors Driven by Variable Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.7 PROCEDURES FOR CONDENSING UNITS

A. Verify proper rotation of fans.

B. Measure entering and leaving air temperatures.

C. Record fan and motor operating data.

3.8 PROCEDURES FOR HEAT TRANSFER COILS

A. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry bulb temperature of entering and leaving air.
2. Wet bulb temperature of entering and leaving air.
3. Airflow.

3.9 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.10 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check bearings and other lubricated parts for proper lubrication.
4. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. Fans are clean.
2. Bearings and other parts are properly lubricated.
3. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan

airflows, and determine the new fan speed and the face velocity of filters and coils.

2. Verify that the indicated airflows of the renovated work result in fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates by more than 5%, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5% or less, equipment adjustments are not required.
4. Balance each air outlet.

3.11 TOLERANCES

A. Set HVAC system's airflow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10%.
2. Air Outlets and Inlets: Plus or minus 10%.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.12 PROGRESS REPORTING

A. Initial Construction Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.13 FINAL TAB REPORT

A. Final TAB Report: The final TAB report shall be a complete record of the HVAC system performance, including conditions of operation, items outstanding, and any deviations found during the TAB process and serve as a reference of the actual operating conditions of the systems. All measurements and test results that appear in the TAB report must be made on site and dated by the AABC technicians and/or TAB engineer performing the work. This report shall be provided as a complete electronic “pdf” file organized as specified and submitted to the A/E for review.

B. Sign & Seal: Final TAB report shall bear the seal and signature of Test and Balance Engineer. TAB Report shall be certified proof that systems have been tested, adjusted, and balanced in accordance with referenced standards; are an accurate representation of

how systems have been installed; are true representation of how systems are operating at completion of testing, adjusting, and balancing procedures; and are accurate record of final quantities measured, to establish normal operating values of the systems.

END OF SECTION 230593

SECTION 230700 – INSULATION FOR HVAC SYSTEMS AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the insulation requirements for HAVC pipe and duct systems as follows:

1. Flexible elastomeric insulation.
2. Adhesives.
3. Mastics.
4. Lagging adhesives.
5. Sealants.
6. Field applied jackets.
7. Tapes.
8. Securements.
9. Corner angles.

1.3 ACTION SUBMITTALS

A. Product Data: For each specified product, include manufacturers cut sheets, dimensional data, thermal performance data, installation instructions, jackets, specified options, and warranty information.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an

apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of twenty five (25) or less, and smoke-developed index of fifty (50) or less.
2. Insulation Installed Outdoors: Flame-spread index of seventy five (75) or less, and smoke-developed index of one hundred fifty (150) or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Specification Section "Hangers and Supports for HVAC Piping Systems."

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.9 WARRANTY/GUARANTEE

A. See Division 23 Specification Section “Basic Mechanical Requirements – HVAC” for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Equipment Design and Selection: Insulation and accessories shall be designed and selected, for the intended use, in accordance with the details on the drawings and the requirements of this specification.

B. Acceptable Manufacturers: Subject to compliance with requirements, provide products by

one (1) of the following:

1. Elastromeric Insulation: Subject to compliance with requirements, provide products by one (1) of the following:

    a. Armstrong.
    b. Armcell
    c. Knauf Inc.

2. Adhesives, Mastics, and Sealants: Provide adhesives, mastics and sealant products recommended by the insulation manufacturer or by one (1) of the following:

    a. Foster Brand.
    b. Fueller Company.
    c. Eagle Bridge.

2.2 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

2.3 FLEXIBLE ELASTOMERIC INSULATION

A. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.

2.4 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

    a. Aeroflex USA, Inc.; Aeroseal.
    b. Armacell LLC; Armaflex 520 Adhesive.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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."

C. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Dow Corning Corporation; 739, Dow Silicone.
b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Speedline Corporation; Polyco VP Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive 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 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, provide one (1) of the following**:**

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.

3. Service Temperature Range: -20°F to +180°F.
4. Solids Content: ASTM D 1644, 58% by volume and 70% by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: -20°F to +180°F.
4. Solids Content: 60% by volume and 66% by weight.
5. Color: White.

2.6 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
b. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0°F to +180°F.
5. Color: White.

2.7 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.Eagle Bridges - Marathon Industries; 405.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
c. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: -40°F to +250°F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: -40°F to +250°F.
5. Color: White.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop cutting and forming. Thickness twenty (20) mil-thick.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.

3. Color: White.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. Factory cut and rolled to size.
b. Finish and thickness: Smooth finish, 0.016 inch thick.
c. Moisture Barrier for Indoor Applications: 1-mil thick, heat-bonded polyethylene and kraft paper.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

a. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: Four (4) inches.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

a. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.

2. Width: Four (4) inches.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, provide one (1) of the following:

    a. ABI, Ideal Tape Division; 488 AWF.
    b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
    c. Compac Corporation; 120.
    d. Venture Tape; 3520 CW.

2. Width: Four (4) inches.

2.10 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide one (1) of the following:

    a. ITW Insulation Systems; Gerrard Strapping and Seals.
    b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch thick, three quarter (3/4) inch wide with wing seal.
3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, three quarter (3/4) inch wide with wing seal.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated.

    a. Products: Subject to compliance with requirements, provide one (1) of the following:

        1) AGM Industries, Inc.; CWP-1.
        2) GEMCO; CD.
        3) Midwest Fasteners, Inc.; CD.
        4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:

    a. Products: Subject to compliance with requirements, provide one (1) of the following:

1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
2) GEMCO; Perforated Base.
3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by two (2) inches square.
c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Products: Subject to compliance with requirements, provide one (1) of the following:

1) GEMCO; Nylon Hangers.
2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by one and one half (1-1/2) inches in diameter.
c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to two and one half (2-1/2) inches.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than one and one half (1-1/2) inches in diameter.

a. Products: Subject to compliance with requirements, provide one (1) of the following:

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than one and one half (1-1/2) inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal three quarter (3/4) inch- wide, stainless steel or Monel.

D. Wire: 0.062-inch soft-annealed, stainless steel.

2.11 CORNER ANGLES

A. Material and thickness shall be same as jacket.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

J. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Cut insulation in a manner to avoid compressing insulation more than 75% of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least four (4) inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least two (2) inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation

continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least two (2) inches.
4. Seal jacket to wall flashing with flashing sealant.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe

insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's

recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with one (1) inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers recommended adhesive.

1. Apply two (2) continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

B. Where metal jackets are indicated, install with two (2) inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands twelve (12) inches o.c. and at end joints.

3.8 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two (2) coats of insulation manufacturer's recommended protective coating.

B. Do not field paint aluminum jackets.

3.9 INSULATION SCHEDULES

A. General: Mechanical System Descriptions for Plumbing, HVAC and Abbreviations used in the following schedules include:

1. Pipe System Descriptions for HVAC Systems:

a. Cold HVAC Piping Systems include: Refrigerant Suction Piping, AC condensate drain.

2. Abbreviations:

a. Field-Applied Jackets:

1) P: PVC.
2) A: Aluminum.

b. Pipe Sizes - NPS: Nominal Pipe Size.
c. N/A: Not Applicable.
d. MER: Mechanical Equipment Room.
e. WP: Weather Proof Covering.

B. Insulation Schedules:

HVAC SYSTEMS – PIPING INTERIOR						
Pipe System	**Pipe Size in Inches (NPS)**	**Materials**	**Thickness in Inches**	**Vaper Barrier Required**	**Field Applied Jacket - MER**	**Field Applied Jacket - NON MER**
A/C Condensate Drain Piping - 40ºF - 110ºF	1/2 to 1, Branch Run – outs	Flexible Elastomeric	1/2	Yes	P	P
Interior Refrigerant Piping	1/2 to 2	Flexible Elastomeric, Refrigerant suction only	3/4	Yes	P	P

HVAC SYSTEMS - PIPING EXTERIOR						
Pipe System	**Pipe Size in Inches (NPS)**	**Materials**	**Thickness in Inches**	**Vaper Barrier Required**	**Field Applied Jacket - MER**	**Field Applied Jacket - NON MER**
Exterior Refrigerant Piping	1/2 to 2	Flexible Elastomeric, Refrigerant Suction only	3/4	Yes	A	A

END OF SECTION 230700

SECTION 230800 – COMMISSIONING HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section and all other sections of Division 23.

B. The OPR and BOD documentation are included by reference for information only.

1.2 SUMMARY

A. This section includes the requirements for commissioning the HVAC systems, assemblies and equipment.

1.3 DESCRIPTION

A. The following equipment and/or accessories shall be commissioned as part of this project:

1. Air distribution systems and equipment
2. Building automation system
3. Interface connections with the BAS.

1.4 ACTION SUBMITTALS

A. Refer to Division 01 Specification Section “COMMISSIONING” for CxA’s role.

B. Refer to Division 01 Specification Section “SUBMITTAL PROCEDURES” for specific requirements.

C. Refer to Division 01 Specification Section “COMMISSIONING” for additional submittal requirements related to submittals of equipment to be commissioned and Cx specific submittals.

1.5 COORDINATION

A. Refer to Division 01 Specification Section “COMMISSIONING” for requirements pertaining to coordination during the commissioning process.

1.6 GENERAL DOCUMENTATION

A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems.

1.7 WARRANTY/GUARANTEE

A. See Division 23, Specification Section "Basic Mechanical Requirements – HVAC" for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Refer to Division 01 Specification Section "COMMISSIONING" for requirements pertaining to testing equipment.

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify in writing to the CxA that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that HVAC instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., for pumps and AHU's normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 TAB VERIFICATION

A. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

B. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC

systems at the direction of the CxA.

1. The CxA will coordinate with the CM and TAB contractor to determine the date of field verification. Notice will not include data points to be verified.
2. The TAB subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
3. Failure of an item includes, other than sound, a deviation of more than +/- 10%.
4. Failure of more than 10% of selected items shall result in rejection of final TAB report.
5. TAB contractor shall remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.3 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of HVAC testing shall include entire HVAC installation. Testing shall include measuring capacities and effectiveness of operational and control functions.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

D. The CxA along with the HVAC contractor, TAB Subcontractor, and HVAC Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 HVAC SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. Procedures: Where applicable follow manufacturer's written procedures. If no procedures are prescribed by the manufacturer, proceed as follows:

1. HVAC Air Distribution Systems: Includes supply, return, general exhaust, and miscellaneous duct systems.

    a. Verify that all ductwork, air devices, and accessories have been installed correctly, are accessible and operate as intended.

2. HVAC Equipment: Includes fans and A/C Units.

    a. Verify that all equipment has been installed in accordance with the manufactures recommendations and all equipment can be easily accessed for maintenance
    b. Verify that all required interfaces with the BAS have been installed correctly and operates as intended.
    c. Operate equipment as intended to ensure the design conditions can be obtained.

3. HVAC Building Automation System:

    a. Verify that all control hardware and software, sequences of operations, and integration of factory controls has been installed correctly and operates as intended.
    b. Verify that all equipment test, training, and startup procedures have been completed per the specifications.
    c. Verify that all required interfaces between the BAS and HVAC equipment have been installed correctly and operates as intended.
    d. Verify that all control graphics and programming has been installed in accordance with the manufactures recommendations and operates as intended.
    e. Operate equipment as intended to ensure the design conditions can be obtained.

END OF SECTION 230800

SECTION 230900 – BUILDING AUTOMATION SYSTEM – RENOVATION PROJECT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the requirements for the BAS System for renovation projects and includes labor, materials, tools, equipment, transportation, insurance, temporary protection, supervision and incidental items essential for proper installation and operation, even though not specifically mentioned or indicated on the drawings but which are usually provided or are essential for proper installation and operation of systems related to this Section, as indicated on the drawings and specified herein.

B. The specifications and drawings describe the minimum requirements for the installation of work, for automation systems and for equipment shown on the drawings.

C. The Building Automation System (BAS) shall include the following systems:

1. Automatic Temperature Control (ATC)
2. University Utility Management System

1.3 REFERENCES

A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made a part of the Contract Documents.

B. Material standards shall be as specified or detailed hereinafter and as follows:

1. NFPA 70 – National Electric Code, latest edition adapted by the State of Maryland.
2. UL-916 – Energy Management Systems.
3. UL-873 – Temperature Indication and Regulating Equipment.
4. FCC; Part 15, Subpart J – Class A computing Equipment.
5. UL-864 – Fire and Smoke Control.

1.4 ACTION SUBMITTALS

A. Product Data: Provide data for each system component and software module.

1. See Division 1 – Shop Drawings, Product Data and Samples for submittal procedures.

B. Shop Drawings:

1. Shop drawings shall have clearly marked the appropriate specification number or drawing designation, for identification of the submittal.
2. Disposition of shop drawings shall not relieve the Contractor from the responsibility for deviations from the drawings or specifications, unless he has submitted in writing a letter itemizing or calling attention to such deviations at time of submission and secured written approval from the University's Representative, nor shall such disposition of shop drawings relieve the Contractor from responsibility for error in shop drawings or schedules.
3. Shop drawings shall include, but shall not be limited to, the following:

a. Control drawings with detailed piping and wiring diagrams, including bill of material and sequence of operation for automation systems and interfaces with other manufacturers' package systems and BAS.
b. Panel layouts and nameplate lists for local and central panels.
c. Valve and damper schedules showing size, configuration, capacity and location of equipment.
d. Data sheets for all control system components.
e. Control strategies (software programs) must be included within the second shop drawing submittal. The listing of each strategy must be in English and demonstrate the desired sequence of operation. Submittal must be complete with proposed schedules, listing of setpoints and end device point listing and addresses.

1.5 INFORMATIONAL SUBMITTAL

A. Manufacturer's Installation Instructions: Indicate manufacturer's installation instructions for manufactured components.

1.6 CLOSEOUT SUBMITTAL

A. Project Record Documents: Record actual locations of control components, including control units, thermostats and sensors.

1. Revise shop drawings to reflect actual installation and operating sequences.
2. Include submittals data in final "Record Documents" form.

B. Operations and Maintenance Data: Include a copy of the final approved submittal for each product in the operation and maintenance manuals.

1. Include interconnection wiring diagrams complete field installed systems with

identified and numbered, system components and devices.

2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
3. Include inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.

C. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in University's name and registered with manufacturer.

1.7 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum ten (10) years of documented experience.

B. Installer: Company specializing in executing the scope of work specified in this section with minimum ten (10) years of documented experience and approved by the BAS manufacturer.

C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. and testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.8 MAINTENANCE SERVICE

A. Provide service and maintenance of energy management and control systems for two (2) year from Date of Substantial Completion.

B. Provide two (2) complete inspections during the two (2) years; one (1) in each season, to inspect, calibrate and tune controls as required and submit written reports.

1.9 SYSTEM DESCRIPTION

A. Furnish and install and program a total building management automation and automatic temperature control system, hereinafter referred to as the BAS, as manufactured by their corporation.

B. The system components shall be as follows:

Device		Type
General – Fans, Dampers		
a.	Logic	DDC
b.	Damper Actuator	Electronic

2. Switchgear Room AC Units

a.	Logic	Integral by Unit Manufacturer
b.	Actuation	Electronic

C. Microprocessor components shall be as manufactured or approved by the BAS Manufacturer. Control system shall be installed by competent control mechanics, electricians and technicians regularly employed by the BAS contractor.

D. Provide electric wiring and connections as required for all systems.

E. The BAS manufacturer shall be responsible for the coordination, of systems or equipment provided by others that interface with the BAS System.

F. Review all HVAC drawings and the specifications to understand equipment and system operations and to verify quantities and types of dampers, operators, alarms, sensors and monitors. Numerous references to the BAS are made throughout this specification identifying work to be performed under this Section, in addition to work specifically indicated herein.

G. Except as otherwise noted, the control system provided shall consist of microprocessors, transmission network, digital system controllers, central monitoring and control system I/O devices, software, sensors, transducers, relays, thermostats, dampers, damper operators, PE and EP switches, control panels, and other accessory equipment, along with a complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete and operable system. All control equipment shall be fully proportioning. Except as otherwise specified, provide operators for equipment such as dampers, where such operators are not required to be provided by the equipment manufacturers.

H. Interlock wiring and installation of control devices associated with the air handling units, pumps, etc., shall be provided under this Section. When the DDC system is fully installed and operational, the BAS manufacturer, Contractor and University’s Representative will review the operation and check out the system. At this time the BAS Manufacturer and Contractor shall demonstrate to all present the operation of the system and prove that it complies with the intent of the drawings and specifications.

I. The BAS scope of work shall include the following:

1. Building Automation System commissioning and acceptance procedures.
2. Equipment labels and graphic designations.
3. Operation and maintenance manuals.
4. Instructional classes on equipment and systems operation for University's facilities personnel.
5. Testing of systems.

J. System Overview:

1. The Building Automation System shall be capable of integrating multiple building functions including equipment supervision and control, alarm management, energy management, and historical data collection and archiving.
2. The Building Automation System (BAS) shall consist of the following:

    a. Communication transmission network (hard-wired topography).
    b. Power wiring and temperature control.

3. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, stand-alone DDC panels, and operator devices.
4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
5. Stand-alone DDC panels shall be able to access any data from, or send control commands and alarm reports directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device.
6. Dynamic Data Access:

    a. Operator devices, either network resident or connected via dial-up modems, shall have the ability to access point status and application report data, or execute control functions for any other devices via the local area network. Access to data shall be based upon logical identification of building equipment.
    b. Access to system data shall not be restricted by the hardware configuration of the building automation system. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.

7. General Network Design:

    a. Network design shall include the following provisions:

        1) High speed data transfer rates for alarm reporting, quick report generation from multiple controllers, and upload/download efficiency between network devices. The minimum baud rate shall be 19,200.
        2) Support of any combination of controllers, and operator workstations directly connected to the local area network. A minimum of fifty (50) devices shall be supported on a single local area network.
        3) Detection and accommodation of single or multiple failures of either workstations, DDC panels or the network media. The

network shall include provisions for automatically reconfiguring itself to allow operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

4) Message and alarm buffering to prevent information from being lost.
5) Error detection, correction, and retransmission to guarantee data integrity.
6) Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.
7) Commonly available, multiple sourced, networking components and protocols shall be used to allow the BAS to coexist with other networking applications such as office automation. ETHERNET and Siemens Protocol II are campus standard technologies.
8) Use of an industry standard IEEE 802.x protocol. Communications must be of a deterministic nature to assure calculable performance under worst case network loading.
9) Synchronization of the real-time clocks in all DDC panels.

8. System Configuration/Architecture:

a. In general, the actual number of stand-alone DDC panel(s) shall be determined by the actual, "realistic" point capacity of each panel's capacity.
b. As a minimum, each supply air handling unit (AHU) shall be equipped with one stand-alone DDC panel.

9. Existing Central Control and Monitoring System:

a. The Existing Central Control Monitoring System (CCMS) for UMB's Campus operates on software developed by Siemens and/or Johnson Controls. Modifications to the Building Automation System (BAS) shall be an extension of and integration into one of these CCMS Systems as directed by UMB.
b. The existing CCMS shall be expanded to include all CCMS workstations, software and connected field panels for this project.
c. The BAS contractor shall provide any upgrades or software revisions necessary and/or available at the time of connection of this project to bring the entire venders CCMS up to current product and software offering. The BAS contractor shall provide training and documentation on any new software revisions, their operation and functionality prior to implementation.
d. It is the intent of this specification the manufacture, provide their current GUI application software and server/client hardware for the main CCMS

system during the construction of the Dental School project and connect this project to that system.

e. Providing a third system is not acceptable.

10. Existing University Utility Management System:

a. The existing Utility Management System server resides in the Facilities Operations Center. This system utilizes the Universities wide area network to gather and process data supplied by utility meters and chiller plants sensors connected to the Campus Chilled Water Loop.

b. The BAS Contractor shall expand the Utility Management System (UMS) to include the data points on the Input/Output Summary identified as "Connected to Existing Utility Management System".

11. Agency Approvals:

a. The entire control system shall be UL approved and listed (UL-916 Energy Management and UL-864 Fire Control) for serial interface between the Building Automation System and Fire Alarm System.

1.10 INCIDENTAL WORK SPECIFIED IN OTHER SECTIONS

A. Work specified in the electrical specifications:

1. Provide power wiring as indicated on the Electrical Drawings.

1.11 ELECTRICAL WIRING (BAS)

A. Electric wiring, wiring connections and interlock wiring required for the installation of the building automation system, as herein specified, shall be provided as specified in this section, unless specifically shown on the Electrical drawings or called for in the Electrical specifications. Electrical power requirements, including junction boxes, for all BAS control devices and equipment shall be provided by the electrical contractor as indicated on the electrical drawing and in the electrical specifications. Extension of power wiring from junction boxes to control devices shall be provided by the BAS contractor.

B. Coordinate necessary auxiliary contacts on magnetic starters with the requirements in the electrical specifications.

C. Furnish labor and material to install the necessary wiring to accomplish the successful and complete operation of the new automation system (DDC).

D. Furnish labor and material to install necessary relays, general purpose enclosures and appurtenances to control designated devices relative to the BAS.

E. Wiring throughout shall be concealed where possible.

F. Conduit used shall be EMT, three quarter (3/4) inch minimum size. Conduit sizes shall be large enough to permit the individual conductors to be readily installed or withdrawn without damage to the conductors or their insulation. Splicing of wires will be permitted only in junction boxes or pull boxes.

G. Conduit is never to be relied upon for a fault current and safety ground return conductor.

H. The ground system must never be used as a current carrying conductor except for faults and noise suppression. The stand-alone DDC panel grounding system shall be used to control noise and transients which might affect the operation of the automation system. As such, the ground requirements are in excess of a grounding system used solely for minimum physical protection.

I. The bond to ground shall be as short as possible. A ground point shall be derated by one (1) point (in order of preference) for each fifty (50) feet of conductor run between it and the automation equipment to be grounded. Therefore, a water pipe bond located ten (10) feet away will be preferable to a structural steel bond located one hundred fifty (150) feet away.

J. Set screw connectors shall be galvanized or plated steel. White metal cast type will not be permitted.

K. Flexible conduit shall be used at field devices, including, pressure switches, flow switches and temperature sensors. Convolutions shall be steel, interlocked continuously. Aluminum will not be permitted. "Liquidtight" or equal shall be used in wet locations.

L. Only core drilling is permitted to pierce the floors in the electrical closets and elsewhere. The use of water for drilling shall be controlled by a suitable vacuum system, using proper dams to prevent damage to floors below.

M. Low voltage wiring in exposed areas, outside air plenums, mechanical/electrical rooms and areas which may be subject to mechanical abuse shall be run in EMT or as noted below:

Sensor to Panel (Stud Wall)	EMT in Wall
Sensor to Panel (Cable Tray)	In Cable Tray
Sensor to Panel (Mechanical Room)	In New Conduit/EMT
Panel to Operator Workstation within New Building	In New Conduit/EMT

N. Wiring:

1. Control wiring, low voltage, 20 AWG pair
2. Control wiring, 120VAC, 14 AWG pair
3. Local area network, LAN, 18 AWG twisted shielded pair
4. Building network, 24 AWG, pair, low capacitance type

O. Low voltage wiring not used for life safety/smoke control applications, above suspended ceilings and in accessible concealed areas may be plenum rated cable.

P. Do not permit the shield from different signal cables to come in contact with each other and make sure that adequate isolation and insulation have been provided.

Q. Transmission Network:

1. Network Configuration: The network configuration shall be a hardwired topography.
2. System Capabilities: The new network shall be 100% compatible with a hardwired based network. No additional or third party software bridges shall be required.
3. Server Client Network shall use UM CCMS, CFMS wide area network for connection of the building work station to the server at the operation centers.
4. Use CCMS, CFMS wide area network for connection of field panels to network server.
5. The UMS shall use the CFMS wide area network to communicate to the UMS server located in the Operations Center. Provide all field data gathering panels and data points necessary to meet the Input/output summary and sequence of operation.

R. At every DDC control panel, application specific controller, and unit controller provide a low voltage toggle-type disconnect switch in the incoming 24 VAC service line. Switch to be mounted in a junction box.

S. Provide Uninterrupted Power Source (UPS) at work stations and field panels.

1.12 WARRANTY/GUARANTEE

A. See Division 23 Specification Section “Basic Mechanical Requirements – HVAC” for warranty and guarantee requirements.

B. Furnish to the University a written guarantee for field programmable microprocessor based units against all defects in materials and workmanship, including without limitation against hardware failure for two (2) years from date of acceptance. Guarantee shall include all parts and labor. See Division 01, Guarantees, Warranties, Bonds, Service and Maintenance Contracts, for submittal form.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Equipment Design and Selection: All BAS equipment and accessories shall be designed and selected, for the intended use, in accordance with the scheduled capacities on the drawings and the requirements of this specification.

B. Replacement of Existing Field Panels: Where existing field panels are considered obsolete/retired (building controllers, equipment controllers, and floor level network controllers), the BAS contractor shall include in his bid the cost to replace the existing obsolete/retired field panels with new field panels. The cost shall include all modifications to the graphics and programming resulting from this change. The obsolete/retired field panels are located in

C. The BAS manufacturer and installer shall be Siemens Building Technologies unless otherwise directed by UMB.

2.2 SOFTWARE

A. General: Provide all necessary software to form a complete operating system as described in this specification. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

B. Control Software Description:

1. Pre-Tested Control Algorithms: The DDC panels shall have the ability to perform the following pre-tested control algorithms:

    a. Two (2) Position Control
    b. Proportional Control
    c. Proportional plus Integral Control
    d. Proportional, Integral, plus Derivative Control
    e. Automatic Control Loop Tuning

2. Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any one (1) hour period.
3. Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.
4. Powerfail Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of controlled equipment, compare it with normal occupancy scheduling, and turn the preselected equipment on or off as necessary in a staggered/time-delayed manner to avoid excess electrical surge. The remainder of the equipment will not automatically start. The system will print out the assigned status of the equipment on the alarm printer. The system shall require a manual command to start any equipment.
5. Temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
6. The system shall be provided complete with equipment and documentation necessary to allow an operator to independently perform the following functions:

a. Add/delete/modify stand-alone DDC Controller panels
b. Add/delete/modify operator workstations
c. Add/delete/modify application specific controllers
d. Add/delete/modify points of any type and all associated point
e. Add/delete/modify alarm reporting definition for points
f. Add/delete/modify control loops
g. Add/delete/modify energy management applications
h. Add/delete/modify time and calendar-based programming
i. Add/delete/modify totalization for points
j. Add/delete/modify historical data trending for points
k. Add/delete/modify custom control processes
l. Add/delete/modify any and all graphic displays, symbols and cross-reference to point data
m. Add/delete/modify dial-up telecommunication definition
n. Add/delete/modify all operator passwords
o. Add/delete/modify alarm messages

7. Definition of operator device characteristics, DDC Controllers individual points, applications and control sequences shall be performed using instructive prompting software.

a. Field Panel Programs shall be manufacturers' standard line program method.
b. Inputs and outputs for any process shall not be restricted to a single DDC Controller. Each Controller shall be able to include data from other network panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).
c. Provide the capability to backup and store system databases on the workstation hard disk. In addition, database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller. Similarly, changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.
d. Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.

A. Energy Management Applications: DDC Panels shall have the ability to perform any or all of the following energy management routines:

1. Time of Day Scheduling
2. Calendar Based Scheduling
3. Holiday Scheduling
4. Temporary Schedule Overrides

5. Optimal Start
6. Optimal Stop
7. Optimal Stop
8. Night Setback Control
9. Peak Demand Limiting
10. Temperature Compensated Load Rolling
11. Variable frequency drive/CFM Control
12. Heating/Cooling Interlock

C. Custom Process Programming Capability: DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

1. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:

    a. Any system-measured point data or status
    b. Any calculated data
    c. Any results from other processes
    d. User-Defined Constants
    e. Arithmetic functions (+,-,*,/, square root, exp, etc.)
    f. Boolean logic operators (and, or, exclusive or, etc.)
    g. On-delay/Off-delay/One-shot timers

2. Process Triggers: Custom processes may be triggered based on any combination of the following:

    a. Time interval
    b. Time of day
    c. Date
    d. Other processes
    e. Time programming
    f. Events (e.g., point alarms)

3. Dynamic Data Access: A single process shall be able to incorporate measured or calculated data from other DDC panels on the local area network. In addition, a single process shall be able to issue commands to points in other DDC panels on the local area network.
4. Advisory/Message Generation: Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device, buffer the information in a follow-up file, or cause the execution of a dial-up connection to a remote device such as a printer or pager.
5. Custom Process Documentation: The custom control programming feature shall be self-documenting. All interrelationships defined by this feature shall be documented via graphic flow charts and English language descriptors.

D. Alarm Management: Alarm management shall be provided to monitor, print, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

1. Point Change Report Description: Alarm or point change reports shall include the point's English language description and the time and date of occurrence.
2. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three (3) priority levels shall be provided. Each DDC panel shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.
3. Report Routing: Alarm reports, messages, and files will be directed to a user-defined list of operator devices, or PC's used for archiving alarm information.

    a. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.

4. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a two hundred (200) character alarm message for each system point to more fully describe the alarm condition or direct operator response. Each stand-alone DDC panel shall be capable of storing a library of at least two hundred fifty (250) alarm messages. Each message may be assignable to any number of points in the panel.

E. Historical Data and Trend Analysis: A variety of Historical data collection utilities shall be provided to automatically sample, store, and display system data in the following ways.

1. Continuous Point Histories: Stand-alone DDC panels shall store Point History Files for analog and binary inputs and outputs. The Point History routine shall continuously and automatically sample the value of analog inputs at half hour intervals. Samples for points shall be stored for the past twenty four (24) hours to allow the user to immediately analyze equipment performance and problem-related events for the past day. Point History Files for binary input or output points and analog output points shall include a continuous record of the last ten (10) status changes or commands for each point.
2. Control Loop Performance Trends: Stand-alone DDC panels shall also provide high resolution sampling capability with an operator-adjustable resolution of ten (10) to three hundred (300) seconds in one (1) second increments for verification

of control loop performance.

3. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of one (1) minute to two (2) hours, in one (1) minute intervals, shall be provided. Each stand-alone DDC panel shall have a dedicated buffer for trend data and shall be capable of storing a minimum of 10,000 data samples.
4. Data Storage and Archiving: Trend data shall be stored at the Stand-alone DDC panels, and uploaded to hard disk storage (minimum 80 megabyte) when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. Trend data shall be available in disk file form for use in 3rd Party personal computer applications.

F. Runtime Totalization: Stand-alone DDC panels shall automatically accumulate and store runtime hours for binary input and output points as specified in the Execution portion of this specification.

1. The Totalization routine shall have a sampling resolution of (1) minute or less.
2. The user shall have the ability to define a warning limit for Runtime Totalization. Unique, user-specified messages shall be generated when the limit is reached.

G. Analog/Pulse Totalization: Stand-alone DDC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, gallons, KBTU, tons. etc.).
2. The Totalization routine shall have a sampling resolution of one (1) minute or less.
3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

H. Event Totalization: Stand-alone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.

1. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.
2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

2.3 STAND-ALONE DDC PANELS

A. General: Stand-alone DDC panels shall be microprocessor based multi-tasking, multi-user, real-time digital control processors. Each stand-alone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power

supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification and drawings.

B. Building Controllers: Building controllers shall include the following:

1. Building Controllers shall be 32 bit, multi-tasking, multi-user, real-time 100 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.
2. Each Building Controller shall have sufficient memory, a minimum of twenty four (24) megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, and operator I/O.
3. Building Controller shall have an integral real-time clock.
4. Each Building Controller shall support firmware upgrades without the need to change hardware.
5. Each Building Controller shall support:

    a. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the Building Controller cabinet.
    b. Monitoring of industry standard analog and digital outputs, without the addition of equipment outside the Building Controller cabinet.

6. Spare Point Capacity. Each Building Controller shall have a minimum of 10 percent spare point capacity.

    a. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than one spare of each implemented I/O type.
    b. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:

        1) Expansion modules
        2) Sensor/actuator
        3) Field wiring/tubing

7. Serial Communication: Building Controllers shall provide at least one EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals. A USB port shall alternatively be available to support local HMI tools

connection.

8. I/O Status and Indication: Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. All wiring connections shall be made to field-removable terminals.
9. Self-Diagnostics: Each Building Controller shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.
10. Power loss: In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of one hundred (100) hours.
11. Environment: Controller hardware shall be suitable for the anticipated ambient conditions as follows:

    a. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).
    b. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

12. Immunity to power and noise.

    a. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.
    b. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
    c. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

        1) RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V.
        2) Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact.
        3) Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power.
        4) Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max).

d. Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:

1) IEEE Standard 587 1980.
2) UL 864 Supply Line Transients.
3) Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11).

13. Minimum Approved Building Controllers. BAS Contractors shall furnish Building Controllers as listed below. Providing an approved controller does not release the contractor from meeting all performance, software and hardware specifications for Building Controllers and system operations.

a. Siemens Building Technologies Inc. – PXC Compact and PXC Modular Building Controllers.

14. Uninterrupted Power Source:

a. Provide a UPS for each Stand Alone DDC Panel.

2.4 BUILDING AND APPLICATION SPECIFIC CONTROLLERS (ASC)

A. General: Provide building and application specific controllers to control each piece of equipment, including, but not limited to the following:

1. Each Building Controller shall be able to communicate with application specific controllers (ASCs) over the Secondary Network to control terminal equipment only.
2. The use of Secondary Network controllers with custom program applications to control AHU's, water systems, etc. is not acceptable.
3. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.
4. Each ASC shall include all point inputs and outputs necessary to perform the specified control sequences. The ASC shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control signals shall not be acceptable. Outputs utilized either for two-state, modulating floating, or proportional control, allowing for additional system flexibility.
5. Communication: Each controller shall perform its primary control function independent of other Secondary Network communication, or if Secondary Network communication is interrupted. Reversion to a fail-safe mode of operation during Secondary Network interruption is not acceptable.
6. Control Algorithms: The controller shall receive its real-time data from the Building Controller time clock to insure Secondary Network continuity. Each

controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via room sensor LCD or the portable operator's terminal as specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

7. Control Applications: Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.
8. Calibration: Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.

    a. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary
    b. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 CFM air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.
    c. Calibration shall be accomplished by zeroing out the pressure sensor and holding damper at last known position until calibration is complete. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.

9. Memory: Memory requirements shall include the following requirements:

    a. Provide each ASC with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of seventy two (72) hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.
    b. Upon replacement, new ASCs shall recover control function and site specific defaults automatically and resume normal operation.

10. Power Supply: The ASCs shall be powered from a 24 VAC source and shall function normally under an operating range of 18 VAC to 28 VAC, allowing for power source fluctuations and voltage drops. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type. The BMS contractor shall provide 24 VAC power to the terminal units by utilizing:

    a. The existing line voltage power trunk and installing separate isolation transformers for each controller.

b. Dedicated line voltage power source and isolation transformers at a central location and installing 24 VAC power trunk to supply multiple ASCs in the area.

11. Environment: The controllers shall function normally under ambient conditions of 32°F to 122°F (0°C to 50°C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.
12. Immunity to noise: Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
13. Manufacturer Installed Controls: Include the following:

    a. BAS manufacturer shall furnish ASC and actuator for factory mounting to equipment manufacturer.
    b. Cost of factory mounting shall be borne by equipment manufacturer.
    c. For each air terminal unit, equipment manufacturer shall provide and install flow-cross sensor, 24 VAC transformer, controls enclosure, SCR and factory install, wire and tube ASC controller and actuator.

2.5 TEMPERATURE SENSORS (DDC)

A. General: Provide temperature sensors for controllers performing space temperature control. Sensors shall be wired thermistor type, with the following features:

1. Accuracy: + .5°F.
2. Operating Range: 35°F to 115°F.
3. Set Point Adjustment Range: 55°F to 95°F.
4. Calibration Adjustments: None required.
5. Installation: Up to one hundred (100) ft. from controller.
6. Auxiliary Communications Port: As required.
7. Set Point Adjustment Dial: As required.
8. Occupancy Override Switch: As required.
9. Terminal Jack: As required.

B. Set Point Modes: Provide the following set point modes:

1. Independent Heating, Cooling.
2. Night Setback-Heating.
3. Night Setback-Cooling.

C. Auxiliary Communication Port: Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator’s terminal.

D. Set Point Adjustment Dial: The set point adjustment dial shall allow for modification of the temperature by the building operators. Set point adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.

E. Override Switch: An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.

F. Room Temperature Sensors and Monitors: The following temperature sensors for space control and/or space monitoring where indicated on the drawings and as required for proper control for the project:

1. Room Temperature Control Sensor: Room sensor shall come with a wall plate suitable for surface mounting in the room. The local setpoint adjustment shall be capable of being locked out by the BAS. The sensors shall be wired to the TEC by a cable which transmits the temperature signal to BAS.

2.6 FIELD DEVICES

A. Local Control Panels:

1. Controls, relays and switches for equipment located within the mechanical equipment rooms shall be mounted on enclosed control panels with hinge lock type door mounted adjacent to the system controlled.
2. Details of each panel shall be submitted for review prior to fabrication. Locations of each panel shall be convenient for adjustment and service. Manual switches shall be flush mounted on the hinged door.
3. Electrical devices within the panels shall be factory prewired to a numbered terminal strip. Wiring within the panel shall be in accordance with NEMA and UL Standards.

B. Temperature Sensors:

1. See temperature sensor specification in this section for requirements.

C. Fan Status:

1. HVAC Fans: Verification of air flow for HVAC fans, which are wired from an electrical motor control center, shall be by a current sensor device unless indicated otherwise on the point schedule. Motor Start/Stop relay module shall provide either momentary or maintained switching action as appropriate for the

motor being started. Relays shall be plugged in, interchangeable, mounted on a circuit board and wired to numbered terminal strips.

2.7 UNINTERRUPTIBLE POWER SUPPLIES (UPS)

A. All Building Automation System field panels and application specific controllers shall be provided with Uninterruptible Power Supplies (UPS). Provide a single UPS, if possible, at each central field panel location, sized for total load of connected equipment. Provide external battery cabinets, if required to meet load requirements.

B. Provide constant on line 1500 kVA minimum UPS with Ethernet card to feed back to IP based UM monitoring system Eaton Model PULSL1500T, Style #86703, 120V 1.5 kVA UPS with a number MS Network Management Ethernet Card, Part # Network - MS, and a UPS bypass for seamless servicing. When a larger UPS is required, increase the kVA capacity as needed. Line interactive UPS's will not be acceptable.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. The sequences listed hereinafter describe the general intent of the automatic temperature control systems. Provide all devices, equipment, and wiring as required to perform the sequences described herein.

B. Unless otherwise noted, size all automatic control valves for a maximum of ten (10) foot water pressure drop at the maximum design flow rate.

C. See plans for location of all room thermostats, control panels, dampers, valves, and equipment; where such devices are not indicated, however required by the sequences, they shall be provided and located in the field as directed by the A/E and UMB.

D. Current Sensor: All motors serving HVAC fans and pumps shall be provided with a current sensor for "on/off" status to the BAS.

E. All temperature, pressure, air flow, and time set points shall be fully adjustable from the Central Control and Monitoring System (CCMS).

F. Provide all hardware, software, devices, equipment and wiring as required to interface with the CCMS.

G. Refer to input/output summary schedule for additional control items not described in the sequences. The input/output summary schedule list the minimum requirements, provide all required points for complete operation of the system.

H. Where indicated on the drawings, the variable frequency drives (VFD) for secondary pumps shall be soft started at minimum speed and increased to operating speed by the

CCMS.

I. The control manufacturer shall prepare and submit for approval a composite control and interlock wiring diagram depicting the control system that will be provided.

3.2 SEQUENCE OF ORERATION – SELF CONTAINED A/C UNITS

A. General:

1. Refer to the contract drawings for full switchgear room sequence of operations.

B. DX A/C Unit:

1. The Building Automation System (BAS) shall send enable/disable signal to the A/C Unit.
2. The unit shall be controlled by the factory furnished and installed microprocessor controls. The unit controls shall enable/disable cooling at the A/C unit by energizing the unit's compressor to maintain space temperature set point as sensed by space temperature sensor.
3. On a call for cooling if the unit compressor fails to start an alarm shall be transmitted to the BAS through the BAC NET IP BMS Card and the unit shall be de-energized.
4. On a call for cooling if the unit compressor starts but the unit fan fails to start an alarm shall be transmitted to the BAS through the BAC NET IP BMS Card and the unit shall be de-energized.
5. When a DX unit has auxiliary drain pans provide a moisture sensor connected to the BAS. When moisture is detected, the sensor shall send an alarm to the BAS and de-energize the unit.
6. Provide BAC NET IP BMS Communication Software to interface with the DX A/C unit controls.
7. The following points are included with the A/C Unit microprocessor controller. BAS shall provide BAC NET IP BMS communication software to allow for BAS monitoring. Listed points are based on Stultz manufactured equipment. Points 'a' through 'm' and 'p' and 'q' shall be alarmed and trended by the BAS:

    a. Unit on/off —Digital Output
    b. Compressor running Module1 —Digital Output
    c. Fan running Module1 —Digital Output
    d. Compressor low pressure alarm Module1 —Digital Input
    e. Compressor high pressure alarm Module1 —Digital Input
    f. Air flow alarm Module1 —Digital Input
    g. Water detector alarm Module1 (condensate pan) —Digital Input
    h. Room temperature to high alarm —Digital Input
    i. Room temperature to low alarm —Digital Input
    j. Supply temperature to high alarm —Digital Input
    k. Supply temperature to low alarm —Digital Input

l. Set point space temperature —Analog Input
m. Set point supply air temperature —Analog Input
n. Return air temperature —Analog Input
o. Supply air temperature —Analog Input

8. For systems requiring auxiliary drain pans the following point shall be alarmed through the BAS:

a. Auxiliary Drain Pan Water Detector Alarm — Digital Input

3.3 SEQUENCE OF OPERATION – FANS

A. Fan Control:

1. The BAS shall energize centrifugal fans. Refer to the contract drawings for sequence of operations for new and existing fans in the switchgear room.
2. The exhaust fan status shall be as determined by a current transducer. If the lead fan fails to energize its isolation damper shall close and a current transducer shall transmit an alarm signal the BAS. The BAS shall signal the lag fan isolation damper to open and after the damper has opened the lag fan shall be energized to run continuously.

3.4 SYSTEM INPUT/OUTPUT POINT SUMMARY

A. Description: For points not listed below and for software association, see sequence of operation. Points shall be able to integrate to trends and totalizations, as applicable. Additional points not specifically called for herein but required to perform the sequences as specified shall be provided at no additional cost to the Owner. Points labeled with * shall be trended.

B. Input/Output Point Summary:

1. General Exhaust Fans:

a. Analog Binary Input:

1) Current Relay *

b. Digital Output:

1) On – Off *

c. Digital Input:

1) Current Sensor for Fan Status*

d. Analog Output:

1) VFD (if applicable)

e. System Features:

1) Alarm *
2) Proof *
3) LAN device for VFD to BAS
4) Trend *

2. Switchgear Rooms:

a. Analog Inputs - Measured:

1) Space Temperature
2) Compressor status
3) RH

b. System Features:

1) Alarm – High Analog Alarm
2) Compressor Failure
3) Safety Trip
4) Com Error
5) General Alarm
6) Water Alarm
7) Trend
8) Alarm Instruction
9) BACnet interface if applicable

3. System Features (typical for all above):

a. General:

1) Color Graphics
2) DDC Control
3) Programming
4) Trend

3.5 PROJECT MANAGEMENT

A. The Contractor shall designate a project manager for the Building Automation System who will be responsible for the following:

1. Construct and maintain BAS project schedule.
2. On-site coordination of BAS requirements with all applicable trades and subcontractors.
3. Authorized to accept and execute orders or instructions for the BAS from the

University's Representative.

4. Attend project meetings as necessary to avoid conflicts and delays.
5. Make necessary field decisions relating to this scope of work.

3.6 NUMERING/NAMING CONVENTIONS

A. Coordinate with the University's Representative to determine the University's preference for naming conventions, etc. before entering the data in the system.

3.7 GRAPHICS AND PROGRAMING

A. Graphics: For campus renovation projects, the BAS Contractor shall provide a graphics package as follows:

1. Existing Graphics: Where graphics exist in the Siemens System for the project, the BAS contractor shall either modify the existing graphics or replace the existing graphics with new graphics indicating the architectural changes to the project area and the locations of air terminal units or HVAC equipment and BAS sensors.
2. New Graphics: Where the Siemens System does not include graphics for the project, the BAS contractor shall provide a new graphics package for the project area indicating the architectural changes to the project area and the locations of air terminal units or HVAC equipment and BAS sensors.
3. New Graphics Background: Where new backgrounds are created by the BAS contractor these backgrounds must reside on and be compatible the Siemens Front End System and software. The BAS contractor can either create the background or utilize a CAD dwg file from the consultant or UMB as the background.

B. Programing: For campus renovation projects, the BAS Contractor shall provide the required programing as follows:

1. Existing Programing: Where programing exists in the Siemens System for the existing air terminal units or HVAC equipment that is either relocated, or removed and replaced, the existing building automation system programming shall be either modified or deleted, and a new program written by the BAS contractor to identify the air terminal units with the rooms they serve as part of the ATC work for the project.
2. New Programing: Where programing does not exist in the Siemens System for the existing air terminal units or HVAC equipment that is either relocated, or removed and replaced, the BAS contractor shall provide new programming to identify the air terminal units with the rooms they serve as part of the ATC work for the project. The new programing must reside on and be compatible the Siemens Front End System and software.
3. Miscellaneous: Programming modifications shall also include the occupied and unoccupied modes of control for each terminal unit or lead/lag operation for HVAC equipment.

3.8 TESTING AND ADJUSTMENT

A. Furnish labor, material, instruments, supplies, and services and bear costs for the accomplishment of all tests herein specified. Correct defects appearing under test, and repeat the tests until no defects are observed. Leave the equipment clean and ready for use.

B. Perform other tests that may be required by the State Building Code, Fire Code, or Underwriter's Laboratory.

C. Furnish necessary testing apparatus, make temporary connections, and perform testing operations required at no additional cost to the University.

D. Upon completion of the project:

1. Completely adjust, ready for use, thermostats, controllers, DDC panels, transducers, valves, damper operators, relays, etc., provided under this Section.
2. Load and debug software and related data base provided for under this Contract.

3.9 START UP AND COMMISSIONING

A. Start Up: Comply with the following:

1. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. Testing, calibrating, adjusting and final field tests shall be completed by the installer. Verify that systems are operable from local controls in the specified failure mode upon panel failure or loss of power.
2. Provide any recommendation for system modification in writing to the University. Do not make any system modification, including operating parameters and control settings, without prior approval of University's Representative.

B. Commissioning: See Division 23, Specification Section "Commissioning HVAC Systems" for requirements. Schedule a time and date with the UMB Commissioning representative through the UMB-PM.

END OF SECTION 230900

SECTION 233113 – HVAC DUCT SYSTEMS AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the requirements for HVAC Duct Systems and related accessories as follows:

1. Sheet metal materials.
2. Sealants and gaskets.
3. Single-wall rectangular ducts and fittings.
4. Hangers and supports.
5. Backdraft dampers.
6. Manual volume dampers.
7. Flexible connectors.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each specified product, include manufacturers cut sheets, dimensional data, performance data, installation instructions, wirings diagrams, power requirements, specified options, and warranty information.

B. For each type of the following products:

1. Construction details for ductwork and fittings.
2. Sealants and gaskets.

1.5 CLOSEOUT SUBMITTAL

A. Operation and Maintenance Data: Include a copy of each approved submittal along with any applicable maintenance data in the project operation and maintenance manual.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

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

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

1.7 WARRANTY/GUARANTEE

A. See Division 23 Specification Section “Basic Mechanical Requirements – HVAC” for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Material Design and Selection: HVAC Duct Systems and Accessories shall be designed and selected, for the intended use, in accordance with the sizes on the drawings and the requirements of this specification.

2.2 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G90.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

D. Tie Rods: Galvanized steel, one quarter (1/4) inch minimum diameter for lengths thirty six (36) inches or less; three eights (3/8) inch minimum diameter for lengths longer than thirty six (36) inches.

2.3 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of twenty five (25) and a maximum smoke-developed index of fifty (50) when tested according to UL 723; certified by an NRTL.

B. Two (2) Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: Three (3) inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: Ten (10) inch wg. positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: - 40°F to +200°F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
11. 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."

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65%.
3. Shore A Hardness: Minimum Twenty (20).
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: Ten (10) inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: Twenty five (25).
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. 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."

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Duct Connection Joint Sealant: For renovation projects where new ductwork connects to existing ductwork provide the following material as a joint sealer between the new and existing duct surfaces:

1. Permatite, Butyl gray non curing tape of sufficient width to seal the duct joints. Material can be purchased from the manufacturer or from Grainger using the either the manufacturers model number DS5285, or the Grainger item number 2EJR3. Seal the external joints as required by these specifications and the ductwork can be placed in service.

2.4 SINGLE WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse

Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are nineteen (19) inches and larger and are 20 gauge or less, with more than ten (10) sq. ft. of unbraced panel area, as indicated in SMACNA "HVAC Duct Construction Standard," Figure 1-4, unless they are lined or are externally insulated.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc

chromate.

2.6 BACKDRAFT DAMPERS

A. Light to Medium Duty (1,000 to 1,500 FPM maximum velocity)

1. Basis-of-Design Product: Subject to compliance with requirements, Ruskin BD2/A1 and Ruskin BD2/A2 or comparable product by one (1) of the following:

   a. American Warming and Ventilating; a division of Mestek, Inc.
   b. Greenheck Fan Corporation.
   c. Ruskin Company.

2. Description: Gravity balanced.
3. Operation Pressure: BD2A1 blades open at 0.03 in. wg. and are fully open at 0.10 inch wg. BD2A2 blades open at 0.10 inch wg. and are fully open at 0.15 inch w.g.
4. Frame: Hat-shaped, 0.090-inch-thick extruded aluminum, with mitered corners.
5. Blades: (1000 FPM maximum velocity) -. Ruskin BD2/A1, 0.025 inch formed aluminum, extruded vinyl edge seals. (1,500 FPM maximum velocity) - Ruskin BD2/A2, 6063T5 extruded aluminum, 0.050 inch wall thickness, extruded vinyl edge seals.
6. Blade Action: Parallel.
7. Blade Seals: Extruded vinyl, mechanically locked.
8. Blade Axles:

   a. Material: Nonferrous metal.
   b. Diameter: 0.20 inch.

9. Return Spring: Adjustable tension.
10. Bearings: synthetic pivot bushings.
11. Accessories:

    a. Screen Mounting: Rear mounted.
    b. Screen Material: Galvanized steel.
    c. Screen Type: Bird.

B. Description: Gravity balanced.

C. Maximum System Pressure: Max 0.04 inch wg. at 1,000 feet per minute

D. Frame: Hat-shaped, 0.090-inch- thick, extruded aluminum, with welded corners or mechanically attached and mounting flange.

E. Blades: Multiple single-piece blades, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum with sealed edges.

F. Blade Action: Parallel.

G. Blade Seals: Extruded vinyl, mechanically locked.

H. Blade Axles:

1. Material: Synthetic
2. Diameter: 0.20 inch.

I. Tie Bars and Brackets: Aluminum.

J. Return Spring: Adjustable tension.

K. Bearings: synthetic pivot bushings.

L. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.

2.7 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Model No. CD36 or comparable product by one (1) of the following:

a. American Warming and Ventilating; a division of Mestek, Inc.
b. Greenheck Corporation.
c. Ruskin Company.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:

a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel.
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

a. Multiple blade with three longitudinal grooves for reinforcement.
b. Parallel or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized-steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.

7. Bearings:

    a. Molded synthetic.
    b. Dampers in ducts with pressure classes of three (3) inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Jackshaft:

1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of three thirty second (3/32) inch- thick zinc-plated steel, and a three quarter (3/4) inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.8 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements products by one (1) of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip three and one half (3-1/2) inches wide attached to two (2) strips of two and three quarter (2-3/4) inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: - 40°F to + 200°F.

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: - 50°F to + 250°F.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of one (1) inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least one and one half (1-1/2) inches.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not

use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or No. 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than four (4) inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than four (4) inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within twenty four (24) inches of each elbow and within forty eight (48) inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of sixteen (16) feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Architectural Specification Sections "Exterior Painting" and/or "Interior Painting."

3.7 START UP

A. Air Balance: Comply with requirements in Division 23 Specification Section "Testing, Adjusting, and Balancing HVAC Systems."

3.8 DUCT SCHEDULE

A. Supply Ducts:

1. Pressure Class: Positive three (3) inch wg.
2. Minimum SMACNA Seal Class: A.
3. SMACNA Leakage Class for Rectangular: 6.

B. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. PVC-Coated Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Match duct material.

C. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1,000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.

2) Mitered Type RE 4 without vanes.

b. Velocity 1,000 to 1,500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1,500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3.9 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install

dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Label access doors according to Division 23 Specification Section "Identification for HVAC Systems and Equipment" to indicate the purpose of access door.

H. Install flexible connectors to connect ducts to equipment.

3.10 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233113

SECTION 233423 – HVAC EXHAUST FANS AND POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the requirements for centrifugal exhaust fans and power ventilators and accessories as follows:

1. Inline centrifugal fans

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan performance ratings on actual project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

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

1. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

a. Certified fan performance curves with system operating conditions indicated.
b. Certified fan sound power ratings.
c. Motor ratings and electrical characteristics, plus motor and electrical accessories.
d. Material thickness and finishes, including color charts.
e. Dampers, including housings, linkages, and operators.
f. Fan speed controllers.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

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. Wiring Diagrams: For power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Include a copy of each approved submittal along with any applicable maintenance data in the project operation and maintenance manual.

1.6 QUALITY ASSURANCE

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. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.7 SOURCE QUALITY CONTROL

A. Certify sound power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA Certified Ratings Seal.

1.8 COORDINATION

A. Coordinate size and location of structural steel support members.

1.9 WARRANTY/GUARENTEE

A. See Division 23 Specification Section “Basic Mechanical Requirements – HVAC” for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Equipment Design and Selection: Fans shall be designed and selected in accordance with the scheduled capacities on the drawings and the requirements of this specification. All

fans shall bear the AMCA Seal, and fan ratings shall be based on test and procedures performed in accordance with AMCA Publication 211, AMCA Publication 311 and comply with the AMCA Certified Ratings Program and be UL and/or CUL listed. For supply air fans see mechanical specifications for switchgear room AC units.

B. Basis of Design: The basis of design for centrifugal fans shall be equipment manufactured by Twin City Fans as follows:

1. Inline Type Centrifugal Fans

C. Other Acceptable Manufacturers: Subject to compliance with requirements, provide fans by one (1) of the following:

1. Inline Type Centrifugal Fans:

a. Greenheck, New York City Blower, Loren Cook, ACME

D. Factory Run Test: Prior to shipment all fans shall be completely assembled and test run as a unit at operating speed or maximum RPM allowed for the particular construction type. Each wheel shall be statically and dynamically balanced in accordance with ANSI/AMCA 204-96 "Balance Quality and Vibration Levels for Fans" to Fan Application Category BV-3, Balance Quality Grade G6.3. Balance readings shall be taken by electronic type equipment in the axial, vertical and horizontal directions on each of the bearings. Records shall be maintained and a written copy shall be available upon request.

E. Motors: Motors shall comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Specification Section "Motor Requirements for HVAC Equipment."

2.2 INLINE TYPE CENTRIFUGAL FANS

A. Fans: Inline centrifugal fans shall comply with the following:

1. Housing: Housings shall be constructed of heavy gauge, continuously welded steel to prevent air leakage. Housings shall include punched inlet and outlet flanges for duct mounting. Motor and bearing supports shall be constructed of heavy gauge steel and shall be suitably braced to prevent vibration and pulsation. Extended lube lines shall be supplied as standard for lubrication of the fan bearings without fan disassembly.
2. Fan construction shall include two removable access panels. Access panels shall be of sufficient size to permit easy access to all interior components. Fan wheel shall be centrifugal, backward-inclined, constructed of aluminum, and shall include a wheel cone matched to the inlet cone. Wheels shall be statically and dynamically balanced.
3. Direct Drive Application: All motors shall be split phase and capacitor start single

phase or three phase induction, permanently lubricated, heavy duty, ball bearing type, closely matched to the fan load and the schedules power requirements.

4. Finished Coating: The entire fan assembly, excluding the shaft, shall be thoroughly degreased and deburred before application of a rust preventive primer. After the fan is completely assembled, a finished coat of paint shall be applies to the entire assembly. Aluminum components shall be unpainted. The fan shaft shall be coated with a petroleum based rust protectant.
5. Electrical Requirements: Provide a single point connection for power. See drawings for power requirements.
6. Accessories: Provide the following accessories as required for the project:

    a. Mounting brackets.
    b. Vibration isolators.
    c. Disconnect switch.
    d. Companion flanges.
    e. Stamped Aluminum name plate.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing in for duct systems to verify actual locations of duct connections before fans are installed.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FAN INSTALLATION

A. Refer to and follow fan manufacturers guidelines for rigging fans to their location.

B. Install fans level and plumb.

C. Install fans to provide access for periodic maintenance including removing motors, fan wheels, couplings, and accessories.

D. Independently support fans and ductwork so the weight of ductwork is not supported by the fans and weight of fans is not supported by the ductwork.

E. Inline Equipment: Install inline fans in a horizontal position from the structure using hangers and supports of the size required to support weight of inline fans. Comply with requirements for hangers and supports specified in Division 23 Specification Section "Hangers and Supports for HVAC Piping Systems."

F. Label units according to requirements specified in Division 23 Specification Section "Identification for HVAC Systems and Equipment."

3.3 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Specification Section "HVAC Duct Systems and Accessories."

B. Ground equipment according to Division 26 Specification Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Specification Section "Low Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Division 23 Specification Section "Testing, Adjusting, and Balancing HVAC Systems" for testing, adjusting, and balancing procedures.

C. Replace fan and motor pulleys as required to achieve design airflow.

D. Lubricate bearings.

END OF SECTION 233423

SECTION 238119 – SELF CONTAINED AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section and all other sections of Division 23.

1.2 SUMMARY

A. This section includes the requirements for direct expansion air conditioning units intended for indoor installations and related equipment as follows:

1. Vertical floor mounted unit

1.3 ACTION SUBMITTALS

A. Product Data: For each specified product, include manufacturers cut sheets, dimensional data, performance data, refrigerant type, micro-processor controller, installation instructions, wirings diagrams, power requirements, specified options, and warranty information.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

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. Wiring Diagrams: For power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Include a copy of each approved submittal along with any applicable maintenance data in the project operation and maintenance manual.

B. Maintenance Material Submittals:

1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

    a. Filters: One (1) set(s) of filters for each unit.
    b. Fan Belts: One (1) set(s) of belts for each unit.

1.6 QUALITY ASSURANCE

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. ARI Compliance:

1. Applicable requirements in ARI 210/240.
2. Applicable requirements in ARI 340/360.
3. Applicable requirements in ARI 390.

C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.7 COORDINATION

A. Coordinate installation of DX air conditioning units with switchgear room access and clearances required.

B. Coordinate sizes and locations of equipment supports, roof steel support structures, and penetrations with actual equipment provided.

1.8 WARRANTY/GUARANTEE

A. See Division 23 Specification Section “Basic Mechanical Requirements – HVAC” for minimum warranty and guarantee requirements.

B. Special Warranty: Provide warranty for a period of 5 years from data of purchase, in which the manufacturer agrees to repair or replace components of the self-contained air conditioning units

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Equipment Design and Selection: Self contained DX units shall be designed and selected in accordance with the scheduled capacities on the drawings and the requirements of this specification.

B. Basis of Design: The basis of design is self contained air conditioning equipment manufactured by Stultz Air Technology as follows:

1. Floor Mounted Vertical Units: Cyber One Model CFD

C. Other Acceptable Manufacturers: Subject to compliance with requirements, provide self contained air conditioning equipment by one (1) of the following:

1. Above Air Technologies
2. Compu-Aire Inc.

D. BAS Interface: Units shall be furnished with software communications interface capability for connectivity to the external Building Automation System through Bac Net IP Protocol and comply with the points list in this specification.

2.2 FLOOR MOUNTED VERTICAL DX UNITS

A. Unit Configuration: Unit configuration shall be as follows:

1. Ductless Configuration: Unit shall be provided with a discharge plenum located on top of the unit with three (3) supply grilles. Return air grille shall be located on the front panel of the unit.

B. Unit Casing and Condensate Drain Pan: Unit casings shall be constructed from 16 gauge galvanized steel panels and supported by internal three sixteenths (3/16) inch galvanized steel frames. Casing shall be lined with Armacell one half (1/2) inch thick, closed cell fiber free elastomeric foam insulation with an ‘R’ value of 2.1 at indicated thickness and conforming to ASTM C534, ASTM E84, NFPA 225, UL 723 and NFPA 90A, 90B. The internal condensate drain pan shall be constructed of 20 gauge stainless steel with drain connection on the same end as the pipe connections for the water cooled condenser. Unit Color shall be the manufacturer’s standard color.

C. Fan Types: Fan type shall be as follows:

1. Non Ducted Units: Supply fan shall be a standard direct drive assembly with a double inlet, dynamically balanced fan with forward curved blades, and motor. Fan and motor shall be mounted on vibration isolators. Fan and motor assemblies that are rigid mounted to the cabinet are acceptable provided the unit is provided with external isolation.

D. Evaporator Coil: Evaporator coil shall be design to provide maximum coil surface area

and minimum depth to provide a high sensible cooling capacity. Coils shall be constructed of seamless drawn copper tubes, mechanically bonded to tempered aluminum fins with a raised lanced fin design for maximum heat transfer. Coil end plates shall be hot dipped galvanized steel. The evaporator coil shall be mounted in a stainless steel condensate drain pan. Coils in a 'A' frame configuration or slab configuration are acceptable.

E. Filter Chamber and Filter: Filters chamber shall be an integral part of the unit, located within the cabinet. Filter shall be slide out type, (2) inch deep class 2 filter per U.L. Standard 900 and shall also have a rating of at least 80% average arrestance as measured by ASHRAE Standard 52-76 test method. Filter shall be accessible through front hinged access door.

F. Refrigeration System: The refrigeration system shall include a single scroll high efficiency, high reliability, low noise compressors, with hot gas bypass, mounted on vibration isolators, type 'L' copper refrigeration tubing with brazed fittings, sight glass, externally equalized expansion valve, liquid line filter dryer, and charging and service ports. The refrigeration system shall be pre charged with HCFC – 407-C or 410–A refrigerant.

G. Control Panel: Unit mounted pre-wired control panel shall include contactors, relays, control transformer, capacitors, high and low refrigerant pressure switches, compressor and fan automatic reset safety devices for a complete control system.

H. Modular Motor Controllers: The systems shall incorporate modular motor controllers utilizing motor start protectors and circuit breakers to eliminate the need for fuses. The control circuit shall be a 24 VAC Class II low voltage circuit, including primary and secondary circuit protection. Low voltage, high voltage, and common wires shall be color-coded and shall be individually numbered at each end for ease of service tracing. All wiring shall be in accordance with the National Electric Code (NEC) and shall include:

1. Motor branch circuit short circuit protection;
2. Motor load switching controllers (contactors)
3. Motor overload protection.

I. Unit Power Supply: Single Source power supply shall include a unit mounted main power dust proof, non fused type disconnect switch with a lockable handle for the following:

1. 460 volt three phase.

J. Microprocessor Control: Provide manufacturer's microprocessor, for each A/C unit, with a BAC NET IP serial card. Microprocessor shall be Model ES by Stultz Air Technology or Model MC 2000 by Above Air Technology. The following I/O addressable points shall be included:

1. Unit on/off
2. Compressor running Module1
3. Fan running Module1
4. Compressor low pressure alarm Module1
5. Compressor high pressure alarm Module1
6. Air flow alarm Module1
7. Water detector alarm Module1 (condensate pan)
8. Room temperature to high alarm
9. Room temperature to low alarm
10. Supply temperature to high alarm
11. Supply temperature to low alarm
12. Water temperature to high alarm
13. Water temperature to low alarm
14. Set point temperature
15. Set point supply air temperature
16. Actual return air temperature
17. Supply air temperature

K. Accessories: Accessories shall include the following:

1. Over Flow Safety Switch: A condensate pan water level switch shall be incorporated to shut the system down if an overflow condition is sensed.
2. Supply Air Temperature Sensor/Monitor: Provide a supply air temperature sensor for field installation in the unit and wired through the microprocessor controller to the BAS. Sensor shall only monitor the supply air temperature with a signal to BAS.
3. Capacity Assist Option: Where multiple units will condition the same room provide the capacity assist option. Program the vertical unit as the active unit and the second unit as the assist unit. On a call for cooling the active unit, shall be energized, through its controller, to maintain the room set point (75). If the active unit cannot satisfy the room set point, the assist unit shall be energized through its unit controller to assist the active unit. When the room set point is satisfied the assist unit shall be de-energizer, then the active unit shall be de-energized. Program the active unit for cooling. Program the assist unit for the same functions and include a 3^{o}F differential between the active and assist units.
4. Provide minimum 6” floor mounted support to elevate unit off of the floor.

2.3 AIR COOLED OUTDOOR CONDENSER:

A. Remote Outdoor Condenser: Basis of design is Stulz model SCS. Condenser casings shall be fabricated from heavy aluminum for corrosion protection and appearance. Structural components shall be fabricated from galvanized steel for support. Motors shall be permanently lubricated ball bearings and be internally protected. Fans shall be propeller type with blades made from aluminum and shall have zinc plated hubs for strength and corrosion protection. The condenser shall be provided with a receiver package, factory pre-assembled on an aluminum mounting skid to allow ease of installation. Each receiver

package shall include an insulated liquid refrigerant receiver with receiver liquid sight glass, rotalock service valves factory installed on the inlet and outlet connections of the receiver for refrigerant isolation, a pressure relief valve, and a receiver heater pad with internal thermostat control. Each condenser shall be provided with a head pressure control valve. Field install head pressure control valve. Condenser coils shall be constructed of copper tubes with aluminum fins spaced no greater than 14 FPI. Coils shall be factory pressure tested to UL1995.

B. Condenser/Fan Cycling Control Box: The condenser control box shall be factory mounted in an outdoor rated enclosure. The condenser control box shall include, but not be limited to:

1. Fan Motor starter(s)/contactor(s)
2. Fan Cycling Aquastat(s) to sense coolant temperature to maintain proper coolant temperature in DX mode.
3. Main Power Non-Fused Disconnect Switch.

C. Terminal strip for external connectivity to A/C Unit or Building Automation System. The terminal strip shall have dry contact available which will allow for the following:

1. Enable/disable condenser
2. Flow status

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with the installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the work.

B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.

C. Examine project area for suitable conditions where DX air conditioning units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Anchor units to structure.

B. Install DX air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to ARI Guideline B.

C. Vertical DX Units for Switchgear Rooms: Comply with requirements specified in Division 23 Specification Sections.

1. Floor mount units indoors at grade.

D. Rooftop Condenser Unit Mounting:

1. Install condensing units on rooftop structural steel.

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Arrange piping to remain clear of manufacturers recommended space for maintenance and service.

B. Condensate Drainage Connection: Provide connections for condensate drain. Pipe drain through existing walls to the building exterior.

C. Refrigerant Piping: Provide connections for refrigerant piping. Route piping from indoor units to the rooftop condensers. Seal all roof penetrations. Field install head pressure control valves. Insulate all refrigerant piping. Refer to specification section 230700 “Insulation for HVAC Systems and Equipment.”

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, and to assist in testing.

B. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation, and inspect for refrigerant leaks.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Provide a seven (7) days notice to UMB for owner to witness the inspection and testing.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare and submit test and inspection reports to the CM.

3.5 STARTUP SERVICE

A. Engage a factory authorized service representative to perform startup service.

B. Provide a seven (7) days notice to UMB for owner to witness the start up service.

3.6 COMMISSIONING

A. See Division 23 Specification Section “Commissioning Mechanical Systems” for requirements.

3.7 DEMONSTRATION

A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

B. Provide a seven (7) days notice to UMB for owner to attend the demonstration.

END OF SECTION 238119

SECTION 260000 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section and all other Electrical Specification Sections.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements, as well as the following basic electrical materials and methods:

1. Submittals.
2. Record documents.
3. Operation and Maintenance manuals.
4. Rough-ins.
5. Electrical installations.
6. Cutting and patching.
7. Access to electrical installations.

B. Summary of Work:

1. Provide a complete integrated electrical system in accordance with the intent of these specifications and the accompanying drawings.

1.3 REFERENCED ORGANIZATIONS AND CODES

A. The following list of abbreviations, are utilized within the specifications and are provided as a reference.

B. All work in Divisions 26, 27, and 28 shall comply with the latest version of following codes and regulations as adopted by the State of Maryland and the State Fire Marshal, unless otherwise specified.

1. NFPA (National Fire Protection Association).
2. NESC (National Electrical Safety Code).
3. ADA (American with Disabilities Act).
4. ANSI (American National Standards Inst.).
5. OSHA (Occupational Safety & Health Act).
6. COMAR (Code of Maryland Regulations).
7. UL (Underwriters Laboratories).
8. IBC (International Building Code).

9. State of Maryland Fire Prevention Code.
10. ANSI/EIA/TIA.
11. NETA (National Electrical Testing Association).
12. NEMA (National Electrical Manufacturer's Association).
13. NECA (National Electrical Contractors Association).

1.4 SITE VISIT

A. Prior to preparing the bid, the electrical subcontractor shall visit the site and become familiar with all existing conditions. Make all necessary investigations as to locations of utilities and all other matters which can affect the work. No additional compensation will be made to the contractor as a result of his failure to familiarize himself with the existing conditions under which the work must be performed.

1.5 OUTAGES

A. For all work requiring an outage, the contractor shall submit an outage request to the UMB Project Manager, using the UMB Standard Request for Outage Form which is available through the UMB Design and Construction Web Site at http://www.umaryland.edu/designandconstruction/, under the Documents Link. The existing mechanical/electrical systems shall remain operational unless turned off by University personnel during the construction of the project. For each electrical outage request include a photograph of the panel index schedule for each panel affected by the outage.

B. Unless otherwise specified, outages of any services required for the performance of this contract and affecting areas other than the immediate work area shall be scheduled at least ten days (10) days in advance with the Office of Facilities Management. All such outages shall be performed on other than normal duty hours.

C. All electrical outages which will interfere with the normal use of the building in any manner shall be done at such times as shall be mutually agreed upon by the contractor and the Office of Facilities Management.

D. The contractor shall include in his price the cost of all premium time required for outages and other work which interferes with the normal use of the building, which will be performed, in most cases, during other than normal work time and at the convenience of the University.

E. The operation of electrical equipment; required to achieve an outage must be accomplished by University personnel only. Prospective subcontractors under this section are cautioned that the unauthorized operation of electrical equipment or other control devices by their personnel can result in extremely serious consequences for which the contractor will be held accountable.

1.6 INSTALLER'S QUALIFICATIONS

A. Electrical Installer shall submit the following evidence:

1. Five (5) comparable completed projects.
2. Reference letters from minimum of three (3) registered professional engineers, general contractors, building owners, explaining proficiency, quality of work, or other attribute on projects of similar size or substance.
3. Copy of Maryland Master Electrician's License.
4. Local or State license where required.
5. BICSI and NICET certification, where required by these specifications.

B. The electrical installer shall utilize a full time project foreman in charge of all electrical work.

1. Fully qualified and experienced in such work.
2. Available, on site, at all times during construction.
3. All communication shall be through this person.

C. Installer of specialized systems such as Fire Alarms, telecommunication systems, etc. shall meet the requirements of the associated spec section(s).

1.7 CUTTING, WELDING, BURNING

A. Before the contractor and/or any sub-contractor commence's any cutting, welding, and/or burning, the contractor shall obtain a hot work permit from Environmental Health and Safety at extension 1-410-706-3490.

B. The hot work permit copy shall remain on the job site at the hot work location until such work is completed at which time the permit shall be returned to Environmental Health and Safety.

1.8 WORK PERFORMANCE

A. All electrical work must comply with the requirements of NFPA 70 (NEC), NFPA 70B, NFPA 70E, OSHA Part 1910 subpart J, OSHA Part 1910 subpart S and OSHA Part 1910 subpart K in addition to other references required by the contract.

B. Before initiating any work, a job specific work plan must be developed by the contractor. The work plan must include procedures to be used on and near the live electrical equipment, barriers to be installed, and safety equipment to be used and exit pathways.

C. Job site and worker safety are the responsibility of the contractor. Compliance with the requirements of NFPA 70E is subject to ongoing inspection by University personnel and failure to comply will result in an immediate Stop Work order being issued and enforced

at the contractor's expense.

D. Energized electrical conductors and circuit parts to which an employee might be exposed shall be put into an electrically safe work condition before an employee performs work any time the employee is within the limited approach boundary or, where an increased risk of injury from an exposure to an arc flash hazard exists.

E. Outages should be scheduled a minimum of ten (10) days in advance.

F. Mandatory Requirements: The following requirements are mandatory:

1. Protective Equipment: Electricians must use full protective equipment (i.e., certified and tested insulating material to cover exposed energized electrical components, certified and tested insulated tools, etc.) while working on energized systems in accordance with NFPA 70E.

2. UMB Energized Work Permit: A UMB Energized Work Permit is required for any work on energized circuits or equipment. Permit must be approved by UMB Department of Operations and Maintenance prior to performing energized work. Submit the work permit with the outage request.

1.9 SUBMITTALS

A. General: Follow the procedures specified in Division 01 Section "Submittals."

B. Product data as specified in the electrical specifications.

C. Shop drawings detailing fabrication and installation requirements for electrical equipment.

D. In addition to the following list, submit other shop drawings as may be requested by UMB.

1. Divisions 26, 27, & 28:
   a. Compression Wire Connectors
   b. Fire Resistant Sealant
   c. Ground Wire
   d. Surface Raceway
   e. Wireways
   f. Raceway, Boxes and Cabinets
   g. Wires and Cables
   h. Fire Alarm System: Refer to Division 28 Section "Digital, Addressable Fire Alarm System" for submittal requirements

E. In instances of complex field wired systems, including but not limited to: fire alarm

system, the contractor shall submit:

1. Cut sheets of every component such as control panels, fire alarm devices, wire, etc.
2. The contractor shall submit detailed riser diagrams detailing point-by-point connections. Diagrams shall indicate cable on raceway between points.
3. Corresponding floor plans showing only this particular system with conduit and wire runs between points.
4. Both riser and floor plan shall indicate address of devices where applicable.
5. Calculations for battery capacity and voltage drop.
6. Preliminary programming information.

F. Submittal File Format: File formats for each submittal shall be electronically as follows:

1. Product Data: “pdf” file format.
2. Shop Drawings: “pdf” file format.
3. Coordinated Drawings: “pdf” or “dwg” file formats.

1.10 QUALITY ASSURANCE

A. Comply with NFPA 70 for components and installation.

B. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms “Listed and Labeled”: As defined in the National Electrical Code, Article 100.
2. Listing and Labeling Agency Qualifications: A “Nationally Recognized Testing Laboratory” (NRTL) as defined in OSHA Regulation 1910.7.

C. Install all components and equipment per manufacturer’s written instructions.

D. Provide installation in accordance with recognized trade organizations and standards:

1. NEMA.
2. NECA “Standards of Installation”

1.11 COORDINATION DRAWINGS

A. General: When required participate in the preparation of the coordinated drawing effort for the project. See Specification Division 01 for general requirements.

B. Coordination Drawings: In addition to the requirements of the Specification Division 01 prepare the plumbing part for the coordination drawing effort. Work with the other trades to ensure the material and equipment installed as part on the electrical system will not be

in conflict with the installation of material and equipment by the other trade contractors. Unless otherwise indicated the coordination drawings, including plans, sections, and elevations shall be prepared at a scale of not less than 1/4 inch = 1 foot- 0 inches. At a minimum, prepare coordination drawings for all mechanical rooms, electrical rooms and substation rooms.

C. File Format: Coordination drawings shall be in a layered structure form as CAD Files or PDF Files for each floor with searchable text as follows:

1. File Structure: The "pdf" or "dwg" files shall have separate layered structure for:

a. Building Elements: Indicate each building element on separate layers, such as:

1) Walls.
2) Reflected ceiling plan.
3) Room numbers.

b. Systems and Sub Systems: Indicate each system or sub system as warranted by congestion or complexity on separate layers such as:

1) Examples of Systems:
a) Lighting System.
b) Power Distribution System.

2) Examples of Sub Systems:
a) Normal Power.
b) Emergency Power.

2. The layered electronic files shall allow building elements, building systems and sub systems to be viewed in isolation or in combinations that are user selectable when the drawing files are being displayed.

D. Coordination Effort: This coordination effort shall include detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of electrical equipment, and materials. Include the following:
a. Planned electrical systems layout, including conduit elbow radii and accessories.
b. Clearances for servicing and maintaining electrical equipment.

c. Exterior wall and foundation penetrations.
d. Fire rated wall and floor penetrations.
e. Sizes and location of required concrete pads and bases.
f. Size and location of all electrical panels.
g. Access doors.

2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations. Show all access doors for concealed junction boxes devices.
4. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, cable trays, sprinklers, access doors and other ceiling mounted items.

1.12 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 01 Section "Contract Closeout." In addition to the requirements specified in Division 01, indicate the following installed conditions:

1. Conduit and wire runs between the points
2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Approved substitutions, Contract Modifications, RFI responses and actual equipment and materials installed.

1.13 OPERARTION AND MAINTENANCE MANUALS

A. Electrical O & M Manual File: Provide one (1) electronic file “pdf format” for the projects Electrical Operation and Maintenance Manual for the Material and Equipment installed in the project included in Divisions 26, 27 and 28 on a CD-R. The electronic Electrical O & M manual shall include one copy of each approved submittal, any manufacturer’s maintenance manuals, all warranty certificates, arranged in file folders for each submittal. Also include the address, phone number and contact person for each supplier. Files shall be stacked and include both a book mark and tree structure for accessing each submittal file as indicated in Division 01 Section “Closeout Procedures”.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.15 SEQUENCING AND SCHEDULING

A. Coordinate electrical equipment installation with other building components.

B. Arrange for chases, slots, and openings in building structure during progress of construction to allow for electrical installations.

C. Coordinate the installation of required supporting devices and set sleeves in poured in place concrete and other structural components as they are constructed.

D. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

E. Coordinate connection of electrical services.

F. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

G. Coordinate requirements for access panels and doors where electrical items requiring access are concealed behind finished surfaces. Access panels and doors are specified in the Architectural Specifications.

H. Coordinate installation of identifying devices after completing covering and painting where devices are applied to surfaces. Install identifying devices prior to installing acoustical ceilings and similar concealment.

1.16 VARIANCES

A. Where variances occur between the drawings and specifications or within either document itself, the item or arrangement of better quality, greater quantity or higher cost shall be included in the contract price. The Engineer shall decide on the item and manner in which the work shall be provided.

1.17 GUARANTEE/WARRANTY:

A. All materials, equipment, etc. provided by the general contractor and/or his subcontractors shall be guaranteed and warranted to be free from defects in workmanship and materials for a period of two (2) years after date of certificate of completion and acceptance of work by UMB. Any defects in workmanship, materials, or performance which appear within the guarantee period shall be corrected by the contractor without cost to the owner, within a reasonable time, to be specified by UMB. In default thereof, owner may have such work done and charge the cost of same to the contractor. In addition to the above statement the Guarantee/Warranty Period shall include all labor cost related to all warranty work. For compressorized equipment include an additional three (3) year Guarantee/Warranty Period.

PART 2 - PRODUCTS

2.1 LISTED MANUFACTURERS:

A. Listed Manufacturers: The listed manufacturers indicated in Part 2 of each specification section as the basis of design represents the minimum level of quality for materials and equipment that is acceptable to UMB. Unless otherwise indicated in each specification section, contractors may submit material and equipment by non listed manufacturers provided said submittals meet the requirements of these specifications. All submitted materials and equipment are subject to approval by the A/E and UMB.

B. Approved Equal Equipment Layouts: The equipment layouts and the related mechanical and electrical service connections, access space and supports indicated on the construction documents represent equipment provided by the specified basis of design manufacturer and model number. When the successful bidder chooses to provide "or approved equal" equipment by one (1) of the other listed manufacturers in the specifications, the bidder shall be responsible for providing all adjustments and modifications to the services necessary to make connections to the equipment, the bidder shall be responsible for installing the equipment such that all required clear access space is maintained, and the bidder shall be responsible for providing all adjustments and modifications to the equipment mounting and supports. All adjustments and modifications shall be provided by the bidder and appropriate subcontractors at no additional cost to the project.

PART 3 – EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. For equipment rough-in requirements see specifications for electrical equipment.

3.2 ELECTRICAL INSTALLATIONS

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

1. Coordinate electrical systems, equipment, and materials installation with other building components.
2. Verify all dimensions by field measurements.
3. Install systems, materials, and equipment to conform with approved submittal data, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual

system requirements, refer conflict to UMB.

4. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
5. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
6. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.3 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1 Section "Cutting and Patching." In addition to the requirements specified in Division 1, the following requirements apply:

1. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

B. Perform cutting, fitting, and patching of electrical equipment and materials required to:

1. Uncover Work to provide for installation of ill timed Work.
2. Remove and replace defective Work.
3. Remove and replace Work not conforming to requirements of the Contract Documents.
4. Disconnect installed work as specified for testing.
5. Install equipment and materials in existing structures.
6. Upon written instructions from UMB, uncover and restore Work to provide for UMB observation of concealed Work.

C. Cut, remove and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical systems and equipment as indicated on the drawings and specifications and other electrical items made obsolete by the new Work.

D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

1. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

a. Refer to Division 01 Section "Definitions and Standards" for definition of "experienced Installer."

2. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.
   a. Refer to Division 01 Section "Definitions and Standards" for definition of "experienced Installer."

3.4 PROTECTION OF WORK

A. Protect work, material and equipment from weather and construction operations before and after installation.

B. Properly store and handle all materials and equipment.

C. Cover temporary openings for electrical equipment to prevent the entrance of water, dirt, debris, and other foreign matter.

3.5 PROVISIONS FOR ACCESS

A. Furnish and install adequate access to all electrical components. The following list shall be used as a guide only:

1. Equipment such as transformers, generators, etc.
2. Distribution panels.
3. Switchgear.
4. Disconnects.

B. Access shall be as required by code and/or as determined by the Architect and Engineer.

C. Refer to contract drawings where access panels have been specifically located.

D. Where access is by means of lift out ceiling tiles or panels mark access each panel using small color coded or numbered tabs. Provide an index chart for identification. Place markers in corner of tile.

3.6 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate operation and maintenance of equipment and systems to Owner’s personnel a minimum two (2) weeks prior to date of final inspection.

1. For equipment requiring seasonal operation, perform instructions for other seasons at the same time.

2. Training period shall be performed within one (1), two (2) week period.

B. Use operation and maintenance manuals and video as basis of instruction. Review contents of manual and video with personnel in detail to explain all aspects of operation and maintenance.

C. Demonstrate the following:

1. Start up.
2. Operation.
3. Control.
4. Adjustment.
5. Trouble shooting.
6. Servicing.
7. Maintenance.
8. Shutdown.

D. Provide at least forty (40) hours straight time instruction to the operating personnel.

1. This instruction period shall consist of not less than five (5) eight (8) hour days.
2. Time of instruction shall be designated by the Owner.
3. This instruction shall be in addition to instructional requirements of specific equipment specified elsewhere in the mechanical specifications.

3.7 EQUIPMENT PROVIDED UNDER ANOTHER DIVISION AND BY OTHERS

A. The Installer of products under Divisions 26, 27, & 28 shall make all system connections required to equipment furnished and installed under another division and by others.

B. It shall be the responsibility of the Installer to obtain all necessary data from the equipment supplied under other Divisions.

3.8 RECORD DRAWINGS (AS BUILT)

A. Upon completion of the electrical installations, the Installer shall deliver to the Architect one (1) complete set of marked-up blueprints of the electrical contract drawings.

1. The mark-ups shall be legibly marked in red pencil to show all changes and departures of the installation as compared with the original design.
2. Refer to General Requirements of Division 01 for additional requirements pertaining to Submittals and Record Drawings.

3.9 CLOSEOUT PROCEDURES

A. Operating and Maintenance Instructions: Submit Complete Package At Least Two (2)

Months Prior To Substantial Completion. Arrange for each installer of equipment that requires regular maintenance to meet with the Owner's personnel to provide instruction in proper operation and maintenance. If installers are not experienced in procedures, provide instruction by manufacturer's representatives. Include a detailed review of the following items:

1. Maintenance manuals, including a customized list of preventive maintenance items and annual schedule for maintenance.
2. Record documents.
3. Complete inventory of spare parts and materials.
4. Tools.
5. Identification systems.
6. Control sequences.
7. Hazards.
8. Cleaning.
9. Warranties and bonds.
10. Maintenance agreements and similar continuing commitments.

B. As part of instruction for operating equipment, demonstrate the following procedures:
1. Start up.
2. Shut down.
3. Emergency operations.
4. Safety procedures.

3.10 INSPECTIONS

A. Contractor shall:
1. Schedule, pay for (as applicable) and attend all inspections required by the Authorities Having Jurisdiction.

2. Deliver all certificates to the Owner prior to final acceptance of work.

B. Notify UMB in advance of scheduled inspections.

C. An electrical foreman, superintendent or other supervisor familiar with the project shall be in attendance for all scheduled electrical inspections.

D. Electrical inspection shall be by the third (3^{rd}) Party Inspector approved by the Maryland State Fire Marshall.

E. Schedule the preliminary and rough-in inspections in a timely manner. Any work covered prior to any inspection in a manner which, in the inspector's opinion, precludes a complete inspection shall be uncovered at the installer’s cost.

3.11 DEMOLITION:

A. Remove and dispose of all existing materials not required for re-use or re-installation.

B. Deliver on the premises, where directed, existing material and equipment which is to be salvaged and remain property of Owner.

C. All other materials removed shall become the property of the Contractor and shall be removed from the premises.

D. Remove conduit, hangers, supports, etc. to a point below the finished floors or behind finished walls and cap. Cut such items flush with masonry surfaces.

E. Remove wiring and conduit back to source panelboard or switch, or to last remaining device on the circuit. Remove conduit, hangers, supports, etc. unless otherwise noted. Conduit may remain to be reused for new work provided it is of the specified size and type and in condition acceptable to UMB.

F. Any conduit abandoned in concrete slabs, walls, or other inaccessible locations shall be left with a nylon pull wire. Ends shall be capped with push plugs for future use.

3.12 REPAIRS & RESTORATION OF SURFACES AND FINISHES:

A. Restore all finishes, equipment and surfaces to original condition, where affected by the work. Provide the following, where applicable, in accordance with accepted trade standards and to Owner’s satisfaction:

1. Replace damaged ceiling tiles.
2. Replace ceiling tiles where removal has left holes or cuts in original tiles.
3. Patch, repair and repaint all walls and surfaces cut, penetrated or otherwise disturbed by the work.
4. Patch holes and penetrations in wood, masonry and plaster.
5. Provide suitable cover plates for all recessed back boxes of equipment removed and not covered by new devices.
6. Provide larger trim or cover plates for new devices, where old back boxes, holes, etc. are not concealed by new work.

3.13 FINAL CLEANING

A. General: General cleaning during construction is required by the General Conditions and included in Section Temporary Facilities.

B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to the condition expected in a normal, commercial building cleaning and maintenance program. Comply with manufacturer's instructions.

C. Remove all electrical clippings, wiring, nuts, bolts, etc. left on top of ceilings and ceiling tiles.

3.14 PROJECT PUNCH OUT

A. Architect/Engineer will perform punch out reviews and will provide the Contractor with a list of punch list items to be completed before contract close out. Each and every punch list item shall be initialed and dated by the Contractor when the work is complete. The Architect/ Engineer will not perform any punch list verification until all items have been completed, initialed, dated and the list returned to the Architect/Engineer. If any items have been initialed as being completed by the Contractor and the Architect/Engineer determines that the work is not complete, the Architect/Engineer shall be reimbursed by the Contractor at his regular hourly rate for any and all items requiring revisiting of the site by the Architect/Engineer. Reimbursement shall be made by deducting the Architect/Engineer fee from the Contractor's final payment.

END OF SECTION 260000

SECTION 260513 - MEDIUM-VOLTAGE CABLES

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 and all other sections of Division 26.

1.2 SUMMARY

A. This Section includes cables and related splices, terminations, accessories and acceptance testing for 15,000 volt electrical distribution systems.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.

C. Samples: Sixteen (16) inch lengths of each type of cable indicated.

D. Qualification Data: For Installer and testing agency. Data submitted shall confirm that the person(s) and firm(s) listed in the "Quality Assurance" Article have demonstrated their capabilities and experience. The data shall include, but limited to a list of completed projects with project names, addresses, names of Architects and UMBs. Additional data includes:

E. Material Certificates: For each cable and accessory type, signed by manufacturers.

F. Source quality-control test reports. Certified reports of manufacturer’s design and production tests indicating compliance of cable and accessories with reference standards.

G. Field quality-control test reports. Field test reports indicating and interpreting test results relative to compliance with performance requirements specified. Include certified copies of field test reports.

H. Installation Manual: Manual shall include all data relative to installing the cables and accessories. Maximum pulling tensions, side wall pressure limitations, type of pulling devices shall all be documented within the manual.

I. Operation & Maintenance Manual: Include recommendation relating to acceptance and periodic maintenance testing and infrared scanning photometry. Recommendation shall include frequency and type of testing. Operation data shall include data of fault indicators and separable connectors and their accessories.

1.5 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable. Submit the following within 30-days of contract award:

1. Name of individual(s) performing splicing/terminating
2. Certification of individual performing test with name and date
3. Number of years of medium voltage splicing/terminating experience
4. Proof of termination/splice of the type to be installed, under supervision of the kit manufacturer, or representative
5. Dummy splice/termination successfully tested as follows. Test to be performed by the splice kit supplier.

Test	Minimum Value
Discharge Ext. Value with, 3 pcs.	13-kV
Ac Withstand, 1 minute	35-kV
DC Withstand, 15 minutes	65-kV

6. List of three recent jobs within last twelve (12) months where specific splices/terminations were installed. Include splice/termination manufacturer, catalogue number, cable type and the quantity installed.

B. Manufacturer Qualifications: Firm experienced in manufacturing medium-voltage cable and accessories similar to those indicated for this project, with a ten (10) year record of successful in-service performance

C. Testing Agency Qualifications: In addition to the requirements specified in Division 1 Section "Quality Control Services," an independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing

laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

D. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with IEEE C2 "National Electrical Safety Code" and NFPA 70.

G. Production Tests shall be performed on the cable at time of manufacture.

1. Resistance requirements of ICEA S-68-516, section 2.5.
2. Insulation resistance test shall be performed in accordance with ICEA S-68-516, part 6.28, and shall have an insulation resistance constant of at least 50,000 megohms-1000 feet at 15^0C.
3. A high voltage ac and dc test shall be performed in accordance with part 6.27 of ICEA S-68-516. The test voltage shall be as follows:

Insulation	Wall	AC kV (5 Minutes)	DC kV (15 minutes)
115	23	45	
220	44	80	

4. The shield resistance shall be measured and recorded from end top end on the complete cable
5. The cable shall be corona discharge tested in accordance with Section G of AEIC CS^. The maximum allowable discharge is <u>five (5)</u> picocoulombs throughout the entire specified test voltage range.
6. Certified test reports shall be furnished to the Engineer, for review, for all cables prior to installation.

1.6 PROJECT CONDITIONS

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

1. Notify UM in writing no fewer than ten (10) days in advance of proposed interruption of electric service.

2. Do not proceed with interruption of electric service without written permission from – UMB PM.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver medium voltage cable on factory reels conforming to NEMA WC 26.

B. Store cables on reels on elevated platforms in a dry location.

C. Provide hot–shrink (cold-shrink not permitted) cable end caps for cable stored outside.

1.8 WARRANTY/GUARANTEE

A. See Division 26 Specification Section "Basic Electrical Requirements' for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cables:

a. General Cable Technologies Corporation.
b. Okonite Company (The).
c. Pirelli Cables & Systems NA.
d. Rome Cable Corporation.
e. Southwire Company.
f. Approved Equal.

2. Cable Splicing and Terminating Products and Accessories:

a. G&W Electric Company.
b. Raychem Corp.; Telephone Energy and Industrial Division; Tyco International Ltd.
c. RTE Components; Cooper Power Systems, Inc.
d. Thomas & Betts Corporation/Elastimold.
e. 3M; Electrical Products Division.
f. Approved Equal.

3. Arc Proofing Products:

a. 3M/ Scotch Products.
b. Plymoth Bishop
c. Thomas and Betts Corporation

2.2 CABLES

A. Cable Type: MV105, single conductor insulated power cable.

B. Comply with UL 1072, AEIC CS 8, ICEA S-93-639, and ICEA S-97-682, ASTM B-8 or B-231.

C. Conductor: Copper.

D. Conductor Stranding: Compact round, concentric lay, Class B.

E. Conductor Insulation: Ethylene-propylene rubber (EPR) conforming to NEMA WC74 (ICEA S-68-516 and AEIC CS6).

1. Voltage Rating: 15 kV.
2. Insulation Thickness: 133 percent insulation level.

F. Shielding: Copper tape, helically applied over semiconducting insulation shield.
1. 25% tape overlay

G. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

2.3 SPLICE KITS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

1. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.

2.4 SOLID TERMINATIONS

A. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
2. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
3. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
4. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

C. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.

4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

F. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, ground cable set and carrying case.

2.6 FAULT INDICATORS

A. Indicators: Manually reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.7 PROTECTIVE CABLE END CAPS

A. Protect MV cables from water penetration on job site, before, during and after cable pulling. Seal cable end with heat-shrinkable end cap. This cap will remain in place until the actual time of termination. Sealing compounds and/or taping shall not constitute acceptable environmental protection. End sealing caps shall be as produced by Raychem Corporation, Type ESC, or equal.

2.8 ARC-PROOFING MATERIALS

A. Tape for First Course on Metal Objects: 10-mil- thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch wide.

2.9 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682, NEMA WC74 before shipping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to manufacturer's written instructions and IEEE 576.

B. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use NRTL - listed and manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
3. Provide written calculations confirming pulling tensions and side wall pressure limits are within cable manufacturer's recommendations. Submit to Engineer prior to start of work.

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

D. Install "buried-cable" warning tape twelve (12) inches above cables.

E. Install fault indicators on each phase where indicated.

F. In manholes, hand holes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.

G. Install cable splices at pull points and elsewhere as indicated; use standard kits.

H. Install terminations at ends of conductors with standard kits.

I. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: Three.
3. Standoff Insulator: Three.

J. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil pipe-wrapping tape.

3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with one (1) inch- wide bands of half-lapped, adhesive, glass-cloth tape two (2) inches o.c.

K. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

L. Identify cables according to Division 26 Section "Identification for Electrical Systems."

M. Prior to installing cables, pull a mandrel sized 1/4" less than conduit ID. Then clean each conduit with a stiff brush to remove debris.

N. Use pulling means including, fish tape, cable, rope, basket-weave wire/cable grips and pulling eyes that will not damage cable or raceways. Do not use rope hitches for pulling attachments to cable.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections: Engage an independent, testing and inspecting agency to perform the following field tests and inspections and prepare test reports at no additional cost to UM:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS and in the presence of UM personnel or authorized agent. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.

    a. VLF high potential per IEEE 400.2-2004
    b. Shield Continuity
    c. Provide live phasing test to ensure redundant feeders are phased and synchronized
    d. If installed cable is being spliced to an existing cable, VLF Hi-Pot test shall be performed prior to it being spliced. Temporary terminations shall be used where appropriate. After splicing is complete, testing shall be performed as indicated above.
3. Infrared Scanning: After Substantial Completion, but not more than sixty (60) days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. The infrared testing shall be performed by minimum Level 1 infrared certified thermographer.

a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice eleven (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.

B. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Remove and replace malfunctioning units and retest as specified above, listing all deficiencies and corrective actions.

END OF SECTION 260513

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 and Division 01 Specification Sections, apply to this section and all other sections of Division 26.

1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.

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

C. Qualification Data: For testing agency.

D. Field quality-control test reports.

E. Operation and Maintenance materials.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

1.7 WARRANTY/GUARANTEE

A. See Division 26 Specification Section “Basic Electrical Requirements’ for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the following:
1. General Cable Corporation.
2. Southwire Company.
3. The Okonite Company.

B. Copper Conductors: Comply with NEMA WC 70.

C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN-2 and XHHW-2.

D. Multiconductor Cable: Comply with NEMA WC 70 for steel-clad cable, Type MC with ground wire.
   1. Fittings: Steel
   2. Provide multiconductor cables for control circuits only.

E. Color Coding:

208/120 Volts		480/277 Volts	
Phase	**Color**	**Phase**	**Color**
A	Black	A	Brown
B	Red	B	Orange
C	Blue	C	Yellow
Neutral	White	Neutral	Gray
Ground	Green	Ground	Green

2.2 CONNECTORS AND SPLICES

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

   1. AFC Cable Systems, Inc.
   2. Hubbell Power Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division.
   5. Tyco Electronics Corp.

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

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.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance and cables #4/0 and larger: Type XHHW-2, single conductors in raceway.

B. Feeders smaller than #4/0: Type THHN-THWN-2, single conductors in raceway.

C. Class 1 Control Circuits: Type THHN-THWN-2, in raceway.

D. Class 2 Control Circuits: Type THHN-THWN-2, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. 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.

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

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

D. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

E. Identify and color-code conductors and cables according to Division 26 Section "Identification 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 and UL 486B.

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

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.

B. Tests and Inspections:

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

   a. Switchgear Battery Chargers.

   b. Low-voltage generator cables.

   c. All low-voltage cables connected to emergency distribution panels.

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 sixty (60) days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

   a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice eleven (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.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

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. Low-voltage control cabling.
2. Control-circuit conductors.
3. Identification products.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. IDC: Insulation displacement connector.

C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

D. RCDD: Registered Communications Distribution Designer.

E. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

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

B. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

C. Source quality-control reports.

D. Maintenance Data: For wire and cable to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of an NRTL.
   1. Testing Agency's Field Supervisor: For UTP and optical fiber cabling, currently certified by BICSI as an RCDD 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.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
   1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
   2. Test each pair of UTP cable for open and short circuits.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install UTP and optical fiber cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems."
   1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.2 LOW-VOLTAGE CONTROL CABLE

A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
   1. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
   2. PVC insulation.
   3. Unshielded.
   4. PVC jacket.
   5. Flame Resistance: Comply with NFPA 262.

2.3 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded copper, Type XHHW multi-conductor, PVC jacketed, in raceway, complying with UL 83.

2.4 IDENTIFICATION PRODUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
2. HellermannTyton.
3. Kroy LLC.
4. Panduit Corp.

B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

C. Color Coding:
1. 120VAC Control Power:
   a. Hot: Red
   b. Neutral: White
   c. Ground: Green
2. 24VDC Power and Control Wire:
   a. Blue.
   b. Common wires: Blue with white tracer (or white with blue tracer)
3. Externally powered wires: Yellow (or orange)
4. Multi-conductor cable shall use ICEA Method E2.

D. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

B. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

C. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

D. Install manufactured conduit sweeps and long-radius elbows if possible.

E. Pathway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering room from overhead.
4. Extend conduits 3 inches (75 mm) above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

F. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

G. Connection to instruments: Provide flexible metal conduit for connection to instruments, maximum 18”. Insertable instruments such as oxygen probes may be longer than 18” if necessary.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Division 26 Section "Raceway and Boxes for Electrical Systems."

D. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (305 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (305 mm).
4. Separation between communications cables in grounded metallic raceways and

power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

E. Connection to Control Panels:

1. All connections to control panels shall be from the sides and bottom only. Nothing shall be connected to the top..

3.3 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables.

3.4 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No 12 AWG.

3.5 GROUNDING

A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross connection.
   a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
4. Optical Fiber Cable Tests:
   a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   b. Link End-to-End Attenuation Tests:
      1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
      2) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

C. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 260523

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 and Division 01 Specification Sections, apply to this section and all other sections of Division 26.

1.2 SUMMARY

A. Section includes grounding systems and equipment, plus the following special applications:
   1. Building wires and cables rated 600 V and less.
   2. Connectors, splices, and terminations rated 600 V and less.

1.3 SUBMITTALS

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

B. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
   1. Grounding for batteries and related equipment.
   2. Grounding for Generators, transfer switches and related equipment.
   3. Grounding for HVAC, pumps and related equipment.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

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

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

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

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

1.5 WARRANTY/GUARANTEE

A. See Division 26 Specification Section "Basic Electrical Requirements' for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper or Tinned-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 Conductor: No. 4 or No. 6 AWG, stranded conductor.
5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; one and five eights (1-5/8) inches wide and one sixteenth (1/16) inch thick.
6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; one and five eights (1-5/8) inches wide and one sixteenth (1/16) inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, one quarter (1/4) by four (4) inches in cross section, with nine thirty seconds (9/32) inch holes spaced one and one eighth (1-1/8) inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 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, pressure type with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

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.

PART 3 - EXECUTION

3.1 APPLICATIONS

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

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

C. Grounding Bus: Install in electrical rooms as shown on drawings.

1. Install bus on insulated spacers two (2) inches minimum from wall, six (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 to specified height above floor; connect to horizontal bus.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

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

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

3.3 INSTALLATION

A. Grounding Electrode and Equipment 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. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

D. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

3.4 LABELING

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.

B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.

1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified independent testing agency to perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. 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.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Substations and Pad-Mounted Equipment: 5 ohms.
5. Maximum ground-resistance value 5 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify UMB 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 and Division 01 Specification Sections, apply to this section and all other sections of Division 26.

1.2 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.7 COORDINATION

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 WARRANTY/GUARANTEE

A. See Division 26 Specification Section “Basic Electrical Requirements’ for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

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

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.

c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

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 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. 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 in which used.

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

1) Cooper B-Line, Inc.; a division of Cooper Industries.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti Inc.
4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Threaded steel.

2.2 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 Division 05 Section "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 except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

C. 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.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

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: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
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 reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

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 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 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. 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 - RACEWAY 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 and Division 01 Specification Sections, apply to this section and all other sections of Division 26.

SUMMARY

B. Related Sections include the following:

1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.2 DEFINITIONS

A. RMC: Rigid metallic conduit.

B. PVC/RMC: PVC coated rigid metallic conduit.

C. EMT: Electrical metallic tubing.

D. EPDM: Ethylene-propylene-diene terpolymer rubber.

E. FMC: Flexible metal conduit.

F. LFMC: Liquidtight flexible metal conduit.

G. NBR: Acrylonitrile-butadiene rubber.

H. RNC: Rigid nonmetallic conduit.

1.3 SUBMITTALS

A. Product Data: For raceways, wire ways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.

1. Custom enclosures and cabinets include layout drawings showing components and wiring.

C. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members in the paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

D. Source quality-control test reports.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

C. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access and eliminate interference problems.

1.5 WARRANTY/GUARANTEE

A. See Division 26 Specification Section “Basic Electrical Requirements’ for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

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

1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. Anamet Electrical, Inc.; Anaconda Metal Hose.
5. Electri-Flex Co.
6. O-Z Gedney; a unit of General Signal.

7. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. EMT: ANSI C80.3 and UL 797.

D. FMC: Zinc-coated steel.

E. LFMC: Flexible steel conduit with PVC jacket.

F. Fittings for Conduit (Including all Types and Flexible and Liquidtight), and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.

G. Joint Compound for Rigid Steel Conduit: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

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

1. AFC Cable Systems, Inc.
2. Arnco Corporation.
3. CertainTeed Corp.; Pipe & Plastics Group.
4. Lamson & Sessions; Carlon Electrical Products.
5. Manhattan/CDT/Cole-Flex.
6. RACO; a Hubbell Company.
7. Thomas & Betts Corporation.

B. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

C. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

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

1. Arnco Corporation.

2. Endot Industries Inc.
3. IPEX Inc.
4. Lamson & Sessions; Carlon Electrical Products.

B. Description: Comply with UL 2024; flexible type, approved for plenum [riser] general-use installation.

2.4 BOXES, ENCLOSURES, AND CABINETS

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

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Hoffman.
4. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
5. O-Z/Gedney; a unit of General Signal.
6. Robroy Industries, Inc.; Enclosure Division.
7. Scott Fetzer Co.; Adalet Division.
8. Spring City Electrical Manufacturing Company.
9. Thomas & Betts Corporation.
10. Walker Systems, Inc.; Wiremold Company (The).

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

D. Exterior and Wet locations
1. Cast aluminum or galvanized cast iron type.
2. Threaded hubs.
3. Gasket screw-on cover plates
4. NEMA FB-1

E. Boxes embedded in concrete
1. NEMA 4X PVC
   a. Glue-in conduit hubs
   b. Gasket cover plates
   c. Sunlight UV resistant

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

2. Nonmetallic Enclosures: Plastic finished inside with radio-frequency-resistant paint.

H. Cabinets:

1. NEMA 250, Type 1, 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.

2.5 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.6 SLEEVE SEALS

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

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex Co.
4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.

1. Sealing Elements: NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Stainless steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: RMC.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Conduits > 2": Rigid Steel.
3. All wiring > than 600 volts: Rigid Steel.
4. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical and Electrical rooms and IT Rooms/Closets.

5. Concealed in Ceilings and Interior Walls and Partitions: EMT.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
7. Damp or Wet Locations: Rigid steel conduit.
8. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: EMT.
9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

C. Minimum Raceway Size: Three quarter (3/4) inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least six (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. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. 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.

I. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

J. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least twelve (12) inches of slack at each end of pull wire.

K. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:

1. Three quarter (3/4) Inch Trade Size and Smaller: Install raceways in maximum lengths of fifty (50) feet.
2. One (1) Inch Trade Size and Larger: Install raceways in maximum lengths of seventy five (75) feet.
3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
4. Use only manufactured sweeps and bends. Pullboxes shall not be substituted for conduit sweeps or bends. Pullboxes shall be provided in straight sections of conduit only.

L. Install raceway sealing fittings at suitable, approved, and accessible locations 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 at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

M. Flexible Conduit Connections: Use maximum of seventy two (72) inches of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

N. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening. Rectangular Sleeve Minimum Metal Thickness:

1. For sleeve cross-section rectangle perimeter less than fifty (50) inches and no side greater than 16 inches, thickness shall be 0.052 inch.
2. For sleeve cross-section rectangle perimeter equal to, or greater than, fifty (50) inches and one (1) or more sides equal to, or greater than, sixteen (16) inches, thickness shall be 0.138 inch.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors two (2) inches above finished floor level.

G. Size pipe sleeves to provide one quarter (1/4) inch annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using 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.

3.4 SLEEVE-SEAL INSTALLATION

A. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.5 FIRESTOPPING

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

3.6 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 260533

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Warning labels and signs.
5. Instruction signs.
6. Equipment identification labels.
7. Miscellaneous identification products.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

1.6 WARRANTY/GUARANTEE

A. See Division 26 Specification Section “Basic Electrical Requirements’ for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. LEM Products, Inc.
2. Panduit Corp.
3. Brady
4. Approved Equal

2.2 POWER RACEWAY IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.

B. Colors for Raceways Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.

2. Legend: Indicate voltage and system or service type.

C. Colors for Raceways Carrying Circuits at More Than 600 V:

1. Black letters on an orange field.
2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch-high letters on twenty (20) inch centers.

D. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

E. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: four (4) inch- wide black stripes on ten (10) inch centers diagonally over orange background that extends full length of raceway or duct and is twelve (12) inches wide. Stop stripes at legends.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Colored Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label. Tape shall not be less than 3 mils thick by 1 inch wide.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

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

2.5 FLOOR MARKING TAPE

A. Two (2) inch- wide, 5-mil pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Interior Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. One quarter (1/4) inch grommets in corners for mounting.

3. Nominal size, seven (7) inches by ten (10) inches.

C. Exterior Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application.
2. One quarter (1/4) inch grommets in corners for mounting.
3. Nominal size, ten (10) inches by fourteen (14) inches.

D. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.7 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum one sixteenth (1/16) inch thick for signs up to twenty (20) sq. inches and one eighth (1/8) inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
4. Minimum letter height shall be three eighth (3/8) inch.

2.8 EQUIPMENT IDENTIFICATION LABELS

A. Stenciled Legend: In non-fading, waterproof, black ink or paint. Minimum letter height shall be one (1) inch.

2.9 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one (1) piece, self locking, Type 6/6 nylon.

1. Minimum Width: Three sixteenth (3/16) inch.
2. Tensile Strength at 73ºF, According to ASTM D 638: 12,000 psi.
3. Temperature Range: -40ºF to + 185ºF.
4. Color: “BLACK” except where used for color-coding.

2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select 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 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two (2) color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at fifty (50) foot maximum intervals in straight runs, and at twenty five (25) foot maximum intervals in congested areas. List typical color codes for systems, i.e. fire alarm, “RED”; security, “BLUE” and “YELLOW”; etc.

G. 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.

H. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

A. Concealed Raceways more than 600 V, within Buildings: Tape and stencil four (4) inch wide black stripes on ten (10) inch centers over orange background that extends full length of raceway or duct and is twelve (12) inches wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with three (3) inch- high black letters on twenty (20) inch centers. Stop stripes at legends. Apply to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within twelve (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, More Than 600 V: Self-adhesive vinyl labels. Install labels at ten (10) foot maximum intervals.

C. Accessible Raceways, 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 ten (10) 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 with the wiring system legend and system voltage. System legends shall include panel and circuit information.

1. Emergency Power – “RED”
2. Fire Alarm System – “RED”
3. Fire-Suppression Supervisory and Control System – “RED” and “YELLOW”
4. Security – “BLUE” and “YELLOW”
5. Mechanical and Electrical Supervisory Systems – “GREEN” and “BLUE”
6. Telecommunication System – “ORANGE” and “YELLOW”
7. Control Wiring – “GREEN” and “RED”

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors 1/0 and larger in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the source and circuit number for each set of conductors. For single phase conductors, identify each 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.

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".

F. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of six (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.

G. Install instructional sign including color-code for grounded and ungrounded conductors using adhesive-film-type labels.

H. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

I. 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 the Operation and Maintenance Manual.

J. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

K. 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.
c. DC Panelboards

L. 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.

M. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum three eighths (3/8) inch- high letters for emergency instructions at equipment used for power transfer and/or load shedding.

N. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the 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 systems unless equipment is provided with its own identification.

1. Labeling Instructions:

a. Indoor Equipment: Engraved, laminated acrylic or melamine label or Stenciled legend 4 inches high. Unless otherwise indicated, provide a single line of text with one half (1/2) inch high letters on one and one half (1-1/2) inch- high label; where two (2) lines of text are required, use labels two (2) inches high.
b. Outdoor Equipment: Stenciled legend four (4) inches high.
c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
d. Unless provided with self-adhesive means of attachment, fasten labels 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 laminated acrylic or melamine label.
b. Enclosures and electrical cabinets - laminated acrylic or melamine labels.
c. Access doors and panels for concealed electrical items laminated acrylic or melamine labels.
d. Switchgear – stencil and paint
e. Switchboards – stencil and paint

f. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary – stencil and paint.
g. Substations – stencil and paint.
h. Emergency system boxes and enclosures – stencil and paint.
i. Enclosed switches – laminated acrylic or melamine label.
j. Enclosed circuit breakers – laminated acrylic or melamine label.
k. Power transfer equipment – laminated acrylic or melamine label.
l. Contactors – laminated acrylic or melamine label.
m. Remote-controlled switches, dimmer modules, and control devices – laminated acrylic or melamine label.
n. Battery-inverter unti – laminated acrylic or melamine label
o. Battery racks – laminated acrylic or melamine label. Power-generating units – stencil and paint.
p. Communication Cabinets/Racks – laminated acrylic or melamine label.
q. Security Cabinets – laminated acrylic or melamine label.
r. Fire Alarm and Annunciator Cabinets – laminated acrylic or melamine label.
s. Control System Cabinets – laminated acrylic or melamine label.
t. Monitoring and control equipment – laminated acrylic or melamine label.
u. UPS equipment – laminated acrylic or melamine label.
v. Each receptacle, light switches and receptacles mounted in surface raceways shall be neatly marked on the inside cover with indelible marker identifying the panel and breaker from which it is fed and durable markers or tag inside outlet box. This to ensure the correct covers are restored after room renovations and/or painting. In addition to marking circuit identification inside the cover, also provide laminated label with circuit number on device cover plates. Provide white background label with black bold lettering.

END OF SECTION 260553

SECTION 260913 - ELECTRICAL POWER MONITORING

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 and all other sections of Division 26.

1.2 SUMMARY

A. Section includes the following for monitoring and control of electrical power system:

1. Communication network and interface modules for RS-485, Modbus TCP/IP and IEEE 802.3 data transmission protocols.
2. Power monitoring equipment (Power Monitors).
3. Programming and Software.

B. This specification contains hardware and software requirements for the metering network only. The metering system shall provide remote and local monitoring of the system only. The metering system shall receive input from the control system but the control system shall not accept input from the metering system. The metering system shall not have control capability of any switchgear. The metering system will communicate over the campus network. The switchgear control system shall communicate over a new dedicated network provided under this project.

C. The campus has an existing Square D metering software package (EcoStruxure Power Monitoring Expert (PME)) that monitors the electric meters throughout the campus.

1.3 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

C. HTML: Hypertext markup language.

D. I/O: Input/output.

E. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.

F. LAN: Local area network; sometimes plural as "LANs."

G. LCD: Liquid crystal display.

H. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

I. Modbus TCP/IP: An open protocol for exchange of process data.

J. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

K. PC: Personal computer; sometimes plural as "PCs."

L. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

M. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.

N. RS-485: A TIA standard for multipoint communications using two twisted-pairs.

O. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

P. THD: Total harmonic distortion.

Q. UPS: Uninterruptible power supply; used both in singular and plural context.

R. WAN: Wide area network.

1.4 ACTION SUBMITTALS

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

1. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.

B. Shop Drawings: For power monitoring and control equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Outline Drawings: Indicate arrangement of components and clearance and access requirements.
2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Field quality-control reports.

C. Other Informational Submittals:

1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power monitoring and control units, to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Operating and applications software documentation.
2. Software licenses.
3. Software service agreement.
4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.

B. Software and Firmware Operational Documentation:

C. Software licenses and upgrades required by and installed for operating and programming digital and analog devices.

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. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Manufacturer Qualifications: A firm experienced in manufacturing power monitoring and control equipment similar to that indicated for this Project and with a record of successful in-service performance.

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.

1.9 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.

1. Match components and interconnections for optimum performance of specified functions.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

1.10 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Through Schneider Electric, provide two (2) years of PowerLogic Technical Support for the UMB Power Monitoring Expert (PME) electrical metering system that will begin on the project’s date of substantial completion.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include the operating systems. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.11 WARRANTY/GUARANTEE

A. See Division 26 Specification Section "Basic Electrical Requirements' for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product by Schneider Electric – Power Management Operation.

2.2 FUNCTIONAL DESCRIPTION

A. Software: Existing Square D software shall be updated to include trending of all new meters on this project. In addition, new schematic representations showing single line drawings with breaker status, and alarm conditions, such as breaker trips, shall be provided for the new switchgear. All new meters will tie into the existing campus communication network.

1. Contractor shall contact Square D for work involving upgrading existing Power Monitoring system. Square-D Owner Representative is: Jeff Pitzer, jeff.pitzer@schneider-electric.com. 717-495-2507.

2.3 SYSTEM REQUIREMENTS

A. Existing Server: Existing server is located in the Health Sciences Library. Server shall be upgraded to include all new meters and workstations.

B. Existing PC Based Work System: Existing workstations shall be upgraded to include all new meters and single lines as described in this specification.

2.4 POWER MONITORING EQUIPMENTPower Meters: For meters on 480V ATS's and meters not specified in MV Switchgear or LV Secondary Substation specifications, provide Square D PM5560 meters. Meters shall have Ethernet communication port.

1. Measured values

a. The Power Meter shall provide the following, true RMS metered quantities:

1) Real-Time Readings
2) Current (Per-Phase, N (calculated), 3-Phase Avg)
3) Voltage (L–L Per-Phase, L-L 3-Phase Avg, L–N Per-Phase, L-N 3-Phase Avg.)
4) Real Power (Per-Phase, 3-Phase Total)*
5) Reactive Power (Per-Phase, 3-Phase Total)*
6) Apparent Power (Per-Phase, 3-Phase Total)
7) Power Factor Signed (3-Phase Total)
8) Frequency
9) THD (Per-Phase, Current and Voltage)

b. Energy Readings

1) Accumulated Energy (Real kWh*, Reactive kVarh*, Apparent KVAh) (Absolute)

c. Demand Readings

1) Demand Current Calculations(Per-Phase):

a) Present
b) Peak

2) Demand Real Power Calculations(3-Phase Total):

a) Present
b) Peak

3) Demand Reactive Power Calculations(3-Phase Total):

a) Present
b) Peak

4) Demand Apparent Power Calculations(3-Phase Total):

a) Present
b) Peak

d. Power Analysis Values

1) THD - Voltage (Per-Phase, Line to Line, Line to Neutral
2) THD - Current (Per-Phase, Neutral)
3) Signed Power Factor (3-Phase)

e. Usage Time: The Power Meter should display the time that the device has been in service, displaying hours and minutes.

* kW, kVAR, kWh, and kVARh are signed net consumption values. The PM750 keeps a single registers with the net consumption values per each type of Energy and Power.

2. Demand: All power demand calculations shall use any one (1) of the following calculation methods, selectable by the user:

a. Block Interval Demand. The three following demand calculation modes shall be possible under Block Interval Demand: Sliding Block, Fixed Block, and Rolling Block.
b. Synchronized Demand
c. Thermal Demand

3. Sampling

a. The current and voltage signals shall be digitally sampled at a rate high enough to provide true rms accuracy to the 15th harmonic.
b. The Power Meter shall provide continuous sampling at a minimum of up to thirty two (32) samples/cycle, simultaneously on all voltage and current channels of the meter.

4. Minimum and Maximum Values

a. The Power Meter shall provide minimum and maximum values for the following parameters:

1) Voltage L-L
2) Voltage L-N
3) Current
4) Power Factor
5) Real Power Total
6) Reactive Power Total
7) Apparent Power Total
8) THD Voltage L-L
9) THD Voltage L-N
10) THD Current
11) Frequency

b. For each min/max value listed above, the Power Meter shall record the following attributes:

1) Min/Max. Value
2) Phase of recorded Min/Max (for multi-phase quantities)

c. Minimum and maximum values shall be available via communications and display.

5. Current Inputs

a. The Power Meter shall accept current inputs from standard instrument current transformers with 5 amp secondary output and shall have a metering range of 5mA-6 amps with the following withstand currents: 10 amp continuous, 50 amp 10 sec per hour, 120 amp 1 sec per hour.
b. Current transformer primaries adjustable from 5 - 32,767 A shall be supported.

6. Voltage Inputs

a. The circuit monitor shall allow connection to circuits up to 480 volts AC without the use of potential transformers. The Power Meter shall also accept voltage inputs from standard instrument potential transformers. The Power Meter shall support PT primaries through 1.6 MV.
b. The nominal full scale input of the Power Meter shall be 277 Volts AC L-N, 480 Volts AC L-L. The meter shall accept a metering over-range of 20%. The input impedance shall be greater than 2 Mohm (L-L) or 1 Mohm(L-N).

7. Accuracy

a. The Power Meter shall comply with IEC62053-22 Class 0.5S for Real Energy and IEC62053-23 Class 2 for Reactive Energy
b. Voltage shall be accurate to 03% from 50 to 227 V. Current shall be accurate to 0.4% from 1 to 6A. Power Factor shall be accurate from 1 to 6A. Power shall be accurate to 0.5%. Frequency metering shall be accurate to + 0.2 % from 45-65 Hz.
c. No annual calibration shall be required to maintain this accuracy.

8. Input/Output

a. The Power Meter shall include on-board two (2) Digital Inputs and One Digital Pulse Output. The Power Meter shall be capable of operating a solid state KY output relay to provide output pulses for a user definable increment of reported real energy. The standard KY output shall operate from 8–36 V DC max range, 24 V DC nominal. @ 25°C, 3.0 kV rms

isolation, 28 Ω on-resistance @ 100 mA. It shall allow for the following operation modes:

1) External-This is the default setting. The output can be controlled by a command sent over the communications link.
2) Alarm-The output is controlled by the power meter in response to a Setpoint controlled alarm condition. When the alarm is active, the output will be ON. Multiple alarms can be associated with the same output simultaneously.
3) kWh Pulse-In this mode, the meter generates a fixed-duration pulse output that can be associated with the kWh consumption.

b. The Power Meter shall be capable of operating the two (2) Digital Inputs to provide all the following modes:

1) Normal-Use the normal mode for simple ON/OFF digital inputs.
2) Demand Interval Synch Pulse-Use this mode to configure a digital input to accept a demand synch pulse from a utility demand meter.
3) Digital Alarm-Use this mode to associate the input operation with any of the alarms. These alarms shall have a fixed pickup and dropout magnitude:
4) The two digital inputs shall operate from 12-36 V DC, 24 VDC nominal, impedance 12k Ohm, maximum frequency 25 Hz, response time 10 msec, and isolation 2.5kV rms

9. Upgrades

a. It shall be possible to field upgrade the firmware in the Power Meter to enhance functionality. These firmware upgrades shall be done through the communication connection and shall allow upgrades of individual meters or groups. No disassembly, changing of integrated circuit chips or kits shall be required and it will not be necessary to de-energize the circuit or the equipment to perform the upgrade.

10. Control Power

a. The Power Meter shall operate properly over a wide range of control power including 100-415 VAC, +/-10%, 5VA; 50 to 60Hz. Or 125-250 VDC, +/-20%, 3W.

11. Communications

a. The Power Meter shall communicate via RS-485 Modbus protocol with a 2-wire connection at speeds up to 19.2 kBaud.

12. Alarms: The Power Meter shall detect 15 predetermined alarms. All alarms shall be configured with the following values when using the display:

    a. Enable-disable (default) or enable.
    b. Pickup Magnitude
    c. Pickup Time Delay
    d. Dropout Magnitude
    e. Dropout Time Delay
    f. Values that can also be configured over communications are:
    g. Alarm Type
    h. Test Register
    i. Alarm Label

13. Display

    a. The Power Meter display shall be back lit LCD for easy viewing, display shall also be anti-glare and scratch resistant.
    b. The Display shall be capable of allowing the user to view four values on one screen at the same time. A summary screen shall also be available to allow the user to view a snapshot of the system.
    c. The Power Meter display shall provide local access to the following metered quantities:

        1) All quantities in Section B
        2) Minimum and Maximum readings in Section E
        3) Any of the Active Alarms from Section P
        4) I/O Status

    d. Reset of the following electrical parameters shall also be allowed from the Power Meter display:

        1) Peak demand current
        2) Peak demand real power (kW) and peak reactive demand (kVAR).
        3) Energy (MWh) and reactive energy (MVARh)

    e. Setup for system requirements shall be allowed from the Power Meter display. Setup provisions shall include:

        1) CT rating
        2) PT rating (Single Phase, 2-Wire)
        3) System type [three-phase, 3-wire] [three-phase, 4-wire]
        4) Watt-hours per pulse
        5) Communication parameters such as address and baud rate
        6) Alarms
        7) Digital I/O
        8) Demand calculation mode settings
        9) Bar graphs
        10) And Passwords for Setup and Reset]

2.5 ELECTRICAL METERING CABINET

A. The metering cabinet shall be appropriate for its environment but at a minimum UL type 1 listed steel enclosure with factory supplied knock-outs, or as specified on the drawings. The cabinet shall be approved for Type 1 and Type 3R applications. The enclosure shall have one set of incoming terminals for connecting the voltage metering leads.

B. Control power and voltage sensing power shall be separated for distribution to each meter from these main set incoming terminals.

C. External control power transformers shall not be needed for any power systems up to and including 480V.

D. Metering cabinet shall have fuse blocks for incoming voltage leads.

E. The enclosure shall have shorting terminal blocks for connecting the current transformer leads from the field to the meters. A factory wiring harness shall be provided to connect the CT circuit from shorting block to the meter.

F. The metering cabinet shall have terminal blocks for incoming and outgoing communications circuit connections.

G. Metering cabinet shall have terminal strip for connecting dry contacts from switchgear to the meter for remote open/close status monitoring. Wetting voltage by power supply within the metering cabinet.

2.6 LAN CABLES

A. Comply with Division 27 Section "Communications Horizontal Cabling."

B. RS-485 Cable:

1. Plenum-Type, RS-485 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, shielded, and fluorinated-ethylene-propylene jacket, and NFPA 70, Type CMP. Belden #8723 or approved equal.

C. Unshielded Twisted Pair Cables: Category 6 as specified for horizontal cable for data service in Division 27 Section "Communications Horizontal Cabling."

2.7 LOW-VOLTAGE WIRING

A. Comply with Division 26 Section "Control-Voltage Electrical Power Cables."

B. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.

1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
2. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION AND SOFTWARE INTEGRATION

A. All new electric meters added under this project including shall receive startup, programming, commissioning, and integration with the existing campus Power Monitoring Expert (PME) system.

3.3 INTEGRATION WITH BAS SYSTEM

A. Contractor shall provide communication with BAS system to provide information into the BAS system for the items listed below. The contractor shall include costs for inserting 10 points into the BAS sytem. The BAS system and metering system are on the same network.
1. Distribution System on Generator (Howard Hall/BRB Generators and Peaking Plant Generators are running and supplying power to the North Switching Station)
2. Common Alarms

3.4 CABLING

A. Comply with NECA 1.

B. Install cables and wiring according to requirements in Division 27 Section "Communications Horizontal Cabling."

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

D. Install LAN cables using techniques, practices, and methods that are consistent with specified category rating of components and that ensure specified category performance of completed and linked signal paths, end to end.

E. Install cables without damaging conductors, shield, or jacket.

3.5 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

B. Label each power monitoring and control module with a unique designation.

3.6 GROUNDING

A. Comply with IEEE 1100, "Recommended Practice for Powering and Grounding Electronic Equipment."

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Electrical Tests: Use caution when testing devices containing solid-state components.
2. Continuity tests of circuits.
3. Operational Tests: Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by manufacturer. Submit sequences for approval. Note response to each test command and operation. Note time intervals between initiation of alarm conditions and registration of alarms at central-processing workstation.

    a. Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled.
    b. Test LANs according to requirements in Division 27 Section "Communications Horizontal Cabling."
    c. System components with battery backup shall be operated on battery power for a period of not less than 10% of calculated battery operating time.
    d. Verify accuracy of graphic screens and icons.

e. Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two locations. Resolve discrepancies greater than 5 percent and record resolution method and results.
f. Record metered values, control settings, operations, cues, time intervals, and functional observations and submit test reports printed by workstation printer.

C. Power monitoring and control equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

F. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

G. Reports: Submit written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

H. Remove and replace malfunctioning devices and circuits and retest as specified above and note corrective action in report.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train owner's maintenance personnel to adjust, operate, and maintain systems. See Division 01 Section "Demonstration and Training."

1. Train owner's management and maintenance personnel in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of two (2) hours training.
2. Training Aid: Use approved final versions of software and maintenance manuals as training aids.

3.9 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within twenty four (24) months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 260913

SECTION 261116 - SECONDARY UNIT SUBSTATIONS

PART 1 - GENERAL

1.1 RELATED DOCOMENTS

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

1.2 DESCRIPTION OF WORK

A. This section provides the specification for the Secondary Unit Substations and related accessories that shall be furnished by the manufacturer.

1.3 DELIVERY

1.4 The supplier's shipping company shall verify all height, weight, and traffic limitations when considering pricing and actual delivery. The delivery at the site for the equipment unloading shall be scheduled for normal working hours of Monday through Friday (7:00am – 3:00pm). The actual delivery through the University of Maryland, Baltimore campus must be scheduled with the University to prevent travel through major campus activity days. The shipper shall consider that it may take up to 4 hours before the secondary unit substation is lifted off the delivery truck and the truck is free to leave.

1.5 SUMMARY

A. This Section includes indoor and outdoor secondary unit substations, each consisting of the following:

1. Primary incoming section.
2. Transformer.
3. Secondary distribution section.

1.6 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.7 SUBMITTALS

A. Compliance Statement as described under the quality assurance section of this specification.

B. Product Data: Include rated capacities, furnished specialties, and accessories.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Dimensioned plans and elevations showing major components and features including working clearances, conduit entry points, and base mounting points.
3. One-line diagram.
4. List of materials.
5. Nameplate legends.
6. Size and number of bus bars and current rating for each bus, including mains and branches of phase, neutral, and ground buses.
7. Short-time and short-circuit current ratings of secondary unit substations and components.
8. Ratings of individual protective devices.
9. Transformer section submittals including:
    a. Dimensioned plan and elevations with tap, control power transformer, fan and temperature monitor locations, and phase, neutral and ground connection locations.
    b. Enclosure details, including removable panel descriptions, louver locations, control wiring routing, sheet metal gauge, and painting details.
    c. Terminal locations and details for phase, neutral and ground connections.
    d. Coil conductor materials and construction.
    e. Insulation materials.
    f. Test data sheets for similar transformers with test data on load losses, no-load losses and sound level.
    g. Temperature control system description, including details on the control power transformer, fans, temperature monitor, alarms and hinged panel for the monitor.
    h. Schematic and connection diagrams for the temperature control system.
    i. Full size copy of the nameplate.
    j. Coil-to-bus/line connection materials, support and details.
    k. Bus bar and line termination connection and support details.
    l. ANSI Damage curve for secondary unit substation transformers.
    m. Detailed location, mounting and wiring of the lightning arrestors.
10. Secondary voltage distribution section submittals containing:
    a. Dimensioned plan and elevations with circuit breaker, current sensor and metering device locations, and phase, neutral and ground bus terminal locations.

b. One line diagram with bus, circuit breaker, trip unit, and fuse quantities and ratings, and interlock provisions.
c. Compartment details including front door and rear panel descriptions, sheet metal gauge, painting details, mimic bus details, and breaker lifting device description.
d. Terminal locations and details for phase, neutral and ground connections.
e. Phase-to-phase clearances and phase-to-ground clearances.
f. Bus bar connection and support details and bus materials.
g. Insulator and barrier details and materials.
h. Circuit breaker, trip unit, and current sensor descriptions.
i. Trip unit time-current characteristic curves.
j. Detailed circuit breaker controls details, schematic and connection diagrams, and sequences of operation including terminal point numbers and locations
k. Secondary metering description, including details on the current transformers, potential transformers, ammeters, voltmeters, and meter switches.
l. Schematic and connection diagrams for the PLC system including terminal point numbers and locations
m. DC Connection schematics including terminal point numbers and locations
n. Nameplate engraving.
o. Time-current curves, including selectable ranges for each type of overcurrent protective device.
p. Mimic-bus diagram.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and ground rod locations.
2. Location of structural supports for structure-supported raceways and busways.
3. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

E. Product Certificates: For secondary unit substations, signed by product manufacturer.

F. Qualification Data: For independent testing agency.

G. Material Test Reports: For secondary unit substations.

H. Factory test reports.

I. Field quality-control test reports.

J. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Compliance Statement: The equipment manufacturer shall include a Compliance Statement, at the time of Bid, listing each Specification Section, and Part 1, 2, and 3 Sub-Sections, stating, paragraph-by-paragraph, compliance with the Specification, each minor nonconformity that is within the intent of the Specification, and proposed nonconformities. Provide short description of minor nonconformities, and detailed explanation of other nonconformities.

B. Independent Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain secondary unit substation through one source from a single manufacturer.

D. Product Options: Drawings indicate size, profiles, and dimensional requirements of secondary unit substations and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

E. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with IEEE C2.

G. Comply with IEEE C37.121.

H. Comply with NFPA 70.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.

B. Coordinate delivery of secondary unit substations to allow movement into designated space.

C. Store secondary unit substation components protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

D. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.

E. Unit Substations are to arrive on site in a phased manner to be established with the electrical contractor and the project schedule. Equipment Manufacturer may manufacturer the switchgear prior to the scheduled delivery date and is responsible for storage prior to the agreed delivery dates.

F. The Electrical Contractor may attempt to coordinate delivery of equipment such that equipment may be set in place on the same day it is delivered on site. If this is not possible, the Electrical Contractor will arrange for offloading at a staging area and will arrange and pay for subsequent transfer to the site, when equipment can be set in place.

1.10 PROJECT CONDITIONS

A. Field Measurements: Indicate measurements on Shop Drawings.

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 UM no fewer than 10 days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without UM’s written permission.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear, and adjacent surfaces and other items. The Equipment Manufacturer shall fabricate the equipment to within indicated maximum dimensions with clearances to accommodate access for maintenance and operation.

1.11 COORDINATION

A. Coordinate layout and installation of secondary unit substations with other construction that penetrates floors and ceilings, or is supported by them, including light fixtures, HVAC equipment, and fire-suppression-system components.

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

1.12 EXTRA MATERIALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Spare Indicating Lights: Six of each type installed.
2. Touchup Paint: One half-pint container of paint matching enclosure's exterior finish.
3. Primary Switch Contact Lubricant: One container.
4. One set of spare mounting gaskets for bushings, handholes, and the gasket between relief cover and flange of pressure relief device

1.13 WARRANTY/GUARANTEE

A. The manufacturer shall warrant the components and equipment installed, as per the specification, to be free from defects in materials or workmanship for a period of not less than 12 months, to begin upon manufacturer completion of the system startup.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. ABB Control, Inc.
2. Eaton
3. Siemens
4. Square D; Schneider Electric.

2.2 MANUFACTURED UNITS

A. Indoor Unit Arrangement: Separate secondary distribution equipment connected with busway

B. Enclosure Finish: Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.

2.3 INCOMING SECTION

A. Primary Incoming Section: Terminal assembly with adequate space for incoming cable terminations and surge arresters, complying with NEMA SG 4 and meeting thermal, mechanical, and dielectric requirements specified for the transformer section.

B. Surge Arresters: Comply with IEEE C62.11, Distribution class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device. Comply with IEEE.

2.4 DRY-TYPE TRANSFORMER SECTION

A. Description: IEEE C57.12.01, IEEE C57.12.51, NEMA ST 20, and dry-type, 2-winding, secondary unit substation transformer.

B. Enclosure: Indoor, ventilated, vacuum-pressure impregnated type, with insulation system rated at 185^0C with an 80^0C average winding temperature rise above a maximum ambient temperature of 40^0 C.

C. Cooling System: Class AA/FA, air cooled with forced-air rating complying with IEEE C57.12.01.
   1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
   2. The temperature controller shall be mounted flush on the front of the transformer, 54 inches above finished floor.
   3. The temperature monitor shall be mounted on a hinged front plate of a flush mounted box. The electrical connection shall be accessible and the monitor shall be removable without de-energizing the transformer.
   4. The wiring for the temperature monitor shall be routed and supported independently of the transformer enclosure so that the enclosure panels can be removed without affecting the wiring. All wiring shall comply with the requirements of the Control Wiring section of this specification.
   5. The temperature monitor shall include an LED or LCD display to allow reading of the hot spot temperature in each phase, and the highest temperature seen on each phase since the last reset. Additional features as listed below:
   6. A reset button shall be provided to reset the maximum readings.
   7. Indication Lights:
   8. Green – Power On
   9. Amber – Fan On
   10. Red – High Temperature
   11. Alarm Silence Pushbutton
   12. Auto/Manual Fan Control Switch
   13. System Test Switch

D. Insulation Materials: IEEE C57.12.01, rated 220^0C.

E. Insulation Temperature Rise: 80^0C, maximum rise above 40^0C.

F. Basic Impulse Level: 95 kV.

G. Full-Capacity Voltage Taps: 4 nominal 2.5% taps, 2 above and two (2) below rated primary voltage.

H. Sound level may not exceed 64dBA level, without fans operating.

I. Impedance: 5.75 percent.

J. If retaining paragraph below, coordinate with Drawings and provide external power and signal connections.

K. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm. Provide Square D Model 98 transformer temperature monitor for remote recording of transformer winding temperatures.

L. Core and Coil Assemblies: Transformer coils shall be copper continuously wound on a non-aging, cold-rolled, grain-oriented, high permeability silicon metal core of electrical grade steel with insulated laminations. Aluminum windings are not acceptable.

M. Core and coil assembly shall be mounted on a structural steel base, which shall be isolated from the rest of the structure by vibration pads.

N. The electrical insulation system shall utilize Class H material in a fully rated 220 degree C system. Transformer design temperature rise shall be based on a 30 degrees C average ambient over a 24-hour period with a maximum of 40 degrees C. Solid insulation in the transformer shall consist of inorganic materials such as porcelain, glass fiber, electrical grade glass polyester or Nomex. All insulating materials must be rated for continuous 220 degree C duty. The insulation between the high and low voltage coils shall be more than sufficient for the voltage stress without the need of a varnish.

O. High-voltage and low-voltage windings shall be copper. The high voltage winding shall be wound over the low voltage winding with sufficient mechanical bracing to prevent movement during fault conditions and sufficient solid insulation to isolate the high voltage winding dielectric potential from the low voltage windings.

P. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.

2.5 SECONDARY DISTRIBUTION SWITCHGEAR

A. The secondary distribution section shall be drawout, low-voltage switchgear, complying with IEEE C37.20.1 and UL 1558.

1. Section barriers between all circuit-breaker compartments shall be extended to rear of section.

B. Switchgear Structure:
   1. Match and align the front and back of the switchgear.
   2. Isolate line bus from load bus at each main and tie circuit breaker with bus isolation barriers.
   3. Allow the following circuit-breaker functions to be performed when the compartment door is closed:

      a. Operate manual charging system.
      b. Open and close the circuit breaker.
      c. Examine and adjust the trip unit.
      d. Read the breaker nameplate.

   4. Locate instrumentation transformers within the breaker cell, and make front accessible and removable.
   5. The sections shall be constructed of steel frames and heavy gauge steel panels sized to maintain required alignments and clearances at all times. The sections shall also be sufficiently rigid to restrict deformation from external forces and weights that may be applied during maintenance activities.
   6. The sections shall be capable of withstanding the lifting, skidding, jacking and/or rolling (in any direction) actions needed to install the equipment. Factory installed lifting eyes shall be provided on each section.
   7. The sections shall have provisions for anchoring to channel embeds in the housekeeping pad.
   8. Section barriers between all circuit-breaker compartments shall be extended to rear of section.
   9. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
   10. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.

C. Switchgear Bus:
   1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
   2. Main Phase Bus: Uniform capacity the entire length of section.
   3. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
   4. Phase-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
   5. Use copper for connecting circuit-breaker line to copper bus.
   6. Contact Surfaces of Buses: Silver plated.
   7. Feeder Circuit-Breaker Load Terminals: Insulated silver-plated copper bus extensions equipped with bolted connectors for outgoing circuit conductors. Provide cable lugs sized as indicated on the drawings.

8. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4-by-2 inches (6 by 50 mm).
9. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
10. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, spray-applied, flame-retardant insulation.

    a. Sprayed Insulation Thickness: 3 mils (0.08 mm), minimum.
    b. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

11. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents, 65kA.
12. The vertical bus shall be held rigid in a support structure of non-hygroscopic and flame retardant molded glass reinforced polyester.
13. Vertical and horizontal busbars shall be isolated from the cable compartment by steel barriers. No live busbars shall be accessible from the rear cable compartments except the circuit breaker load side terminations.
14. Cable feeder compartments shall have sufficient space for all cables entering from above and shall be easily accessible from the rear. Cable tie points shall be provided on the sides of such sections. No cable tie bars shall block access to the rear of the switchgear.

D. Special Provisions to Accommodate Switchgear Maintenance:
    1. Barriers covering the bus sub-assembly in each section of gear shall be designed for ease of removal to accommodate maintenance.
    2. Where carriage bolt assemblies are installed at bus connections, the bolts shall face the rear of the switchgear to facilitate access for maintenance.
    3. The switchgear shall be arranged to allow thermal and ultrasonic scans with the bus energized and under load.

        a. Provide two (2) combined visual, Ultraviolet (UV), and Infrared (IR), rectangular
        b. viewing windows in the rear cover of each switchgear section. Center each window at 1/3 points along the height of the section and centered horizontally on the section so that all cable terminations can be scanned through the windows.
        c. Provide one (1) round ultrasonic scan window in the front door of each breaker compartment. Locate the window so that a scan can be made of the arc chutes and contacts of the breaker.

    4. Provide design details to the Government's Representative prior to manufacturer to confirm compliance with the above provisions.

E. Circuit Breaker Compartment:

1. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:

    a. Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed, and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
    b. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit the manual withdrawal of an open circuit breaker to a position for removal from the structure. When the compartment door is open, status for connection devices for different positions includes the following:

        1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
        2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

2. Primary Disconnect: Mount on the stationary part of the compartment. The disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the "connected" position. The assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.
3. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts at the front of the breaker. Disconnecting devices shall be gold plated, and engagement shall be maintained in the "connected" and "test" positions.
4. Each compartment shall be dead-front. Shutters shall close automatically as a breaker is racked out of the “connected” position. Control contacts shall be “made” when the breaker is in the “test” or “connected” position.
5. A guide rail system shall be used to ensure accurate alignment of the breaker primary and secondary disconnects during drawout operation.
6. Positive mechanical interlocks shall prevent the circuit breaker from being racked in or out unless the circuit breaker is open, and shall prevent the circuit breaker from being closed while it is being racked in or out. The circuit breaker shall not be permitted to close except in the “connected” and “test” positions.
7. Each circuit breaker cubicle shall contain a positive rejection mechanism so that only the circuit breaker frame for which the cubicle was designed can be inserted.
8. Anti-pumping mechanism shall be provided.
9. Compartment doors shall have padlocking hasps.

10. Circuit breakers shall be capable of being padlocked in the drawn-out position.
11. Main, Tie, and Feeder Circuit Breaker Compartments: Shutters shall be supplied to cover circuit breaker primary line and load disconnects when the circuit breaker carriage is removed from its compartment.

F. Circuit Breakers:
1. Circuit breakers shall be individually mounted, drawout, 600 volt (nominal) power circuit breakers in compliance with ANSI C37.13, C37.16, C37.17, C37.50, NRTL-listed and labeled to UL-1066.
2. Ratings: For continuous, interrupting, and short-time current ratings for each circuit breaker as indicated on the drawings; voltage and frequency ratings same as switchgear.
3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

    a. Normal Closing Speed: Independent of both control and operator.
    b. Slow Closing Speed: Optional with operator for inspection and adjustment.
    c. Stored-Energy Mechanism: Electrically charged, and .the operator's choice of manual charging.

        1) Operating Handle: One for each circuit breaker capable of manual operation.
        2) Electric Close Button: One for each electrically operated circuit breaker. This control switch shall be a Series 31-B knob.
        3) All open and close buttons on the circuit breakers shall be equipped with a protective cover to prevent inadvertent operation.

    d. Operation counter.

4. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:

    a. Provide trip devices which are interchangeable between compatible breaker frames. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker. The rating plug shall be interlocked with the tripping mechanism to automatically "open" the breaker when the plug is removed. The breaker shall remain "trip free" with the plug removed. In addition, rating plugs shall be keyed to prevent incorrect application between different frame ratings.
    b. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
    c. Temperature compensation that ensures accuracy and calibration stability from minus 5 to plus 40 deg C. Circuit breakers shall have short circuit current withstands and interrupting ratings that meet or exceed 65kA symmetrical fault current.

d. Field-adjustable, time-current characteristics.
e. Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or a combination of these methods.
f. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
g. Pickup Points:

1) Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-t operation.
2) Five minimum, for instantaneous-trip functions.

h. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup.

1) Arrange to provide protection for three-wire circuit or system.
2) Arrange to provide protection for four-wire circuit or system.
3) Arrange to provide protection for four-wire, double-ended substation.

5. All trip units shall be provided with zone selective interlocking schemes.
6. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
7. Auxiliary Contacts:

a. Contacts and switches required for normal circuit-breaker operation, sufficient for interlocking and remote indication of circuit-breaker position.
b. Spare auxiliary switches, at least two, unless other quantity is indicated. Each switch shall consist of two Type A and two Type B contacts wired through secondary disconnect devices to a terminal block in stationary circuit-breaker compartment.

8. Arc Chutes: Readily removable from associated circuit breaker when it is in "disconnected" position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
9. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
10. Circuit breakers shall contain a true two-step, stored energy mechanism providing quick-make, quick-break operation capable of charging-after-close operation. It shall be possible to discharge the closing springs without closing the main contacts. Maximum closing time shall be 5 cycles at nominal control voltage.
11. The tie breaker shall be identical to the main breakers and shall be capable of being exchanged with either main breaker.
12. A factory-installed "OFF" button padlock provision shall be included to prevent charging of the breaker mechanism when it is engaged.
13. Movement of the breaker handle alone shall not cause the breaker to change state (open or close).

G. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

H. Key Interlocks: Arranged to prevent opening or closing interlocked circuit breakers, except in a specified sequence. Include mountings and hardware for future installation of key interlocks.

I. Sync Check Relays: Provide sync check relays on Main and Tie breakers to allow closing of breakers when both sides of breakers are synchronized or when closing into a dead bus. Sync check relays will also allow for closed transition transfer of sources.

J. Breaker Time-out: Provide a timer (factory set to 10 seconds, adjustable) that opens the tie breaker if both main breakers and the tie breaker are closed for an extended period of time.

K. Control Power:
   1. Manual spring charging operators and close and trip pushbuttons shall be accessible from the front of the circuit breaker when it is installed in a cubicle, with the cubicle door closed.
   2. The following circuit breaker operating status mechanical indicators at the front door of each circuit breaker compartment:

      a. Closing spring status (charged/discharged).
      b. Circuit breaker main contact status (open/closed).
      c. Circuit breaker drawout position (connect/test/disconnect).

   3. Standard padlocking provisions, on the front of the circuit breaker, to lock the circuit breaker open and mechanically trip-free. The padlock provision shall accept up to three padlocks with 1/4 to 3/8 inch diameter shank.
   4. Provide circuit breaker mechanism operated contacts (MOC) and truck operated contacts (TOC) as required for implementation of the specified control logic.
   5. Provide two spare sets of contacts that open when the circuit breaker is open and close when the circuit breaker closes (52a), and two spare sets of contacts that close when the circuit breaker is open and open when the circuit breaker closes (52b), wired through secondary disconnect devices to a terminal block in the stationary housing. Provide an auxiliary relay to provide additional “52a” and “52b” contacts for each breaker. Provide the maximum number of contacts allowable for each type.
   6. Circuit breakers shall be equipped with wheels that allow the circuit breaker to be rolled into the cubicle once it is installed on the drawout rails.

L. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage and adjustable time delay.

M. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices. All indicating lights shall be LED type with push-to-test feature.
   1. Red – Closed
   2. Green – Open
   3. Amber/Blue/White – General Indication as required for interlocking.

2.6 LOW VOLTAGE INSTRUMENT SECTION

A. Instrument Transformers: Comply with IEEE C57.13.
   1. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y shall be provided on the bus side of the main breaker.
   2. Protection Current Transformers: Integral to circuit breaker rating plug assembly. Rating plugs shall be removable for increasing/decreasing trip unit rating without removing or replacing the trip unit itself.

B. Control Wiring: Factory installed type SIS rated 600 volt, 90 degrees C, furnished with wire markers at each termination except where installation environments (temperature and chemical) require specialized insulation systems. Wires shall terminate on terminal blocks with marker strips numbered in agreement with detailed connection diagrams complete with bundling, lacing, and protection. Complying with the following:
   1. Flexible stranded conductors for No. 12 AWG and larger.
   2. Minimum size of #14 AWG for 120VAC circuits, minimum size of #12 AWG for 125VDC circuits.
   3. All current transformer circuits shall be #10 AWG and wired through shorting type terminal blocks.
   4. All control wiring shall be 600V SIS. The use of nylon or PVC jackets is not acceptable.
   5. Each control wire shall be uniquely numbered at each end and at each termination point.
   6. No more than two wires shall be connected at a single wiring terminal. Thread on wire nuts or split bolt connectors are not permitted. In-line control wire splices are not acceptable.
   7. Terminal block shall be provided for all conductors requiring connection to circuits external to the specified equipment, where internal circuits cross shipping splits, and where equipment part replacement and maintenance will be facilitated.
   8. Leave slack in bundled conductors at hinges and interconnections between shipping units. Wiring traversing hinges or other forms of flexible constructions shall be high stranded and shall traverse the area of bending normal to the plane of rotation so as to impart a twisting rather than a bending motion to the cable or wire bundle.
   9. Short circuiting type terminal blocks shall be provided for shorting and grounding all CT leads. Non-short circuiting type terminal blocks shall be provided for terminating all control and protection leads.

10. All control wiring shall be routed through the low voltage compartments and secured using tie wraps.

2.7 ACCESSORIES

A. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
   1. Racking handle to manually move circuit breaker between "connected" and "disconnected" positions. (Total of 4 per unit substation)
   2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
   3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
   4. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.
   5. Remote Racking Device: Remote racking device capable of remotely inserting or removing the drawout circuit breakers while the operator is away from the switchgear. Device should operate off 120V receptacle.

B. Combination visual, UV, and IR scan windows shall be rectangular having an overall outside dimension of 12”W x 8.1”H with a window dimension of 9.3”W x 5”H. Window housing shall be aluminum with a locking cover and 316 stainless steel hardware. Optical material shall be a UL 746 compliant visual, UV, and IR transmissive polymer. Window shall be rated IP65/NEMA 4. Window shall be IRISS CAP-CT-12.

C. Ultrasound ports shall be round with a body diameter of 2.6” with a port diameter of 0.5”. Ports shall be made of UL 94 5VA nylon with a stainless steel cover. Ports shall be rated IP65/NEMA 4 when closed. Ports shall be IRISS VP-12-US.

2.8 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.9 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to ANSI C37.51.
   1. The PLC programmer shall be available and present at the factory site during the full factory witness testing period so that any discovered issues or necessary modifications may be addressed at that time. The same PLC programmer shall be

available during the complete site start-up and testing effort (see Part 3) and shall be present during the full site witness testing period so that any discovered issues or necessary modifications may be addressed at that time.

2. Submit all test procedures for approval and notify the Project Manager thirty days prior to commencement of any tests. Testing shall be witnessed by the Owner, and/or their duly authorized representatives. Indicate the approximate duration of the tests.
3. Provide four (4) copies of the factory test reports within two weeks of the completion of factory testing detailed herein.

B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:
   1. Transformer Tests:

      a. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
      b. Ratios on the rated voltage connection and on tap extreme connections.
      c. Polarity and phase relation on the rated voltage connection.
      d. No-load loss at rated voltage on the rated voltage connection.
      e. Exciting current at rated voltage on the rated voltage connection.
      f. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
      g. Applied potential.
      h. Induced potential.
      i. Tests in "Temperature Test" Subparagraph below are optional; select to suit Project conditions. If Project covers more than one unit of a given kVA rating, consider testing one unit only.
      j. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class AA rating and highest kVA Class AFA rating.
      k. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.

   2. Switchgear Tests:

      a. The switchgear shall be completely assembled, wired, adjusted and tested at the factory.
      b. After assembly, the complete switchgear shall be tested to ensure the accuracy of the wiring and the functioning of all equipment.
      c. The main bus system shall be given a dielectric test of 2200 volts for one minute between live parts and ground and between opposite polarities.
      d. The wiring and control circuits shall be given a dielectric test of 1500 volts for one minute, or 1800 volts for one second, between live parts and ground, in accordance with ANSI C37.20.1.
      e. Completely demonstrate the special provisions to accommodate switchgear maintenance.

f. A certified test report of all standard production tests shall be shipped with each assembly.
g. Verify mechanical operation; interlocks and interchangeability of selected breakers.

C. Factory Tests: A complete test of the custom PLC logic and other special features including actual operation of all the breakers in the switchgear to demonstrate all possible conditions of operation. All procedures for system configuration shall be demonstrated and testing shall include attempted operation of all breakers to verify proper interlocking.
1. Provide contactors as necessary to simulate interfacing PLC control of the 480V switchgear with the medium voltage switchgear. Refer to the Sequence of Operation Specification for requirements.

D. Owner will witness all required factory tests. Contractor to provide accommodations if more than 50 mi from site. Notify Owner at least 14 days before date of tests and indicate their approximate duration.
1. Attendance or non-attendance by the Owner and/or their duly authorized representatives at factory tests shall not relieve the manufacturer of responsibility to correct any defects or items of non-conformance with these specifications discovered during site testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for secondary unit substations and other conditions affecting performance of work.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.

C. Examine walls, floors, roofs, and concrete bases for suitable conditions for secondary unit substation installation.

D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at secondary unit substation location.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install secondary unit substations on concrete bases.
   1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.
   2. Use 3,000-psi, twenty eight (28) day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of secondary unit substation.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Testing: Engage a qualified independent testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test according to NETA ATS. Certify compliance with test parameters.
2. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation tested at the specified value or less.
3. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
4. Set field-adjustable switches and circuit-breaker trip ranges as indicated and per short circuit analysis and recommendations of coordination.

    a. Remove and replace malfunctioning units and retest as specified above.

C. Switchgear Field Tests:

1. Visual and Mechanical Inspection:

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, grounding, and required area clearances.
    c. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
    d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as to the address of the circuit breaker that is used to identify it in microprocessor-communication software.
    e. Verify that current and voltage-transformer ratios correspond to Drawings.
    f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

        1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
        2) Make key exchange with devices operated in off-normal positions.

    g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
    h. Inspect insulators for evidence of physical damage or contaminated surfaces.
    i. Verify correct barrier and shutter installation and operation.
    j. Exercise all active components.
    k. Inspect mechanical indicating devices for correct operation.
    l. Verify that filters are in place and vents are clear.
    m. Inspect control power transformers as follows:

        1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
        2) Verify that primary- and secondary-fuse or circuit-breaker ratings match Drawings and comply with manufacturer's recommendations.
        3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

n. A complete test of the custom PLC logic and other special features, including actual operation of all the breakers in the Load Center to demonstrate all possible conditions of operation. All procedures and the remote/local interlocks for system configuration shall be demonstrated and testing shall include attempted operation of all breakers to verify proper interlocking.

2. Electrical Tests:

a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg. C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.

b. Perform a dielectric-withstand-voltage test on each bus section, each phase-to-ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring shall not be less than 2 megohms.

d. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.

2) Verify secondary voltages by energizing the primary winding with system voltage.

e. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

f. Verify operation of space heaters.
g. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean.
e. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
f. Verify that cooling fans operate and that fan motors have correct overcurrent protection.
g. Perform specific inspections and mechanical tests recommended by the manufacturer.
h. Verify that as-left tap connections are as specified.
i. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.

b. Perform power-factor or dissipation-factor tests on windings according to the test equipment manufacturer's published data. Investigate and correct power-factor values that exceed:

1) 2.0 percent for power transformers.
2) 5.0 percent for distribution transformers.

c. Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.
d. Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV. Tip-up test result exceeding 1.0 percent shall be investigated.
e. Perform turns-ratio tests at all tap positions. The test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If the test fails, replace the transformer.
f. Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if the test shows a different pattern.
g. Measure the resistance of each winding at each tap connection.
h. Perform an applied-voltage test on all high- and low-voltage windings-to-ground. See IEEE C57.12.91, Sections 10.2 and 10.9. The ac dielectric-withstand-voltage test result shall not exceed 75 percent of factory test voltage for one-minute duration. The dc dielectric-withstand-voltage test result shall not exceed 100 percent of the ac rms test voltage specified in IEEE 57.12.91, Section 10.2, for one-minute duration. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.
i. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

E. Low-Voltage Power Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that all maintenance devices are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Verify that the arc chutes are intact.
f. Inspect moving and stationary contacts for condition and alignment.
g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

h. Perform mechanical operator and contact alignment tests on both the breaker and its operating mechanism according to manufacturer's published data.
i. Verify cell fit and element alignment.
j. Verify racking mechanism operation.
k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
l. Perform adjustments for final protective-device settings according to coordination study provided by end user.
m. Record as-found and as-left operation counter readings.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.
b. Measure contact resistance across each power contact of the circuit breaker. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Determine long-time pickup and delay by primary current injection. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times shall not exceed the value shown in NETA ATS, Table 100.7.
d. Determine short-time pickup and delay by primary current injection. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
e. Determine ground-fault pickup and delay by primary current injection. Ground-fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
f. Determine instantaneous pickup value by primary current injection. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.8.

g. Test functions of the trip unit by means of secondary injection. Pickup values and trip characteristic shall be as specified and within manufacturer's published tolerances.
h. Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall conform to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
i. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
j. Verify correct operation of any auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and trip unit battery condition. Reset trip logs and indicators. Auxiliary features shall operate according to manufacturer's published data.
k. Verify operation of charging mechanism. The charging mechanism shall operate according to manufacturer's published data.

3.7 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5% during the test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:

   a. Adjust transformer taps.
   b. Rebalance loads.

3. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
4. Report: Present field copy and prepare a written report covering monitoring performed and corrective action taken.

3.8 DEMONSTRATION

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

END OF SECTION 261116

SECTION 261329 - MEDIUM-VOLTAGE, PAD-MOUNTED SWITCHGEAR

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 dead-front, remotely controlled insulated vacuum load and fault interrupting switchgear.

1.3 DEFINITIONS

A. BIL: Basic Impulse Insulation Level.

B. NETA ATS: Acceptance Testing specification

1.4 SUBMITTALS

A. Compliance statement as described under the quality assurance section of this specification.

B. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Time-current characteristic curves for overcurrent protective devices.

C. Shop Drawings: For pad-mounted switchgear.

1. Include a tabulation of installed devices with features and ratings.
2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations shall show major components and features, and they will mimic bus diagram.
3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended work space, and locations of penetrations for grounding and conduits. Show location of anchor bolts and leveling channels.
4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of each field connection.

5. Include list of materials.
6. Locate accessory and spare equipment storage.
7. Include single-line diagram.
8. Include control power wiring diagrams.
9. Include copy of nameplate.
10. Switchgear Ratings:

    a. Voltage.
    b. Continuous current.
    c. Short-circuit rating.
    d. BIL.
11. Wiring Diagrams: For each switchgear assembly, include the following:

    a. Power, signal, and control wiring.
    b. Three-line diagrams of current and future secondary circuits, showing device terminal numbers and internal diagrams.
    c. Schematic control diagrams.
    d. Diagrams showing connections of component devices and equipment.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:
   1. Dimensioned concrete base, outline of switchgear, conduit entries, and grounding equipment locations.

B. Qualification Data: For testing agency.

C. Product Certificates: For pad-mounted switchgear.

   1. Switch ratings as listed in IEEE C37.74.
   2. Interrupter ratings as listed in IEEE C37.60.
   3. Coating system compliance with the IEEE standard listed in "Enclosure" Article.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
b. Time-current curves, including selectable ranges for each type of overcurrent protective device.
c. Record as-left set points of adjustable devices.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in "Field Quality Control" Article.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver in sections of lengths that can be moved past obstructions in delivery path as indicated.

B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.9 WARRANTY

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

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. S&C Electric Company
2. G&W Electric

2.2 SYSTEM DESCRIPTION

A. Manufactured Unit: Pad-mounted switchgear, designed for application in solidly grounded neutralunderground distribution systems.

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 IEEE C2.

D. Comply with IEEE C37.74.

2.3 PERFORMANCE REQUIREMENTS

A. Service Conditions:

1. Switchgear shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.20.3.

2.4 RATINGS

A. Switchgear is applied to a nominal 13.2 kV (L-L) medium-voltage electrical power system. Minimum ratings of the switchgear shall be as follows:

1. Rated Maximum Voltage and Rated BIL: 15.5 kV and 95 kV BIL.
2. Continuous and Load Interrupting Current: 600 A.
3. Short-Time and Short-Circuit Interrupting Current: 40 kA rms Sym.

2.5 SWITCHGEAR ENCLOSURE

A. Custom interior enclosure, designed for mounting on a concrete pad, with provision for anchoring the frame to the pad. The enclosure shall be suitable for mounting against a wall with front access only.

B. Enclosure Integrity: Comply with IEEE C57.12.28 for compartmentalized enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.

C. Enclosure Material: The basic material for the enclosure shall be 14-guage hot-rolled, pickled, and oiled sheet steel.

D. Corrosion Protection: Enclosure coating system shall be factory applied, meeting the requirements of IEEE C57.12.28, in manufacturer's standard color.

2.6 SWITCHGEAR CONSTRUCTION

A. Dead-front, front access only switchgear.

B. Each disconnect switch in switched ways shall be in a sealed, dielectric filled steel tank, factory-filled with SF6 gas.

1. SF6 Gas: Comply with ASTM D2472. Provide enclosure with pressure gauge and self-sealing fill valve.

2. A gas-fill valve shall be provided.

3. A temperature-compensated pressure gauge shall be provided that is color coded to show the operating range. The gauge shall be mounted inside the gas-tight tank (visible through a large viewing window) to provide consistent pressure readings regardless of the altitude at the installation site.

C. Construct switchgear assembly with switched ways that have front-accessible terminations for cables entering from below and cables exiting from above and with manual operating provisions with a lineman's hotstick.

D. Viewing Windows: For each switch, located adjacent to manual operating devices, and positioned to show switch contact position.

E. Grounding: Provision to make grounding cable and wire connections at each way.

F. Connections: Load interrupter switches and fault interrupters shall be equipped with 600-ampere bushings. Bushings and bushing wells shall be located on one side of the gear to reduce the required operating clearance.

2.7 SWITCHED WAYS

A. Source Switch Ways: Non-fused, hotstick operated, ganged vacuum load interrupter switches, with visible-break disconnect switch.

1. Rated Continuous Current and Load Switching Current: 600 A.
2. Vacuum Load Interrupter:

a. With 120 V ac motor operators to open or close the load interrupter.
b. Trip-free switch mechanism. Closing the switch shall be independent of the speed of the operating handle.

3. Visible-Break Disconnect Switch: Three positions, with open, closed, and ground positions. The switch shall be mechanically interlocked so that the vacuum interrupter opens and closes first.

a. Switch position indicator, clearly labeled.
b. Padlocking and tagging provisions.

B. Fault Interrupting Switched Ways: Non-fused, hotstick-operated, ganged vacuum fault interrupter switches, in series with a visible-break disconnect. With internally mounted current transformers and electronic overcurrent sensing for three-phase ganged tripping of the interrupter. Comply with IEEE C37.60.

1. Rated Continuous Current and Load Switching Current: 600 A.
2. Vacuum Fault Interrupter:

a. Operated by a motor-charged stored energy mechanism, with provision to manually charge the mechanism. Charging motors shall operate at 120 V ac.
b. Auxiliary Switches: Provide two auxiliary switches, each with field-selectable NC or NO switch position, for connection of remote indication of the position of the switched way. The switches shall be rated at 15 A, 120 V ac, and 1 A, 120 V dc.
c. Trip-free switch mechanism when manually operated. Closing the switch shall be independent of the speed of the operating handle.
d. Single operating handle and a clearly labeled switch position indicator; open, closed, tripped.
e. Operations Counters: Mechanical type, linked to the operating handle of each switched way.
f. Padlocking and tagging provisions.

3. Visible-Break Disconnect Switch: Three positions, with open, closed, and ground positions. The switch shall be mechanically interlocked so that the switch cannot be operated unless the vacuum fault interrupter is open.

a. Switch position indicator, clearly labeled.
b. Padlocking and tagging provisions.

C. Controls:

1. Motor Actuators: "Open," "close," and "stop" push buttons.
2. Switch Status LEDs: "Open" and "closed" lights. Show status of disconnect switch using its auxiliary contact.
3. Motor Actuator Process LEDs: "Opening" and "closing" lights indicating that the selected motor is operating the switch.
4. Power Switch: "On" and "off" toggle switch and circuit protector, to disconnect the dc supply to its motor and provide overload and short-circuit protection.
5. 120 V ac LED to display battery system power level.
6. Battery voltage meter to show battery condition.
7. Local and Remote Selector: In the "local" position remote operation of the switches is disabled and is possible only under the control of switchgear-mounted push buttons.

D. Overcurrent and Control Relays: Field-adjustable microprocessor electronic relays in each phase at indicated locations. Provide for current adjustment from 0 to 600 A.

1. Device Functions: 51/50, 51N/50N, or 51G/50G according to IEEE C37.2.

2.8 POWER SUPPLY

A. The power supply for instrumentation, communications, and switch operations shall be from a potential transformer installed as part of the switchgear.

2.9 AUTOMATIC SOURCE TRANSFER CONTROLS

A. An automatic switch control system shall execute manual, automatic source-transfer, and SCADA operation of the source and fault interrupting switch ways. The source-transfer controls shall open an incoming switch way where voltage is lost and close the other incoming switch way if voltage is present. The controls shall include an overcurrent lockout that prevents the closing of a switch way into a system fault.

B. The automatic switch control system shall include the ability to execute remote commands received from a SCADA master station and transmit switchgear operation information to a SCADA master station using DNP3 communications protocol. Execution of remote commands shall include enabling of the source-transfer controls and transfer of switch ways to "close," "open," and "ground" positions. Transmission of switchgear information shall include switch way positions and DC supply system status. Additional switchgear information that shall be transmitted follows:

1. Voltage.
2. Current in load ways.

C. The control shall have communication port provisions for connection to a multi-mode serial fiber link.

2.10 BUSHINGS

A. Separable insulated connectors shall be used to connect primary cable. Comply with requirements in Section 260513 "Medium-Voltage Cables."

1. Bushings: One-piece, 600 A, BIL ratings the same as the connectors. Comply with IEEE 386.
2. Supply a standoff bracket or parking stand for each bushing, mounted horizontally adjacent to each bushing.

2.11 SURGE ARRESTERS

A. Distribution class; metal-oxide-varistor type, fully shielded, separable elbow type, suitable for plugging into the inserts. Comply with IEEE C62.11 and IEEE 386.

1. Nominal System Line-to-Line Voltage: 13.2 kV rms.
2. Maximum Continuous Operating Voltage: 10 kV rms.

2.12 Instrument Transformers: Comply with IEEE C57.13.

A. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

B. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

C. Current transformer poles shall have shorting auxiliary contacts and all CT wiring shall be on shorting type terminal blocks.

D. All potential transformer poles shall have fused secondaries.

2.13 DIGITAL METERING

A. Refer to specification 260913 for metering requirements.

B. Dry contacts shall be provided from the switchgear to the digital meter remote open/close status monitoring. Wetting voltage by power supply within metering cabinet.

2.14 WARNING LABELS AND SIGNS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for labels and signs.

1. High-Voltage Warning Label: Self-adhesive labels on the outside of the high-voltage compartment door(s). Legend shall be "DANGER HIGH VOLTAGE" printed in two lines of minimum 2-inch (50 mm) high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.
2. Arc-Flash Warning Label: Self-adhesive labels on the outside of the high-voltage compartment door(s), warning of potential electrical arc-flash hazards and appropriate personal protective equipment required.

2.15 SOURCE QUALITY CONTROL

A. Factory Tests: Comply with requirements in IEEE C37.60 and IEEE C37.74 for testing procedures.

1. Circuit Resistance Test: Verify that switchgear contacts have been properly aligned and current transfer points have been properly assembled.
2. Power-frequency dry withstand voltage test.
3. Dielectric withstand test; one-minute dry power-frequency.
4. Calibrate overcurrent devices for conformance to published time-current characteristic curves.
5. Sealed Tank Leak Test:

a. Comply with IEC 62271-1 for test procedure for switchgear using SF6.
b. The test procedure for vacuum switchgear shall be as follows:

1) Each vacuum tube shall be identified by its serial number. Its vacuum pressure level shall be tested by the manufacturer of the vacuum interrupter. Document the test results.
2) After assembly of the switchgear way, test the vacuum pressure level of the vacuum tubes by the routine dielectric test across the open contacts. The test voltage shall be stated by the manufacturer. The dielectric test shall be carried out after the mechanical routine test.

6. Operating tests shall verify the following:

a. Switch position indicators and contacts are in the correct position for both the open and closed positions.
b. Insulating medium quantity indicator (if provided) is functioning properly.
c. Circuit configuration is shown correctly.
d. Mechanical interlocks are in place and operative.
e. Position and polarity of current transformers meets requirements.
f. Control, secondary wiring, and accessory devices are connected correctly.
g. Devices and relays actually operate as intended. Circuits for which operation is not feasible shall be checked for continuity.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Upon delivery of switchgear and prior to unloading, inspect equipment for damage.

1. Examine tie rods and chains to verify they are undamaged and tight and that blocking and bracing are tight.

2. Verify that there is no evidence of load shifting in transit and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
3. Examine switchgear for external damage, including dents or scratches in doors and sill, and termination provisions.
4. Compare switchgear and accessories received with the bill of materials to verify that the shipment is complete. Verify that switchgear and accessories conform to the manufacturer's quotation and Shop Drawings. If the shipment is not complete or does not comply with project requirements, notify the manufacturer in writing immediately.
5. Unload switchgear, observing packing label warnings and handling instructions.
6. Open compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle switchgear, according to manufacturer's recommendations; avoid damage to the enclosure, termination compartments, base, frame, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.
2. Transport switchgear upright to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.
3. Use spreaders or a lifting beam to obtain a vertical lift and to protect switchgear from straps bearing against the enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
4. Do not damage structure when handling switchgear.

C. Storage:

1. Switchgear may be stored outdoors. If possible, store switchgear at final installation locations on concrete pads. If dry concrete surfaces are not available, use pallets of adequate strength to protect switchgear from direct contact with the ground. Ensure switchgear is level.
2. Protect switchgear from physical damage. Do not store switchgear in the presence of corrosive or explosive gases.
3. Store switchgear with compartment doors closed.

D. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders have to cross section barriers to reach load or line lugs.

E. Pre-Installation Checks:

1. Verify removal of any shipping bracing after placement.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SWITCHGEAR INSTALLATION

A. Comply with NECA 1.

B. Equipment Mounting:

1. Install switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

C. Install level and plumb, tilting less than 1.5 degrees when energized.

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and IEEE C2.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
2. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm). Bond each gate section to the fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
4. Terminate all grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure.
5. Complete the switchgear grounding and surge protector connections prior to making any other electrical connections.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
2. Bundle associated phase, neutral, and equipment grounding conductors together within the switchgear enclosure. Arrange conductors such that there is not excessive strain on the connections that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.

C. Terminate medium-voltage cables in incoming section of switchgear according to Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with OSHA 29 CFR 1910.269.

3.5 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 tests and inspections with the assistance of a factory-authorized service representative.

D. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" chapter.
2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
3. After installing switchgear but before primary is energized, verify that grounding system at the switchgear is tested at the specified value or less.
4. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.

E. Medium-Voltage Switchgear Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that current and voltage transformer ratios correspond to Drawings.
b. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
c. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

    1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
    2) Make key exchange with devices operated in off-normal positions.

d. Inspect control power transformers.

    1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
    2) Verify that primary and secondary fuse or circuit breaker ratings match Drawings.

2. Electrical Tests:

    a. Inspect bolted electrical connections using a low-resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

        1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
        2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

    c. Perform a dielectric withstand voltage test on each bus section, each phase-to-ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 V dc for 300 V-rated cable and 1000 V dc for 600 V-rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring shall not be less than two megohms.

e. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

f. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

g. Perform system function tests according to "System Function Tests" Article.
h. Verify operation of space heaters.
i. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

F. Medium-Voltage Vacuum Interrupter Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required clearances.
c. Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Perform mechanical operation tests on operating mechanism according to manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism shall be according to manufacturer's published data.

g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.
b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range according to manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform minimum pickup voltage tests on trip and close coils according to manufacturer's published data. Minimum pickup voltage of the trip and close coils shall comply with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
d. Verify correct operation of any auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features shall operate according to manufacturer's published data.
e. Trip circuit breaker by operation of each protective device. Reset trip logs and indicators.
f. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed. Power-factor or dissipation-factor values shall comply with manufacturer's published data.
g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position according to manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the specimen is considered to have passed the test.

h. Perform a dielectric-withstand-voltage test according to manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the specimen is considered to have passed the test.

G. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded according to manufacturer's instructions.
g. Set the relay according to results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame according to manufacturer's published data.
b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme.
d. Control Verification:

1) Functional Tests:

a) Check operation of all active digital inputs.
b) Check output contacts or silicone-controlled rectifiers, preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

H. Switchgear will be considered defective if it does not pass tests and inspections.

I. Prepare test and inspection reports.

3.6 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after "Field Quality Control" tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

3.7 FOLLOW-UP SERVICE

A. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary covers prior to the inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the switchgear.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C.
3. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the results as follows:

    a. Description of equipment to be tested.
    b. Discrepancies.
    c. Temperature difference between the area of concern and the reference area.
    d. Probable cause of temperature difference.
    e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
    f. Identify load conditions at time of inspection.
    g. Provide photographs and thermograms of the deficient area.

4. Act on inspection results according to the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261329

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 and Division 01 Specification Sections, apply to this section and all other sections of Division 26.

1.2 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.

1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Qualification Data: For testing agency.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.5 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.

1.6 COORDINATION

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

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

1.7 WARRANTY/GUARANTEE

A. See Division 26 Specification Section “Basic Electrical Requirements’ for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. ACME Electric Corporation; Power Distribution Products Division.
2. Challenger Electrical Equipment Corp.; a division of Eaton Corp.
3. Eaton Electrical Inc.; Cutler-Hammer Products.
4. Sola/Hevi-Duty.
5. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Cores: One leg per phase.

C. Enclosure: Ventilated NEMA 250, Type 2.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

D. Enclosure: Ventilated, NEMA 250, Type 4X, stainless steel.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: ANSI 49 gray.

F. Taps for Transformers 7.5 to 24 kVA: One (1) 5 %_tap above and one (1) 5 % tap below normal full capacity.

G. Taps for Transformers 25 kVA and Larger: Two (2) 2.5 % taps above and two (2) 2.5 % taps below normal full capacity.

H. Insulation Class: 220^0C, UL-component-recognized insulation system with a maximum of 115^0C rise above 40^0C ambient temperature.

I. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 2.

J. 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.
3. Shield Effectiveness:

a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

K. Wall Brackets: Manufacturer's standard brackets.

L. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

M. Low-Sound-Level Requirements: Maximum sound levels, when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and Less: 37 dBA.
2. 30 to 50 kVA: 42 dBA.
3. 51 to 150 kVA: 47 dBA.
4. 151 to 300 kVA: 52 dBA.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

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 Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 3 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

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

C. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. 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 10 % and not being lower than nameplate voltage minus 3% at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare 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 262413 - SWITCHBOARDS

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 and all other sections of Division 26.

1.2 SUMMARY

A. Section Includes:
1. Service and distribution switchboards rated 600 V and less.
2. Generator Quick Connect Switchboard
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.3 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuits current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail utility company's metering provisions with indication of approval by utility company.

7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Include selectable ranges for each type of overcurrent protective device.

9. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Qualification Data: For qualified testing agency.

D. 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.

E. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer's written instructions for testing, maintaining and adjusting overcurrent protective devices.
3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Include selectable ranges for each type of overcurrent protective device.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member Company of NETA or an NRTL.

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

C. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

F. Comply with NEMA PB 2.

G. Comply with NFPA 70.

H. Comply with UL 891.

1.5 DELIVERY, STORAGE, AND HANDLING

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

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

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

1.6 PROJECT CONDITIONS

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

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weather-tight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 104^0F (40^0C).
    b. 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 UMB, in writing, no fewer than 10 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 UMB's written permission.
4. Comply with NFPA 70E.

1.7 COORDINATION

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

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

1.8 WARRANTY

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

1. Warranty Period: Five years from date of Substantial Completion.

1.9 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Potential Transformer Fuses: Equal to 10% of quantity installed for each size and type, but no fewer than two (2) of each size and type.
2. Control-Power Fuses: Equal to 10 % of quantity installed for each size and type, but no fewer than two (2) of each size and type.
3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 % of quantity installed for each size and type, but no fewer than three (3) of each size and type.
4. Fuses for Fused Switches: Equal to 10 % of quantity installed for each size and type, but no fewer than three (3) of each size and type.
5. Fuses for Fused Power-Circuit Devices: Equal to 10 % of quantity installed for each size and type, but no fewer than three (3) of each size and type.
6. Indicating Lights: Equal to 10 % of quantity installed for each size and type, but no less than one of each size and type.
7. Provide Fuse cabinet, to location coordinated with Owner.

1.10 WARRANTY/GUARANTEE

A. See Division 26 Specification Section "Basic Electrical Requirements' for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product by one (1) of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Square D; a brand of Schneider Electric.
3. Approved Equal

B. Front- and Side-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

C. Nominal System Voltage: As shown on drawings.

D. Main-Bus Continuous: As shown on drawings.

E. Indoor Enclosures: Steel, NEMA 250, Type 1.

F. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's ANSI 49 gray finish over a rust-inhibiting primer on treated metal surface.

G. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

H. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

I. Buses and Connections: Three-phase, four-wire unless otherwise indicated.

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, with copper feeder circuit-breaker line connections.
2. Ground Bus: 1/4-by-2-inch hard-drawn copper of 98 % conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
4. Neutral Buses: 100 % of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

J. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
   1. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   2. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

      a. Standard frame sizes, trip ratings, and number of poles.
      b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.

2.3 GENERATOR QUICK CONNECT SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Eaton / Cutler-Hammer
   2. Square D
   3. Trystar

B. Ratings:
   1. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current at rated voltage as indicated on the Drawings.
   2. Additional ratings for voltage, ampere, etc as indicated on the Drawings.
   3. The assembly shall be listed for use as service entrance equipment.

C. Construction
   1. Generator quick connect switchboard shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides and rear shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.

2. Front and side access only switchboards shall be supplied where indicated on the drawings. Protective devices, cable lugs, and all field adjustable components shall be accessible from the side or front of the switchboard.
3. Provide additional cable pull sections if required for cable and conduit entry.
4. All sections of the switchboard shall be front and rear aligned with the minimum depth required for the each installation. All protective devices shall be group mounted. Devices shall be front removable and load connections front and rear accessible. Rear access shall be provided as standard, and front and side access only switchboards shall be provided as shown on the Drawings.
5. The switchboard shall be provided with load connection options to cross bus or mechanical outgoing cable terminations, which shall be suitable for copper conductors. Provide the required line and load lugs for each application.
6. The assembly shall be provided with adequate lifting means.

D. Bus
1. All bus bars shall be silver-plated copper. Bus ampacity shall be based on NEMA standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).
2. Provide a full capacity neutral bus.
3. A copper ground bus (minimum ¼ inch by 2 inch) shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard.
4. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.

E. Wiring and Terminations
1. Normal Power and Load Cable Connections: The switchboard shall be provided with mechanical lugs for load and normal power feeder connections. Size and quantity of lugs shall be adequate for the switchboard ampacity and to accommodate cables being provided.
2. Switchboards designed with a single generator protection device shall be provided without normal power mechanical lug connections as shown on the Drawings.
3. All switchboards shall be provided with mechanical lugs and cam-type receptacle assembly for connection of generator power phases (A, B, C), neutral and grounding conductors. All connections for phases, neutral, ground, etc., shall be clearly labeled.
4. Cam-type receptacles: Multiple single pole receptacles per phase, neutral, and ground shall be provided. Cam-type receptacles shall be approved during the shop drawing submittal process by the engineer and Director’s Representative.
5. Each single pole cam-type receptacle shall be rated for no less than 400 amps at 90 deg C.
6. Contact material of the receptacle shall be composed of brass.
7. Single pole Cam-type receptacles shall be UL 498 listed for Attachment Plugs and Receptacles and UL 1691.
8. Cam-type receptacles shall be suitable for use in outdoor environments.

9. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification corresponding to appropriate designations on manufacturer's wiring diagrams.
10. Where applicable all control wire shall be type SIS, bundled and secured with nylon ties. Insulated locking spade terminals shall be provided for all control connections, except where saddle type terminals are provided integral to a device. All current transformer secondary leads shall first be connected to conveniently accessible short-circuit terminal blocks before connecting to any other device. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Provide wire markers at each end of all control wiring.

F. Molder Case Circuit Breaker
1. Protective devices shall be molded case circuit breakers with inverse time and instantaneous tripping characteristics.
2. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be nonwelding silver alloy and arc extinction shall be accomplished by means of DE-ION arc chutes. A push-to-trip button on the front of the circuit breaker shall provide a local manual means to exercise the trip mechanism.
3. Circuit breakers shall have a minimum symmetrical interrupting capacity as indicated on the Drawings.
4. Circuit breakers 800 ampere frame and below shall include thermal-magnetic trip units and inverse time-current characteristics. Circuit breakers above 800 ampere frame shall include microprocessor-based rms sensing trip units.
5. Ground fault protection shall be provided for all circuit breakers.
6. Circuit breakers above 800 ampere frame shall be UL listed for applications at 100% of their continuous ampere rating in their intended enclosure.

G. Optional Features
1. Provide Key interlocks between Generator Switchboard Main and Generator breaker to prevent inadvertent interconnection and utility back feed or paralleling of unsynchronized sources.
   a. Where indicated on the drawings provide key interlocks with existing overcurrent protection devices and Generator breaker.
2. The switchboard shall be provided with a thermostatically controlled space heater. Power for the space heaters shall be obtained from a control power transformer within the switchboard. Supply voltage shall be 120 volts AC.

H. Enclosure
1. Indoor Enclosures: Steel, NEMA 250, Type 1.

2. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's ANSI 49 gray finish over a rust-inhibiting primer on treated metal surface.

2.4 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

B. Permanent Engraved Phenolic Nameplates: Provide white with black lettering ID plates for each circuit.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, four (4) inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete Miscellaneous Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on eighteen (18) inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

G. Set field-adjustable switches and circuit-breaker trip ranges according to the settings that will be provided by the Engineer. Allow for 14 days to receive settings after requested by the Contractor.

H. Comply with NECA 1.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
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 sixty (60) days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and side panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard eighteen (18) 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.

    d. Follow NFPA 70E requirements

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

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

3.6 ADJUSTING

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

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

3.7 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

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 and all other sections of Division 26.

1.2 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. TVSS: Transient voltage surge suppressor.

1.4 PERFORMANCE REQUIREMENTS

1.5 SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. 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. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

6. Include wiring diagrams for power, signal, and control wiring.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Also include selectable ranges for each type of overcurrent protective device.

C. Qualification Data: For qualified testing agency.

D. 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.

E. Panelboard Schedules: For installation in panel boards. Submit final versions after load balancing.

F. Operation and Maintenance Data: For panel boards, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for maintaining, testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 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 panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. 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.

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 NEMA PB 1.

F. Comply with NFPA 70.

1.7 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 NEMA PB 1.

1.8 PROJECT 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 23^0F to plus 104^0F.
    b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

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 UM, in writing, no fewer than 10 days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without UM's written permission.
3. Comply with NFPA 70E.

1.9 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other

types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

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

1.10 WARRANTY

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

1. Warranty Period: Five years from date of Substantial Completion.

1.11 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

1.12 WARRANTY/GUARANTEE

A. See Division 26 Specification Section “Basic Electrical Requirements’ for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Surface-mounted cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type
b. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids including mechanical rooms: NEMA 250, Type 12.

2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
3. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
4. Finishes:

    a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two (2) coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    b. Back Boxes: Galvanized steel.

5. Directory Card: Inside panelboard door, mounted in transparent card holder.

B. Incoming Mains Location: Top or bottom fed as needed.

C. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 % conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

D. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 % conductivity.
2. Main and Neutral Lugs: Mechanical type.
3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device as needed.
6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

F. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Mains: Circuit breaker

D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Match panelboard manufacturer.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip). Provide where indicated on drawings.
3. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip). Provide where indicated on drawings.
4. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration. Provide where indicated on drawings.
5. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.

f. Handle Clamp: Loose attachment for holding circuit-breaker handle in on position.

2.4 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. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

C. Mount top of trim 90 inches above finished floor unless otherwise indicated.

D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

E. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

F. Install filler plates in unused spaces.

G. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

H. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Comply with NFPA 70E.

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

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

3.5 ADJUSTING

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

B. Load Balancing: After Substantial Completion, but not more than sixty (60) days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical twenty four (24) hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 % between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.6 PROTECTION

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

END OF SECTION 262416

SECTION 262419 - MOTOR-CONTROL CENTERS

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 MCCs for use with ac circuits rated 600 V and less, with combination controllers and having the following factory-installed components:

1. Automatic power transfer.
2. Feeder-tap units.
3. Measurement and control.
4. Auxiliary devices.
5. Panelboards.
6. Transformers.

1.3 DEFINITIONS

A. CPT: Control power transformer.

B. MCC: Motor-control center.

C. MCCB: Molded-case circuit breaker.

D. MCP: Motor-circuit protector.

E. OCPD: Overcurrent protective device.

F. PID: Control action; proportional plus integral plus derivative.

G. PT: Potential transformer.

H. SPD: Surge protective device.

I. SCR: Silicon-controlled rectifier.

J. VFC: Variable-frequency controller.

K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for MCCs.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories for each cell of the MCC.

B. Shop Drawings: For each MCC, manufacturer's approval and custom drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Enclosure types and details.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.
f. Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.
g. Specified optional features and accessories.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.
3. Nameplate legends.
4. Vertical and horizontal bus capacities.
5. Features, characteristics, ratings, and factory settings of each installed unit.

1.5 INFORMATIONAL SUBMITTALS

A. Standard Drawings: For each MCC, as defined in UL 845.

B. Production Drawings: For each MCC, as defined in UL 845.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around MCCs where pipe and ducts are prohibited. Show MCC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Qualification Data: For testing agency.

E. Product Certificates: For each MCC.

F. Source quality-control reports.

G. Field quality-control reports.

H. Load-Current and Overload Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

I. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

J. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
2. Manufacturer's Record Drawings: As defined in UL 845. In addition to requirements specified in UL 845, include field modifications and field-assigned wiring identification incorporated during construction by manufacturer, Contractor, or both.
3. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
4. Manufacturer's written instructions for setting field-adjustable overload relays.
5. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

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. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

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

B. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, and marked for intended use.

D. UL Compliance: MCCs shall comply with UL 845 and shall be listed and labeled by a qualified testing agency.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver MCCs in shipping splits of lengths that can be moved past obstructions in delivery paths.

B. Handle MCCs according to the following:

1. NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."
2. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."

C. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside MCCs; install temporary electric heating, with at least 250 W per vertical section.

1.10 WARRANTY

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

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.
4. Rockwell Automation

2.2 SYSTEM DESCRIPTION

A. NEMA Compliance: Fabricate and label MCCs to comply with NEMA ICS 18.

B. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F (40 deg C), with an average value not exceeding 95 deg F (35 deg C) over a 24-hour period.
2. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
3. Humidity Rating: Less than 95 percent (noncondensing).
4. Altitude Rating: Not exceeding 6600 feet (2000 m), or 3300 feet (1000 m) if MCC includes solid-state devices.

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.

2.3 PERFORMANCE REQUIREMENTS

A. Capacities and Characteristics:

1. MCC Enclosure and Assembly:

a. Nominal System Voltage: 277/480-V ac.
b. Service Equipment Rated: No.
c. Enclosure: NEMA 250, Type 12

2. Integrated Short-Circuit Rating for MCC:

a. Fully rated; 42 kA.

3. Integrated Short-Circuit Rating for Each Unit:

a. Fully rated; 42 kA.

4. Bus:

a. Horizontal Bus: 42 kA.
b. Neutral Bus: Full size.

5. Main Disconnect Device:

a. Main Disconnect: MCCB, UL 489, three pole, 225 A.
b. SPD: UL 1449, Type 1.

6. Magnetic Controllers: Refer to drawings for sizes.

7. Controller-Mounted Auxiliary Devices:

a. Push Buttons and Selector Switches: Standard-duty, oiltight type.
b. Feeder Tap Units: Main Disconnect: MCCB, UL 489 three pole.

2.4 MOTOR CONTROL CENTER ENCLOSURES

A. Indoor Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, Type 12 unless otherwise indicated to comply with environmental conditions at installed location.

B. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

2.5 ASSEMBLY

A. Structure:

1. Units up to and including Size 3 shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
2. Pull Boxes:

a. Include provisions for ventilation to maintain temperature in pull box within same limits as the MCC.
b. Covers: Removable covers forming top, front, and sides.
c. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.
d. Cable Supports: Arranged to facilitate cabling and adequate to support cables, including supports for future cables.
e. When equipped with barriers, supply with access to check bus bolt tightness.

B. Compartments: Modular; individual doors with concealed hinges and quick-captive screw fasteners.

1. Interlock compartment door to require that the disconnecting means is "off" before door can be opened or closed, except by operating a concealed release device.
2. Compartment construction shall allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC.
3. The same-size compartments shall be interchangeable to allow rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

C. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same-size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

D. Wiring Spaces:

1. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
2. Horizontal wireways in top of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.

E. Provisions for Future:

1. Compartments marked "future" shall be bused, wired and equipped with guide rails or equivalent, and ready for insertion of drawout units.
2. Compartments marked "spare" shall include provisions for connection to the vertical bus.

F. Integrated Short-Circuit Rating:

1. Short-Circuit Current Rating for Each Unit: Fully rated; 42 kA.
2. Short-Circuit Current Rating of MCC: Fully rated with its main overcurrent device; 42 kA.

G. Control Power:

1. 120-V ac, supplied centrally from a CPT.
2. 120-V ac; obtained from CPT integral with controller; with primary and secondary fuses. The CPT shall be of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 150 VA.

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

1. Wiring Class: NEMA ICS 18, Class I.
2. Control and Load Wiring: Factory installed, with bundling, lacing, and protection included. Use flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

I. Bus:

1. Main Horizontal and Equipment Ground Buses: Uniform capacity for entire length of MCC's main and vertical sections.
2. Vertical Phase and Equipment Ground Buses: Uniform capacity for entire usable height of vertical sections, except for sections incorporating single units.
3. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity or silver plated alloy, with compression connectors for outgoing conductors.
4. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for ground conductors, minimum size 1/4-by-2 inches (6 by 50 mm). Equip with compression connectors for outgoing conductors.
5. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Insulation temperature rating shall not be less than 105 deg C.

2.6 MAIN DISCONNECT AND OVERCURRENT PROTECTIVE DEVICE(S)

A. MCCB : Fixed mounted, manually operated air-circuit breaker. Comply with UL 489.

1. MCCB shall have quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, its position shall be shown by the position of the handle, and manual push-to-trip push button.
2. Solid-state monitoring and tripping system to show system status monitoring, adjustable time-current protection, and shunt trip.

a. Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
b. Trip-setting dials or interchangeable plugs to establish the continuous trip of the circuit breaker. Plugs shall not be interchangeable between frames, and the breaker may not be closed without the plug. With neutral ground-fault sensor.
c. Time-current adjustments to achieve protective-device coordination as follows:

1) Adjustable long-time delay.
2) Adjustable short-time setting and delay to shape the time-current curve.
3) Adjustable instantaneous setting.
4) Individually adjustable ground-fault setting and time delay.

d. Built-in connector to test the long-time delay, instantaneous, and ground-fault functions of the breaker.

3. Switch operator power shall be from control power specified in "Assembly" Article.

B. Surge Suppression: Factory installed as an integral part of the incoming feeder, complying with UL 1449, SPD Type 1.

2.7 MAGNETIC CONTROLLERS

A. Controller Units: Combination controllers.

B. Disconnects:

1. Fusible Switch:

a. UL 98 and NEMA KS 1, heavy-duty, horsepower-rated fusible switch, with clips or bolt pads to accommodate UL 248-8 Class J fuses.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
c. Auxiliary Contacts: NC/NO, arranged to activate before switch blades open.

2. MCP:

a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.

c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
d. NC/NO alarm contact that operates only when MCP has tripped.
e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3. MCCB:

a. UL 489, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.

C. Controllers: Comply with UL 508.

1. Full-Voltage Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.

D. Overload Relays:

1. Bimetallic Overload Relays:

a. Inverse-time-current characteristic.
b. Class 20 tripping characteristic.
c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

2.8 CONTROLLER-MOUNTED AUXILIARY DEVICES

A. Control-Circuit and Pilot Devices: Factory installed in controller enclosure cover unless otherwise indicated. Comply with NEMA ICS 5.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, oiltight type.

a. Push Buttons: Recessed types; momentary contact unless otherwise indicated.
b. Pilot Lights: LED types;; push to test.
c. Selector Switches: Rotary type.

B. Elapsed-Time Meters: Heavy duty with digital readout in hours; nonresettable.

C. Auxiliary Dry Contacts: Reversible NC/NO.

2.9 MEASUREMENT AND CONTROL DEVICES

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
   1. CPTs: Dry type, mounted in separate compartments for units larger than 3 kVA.

B. Instrument Switches: Rotary type with off position.

   1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and phase-to-neutral voltages where a neutral is included.
   2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

2.10 FEEDER TAP UNITS

A. MCCBs: Fixed mounted, with 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. Comply with UL 489, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

   1. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   2. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

      a. Instantaneous trip.
      b. Long- and short-time pickup levels.
      c. Long- and short-time time adjustments.
      d. Ground-fault pickup level, time delay, and I^2t response.

2.11 SOURCE QUALITY CONTROL

A. MCC Testing: Test and inspect MCCs according to requirements in NEMA ICS 18.

B. MCCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive MCCs, with Installer present, for compliance with requirements for 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. NEMA Industrial Control and Systems Standards: Comply with parts of NEMA ICS 2.3 for installation and startup of MCCs.

B. Floor Mounting: Install MCCs on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

E. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

F. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification of MCC, MCC components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components.
2. Install required warning signs.
3. Label MCC and each cubicle with engraved nameplate.
4. Label each enclosure-mounted control and pilot device.
5. Mark up a set of manufacturer's connection wiring diagrams with field-assigned wiring identifications and return to manufacturer for inclusion in Record Drawings.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers and remote devices and facility's BAS. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

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

3.5 CONNECTIONS

A. Comply with requirements for installation of conduit in Section 260533 "Raceways and Boxes for Electrical Systems." Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 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 tests and inspections with the assistance of a factory-authorized service representative.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, 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. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. MCCs will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to NETA Acceptance Testing Specification and manufacturer's written instructions.

3.8 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload relay pickup and trip ranges.

B. Adjust overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges per the study provided by Others,

END OF SECTION 262419

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 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. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
5. UMB 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.

C. Qualification Data: For qualified testing agency.

D. 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.

E. Manufacturer's field service report.

F. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.5 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 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.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22^0F and not exceeding 104^0F.
2. Altitude: Not exceeding six thousand six hundred (6,600) feet.

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

1. Notify UMB no fewer than ten (10) 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 UMB's written permission.
4. Comply with NFPA 70E.

1.7 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.

1.8 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 % of quantity installed for each size and type, but no fewer than three of each size and type.
2. Fuse Pullers: Two (2) for each size and type.

1.9 WARRANTY/GUARANTEE

A. See Division 26 Specification Section "Basic Electrical Requirements' for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 240 or 600 V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position. Fuses shall be rated for an interrupting capacity of 200,000 amps.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: **One** NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.2 NONFUSIBLE SWITCHES

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

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 240 or 600 V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4X non-metallic.
3. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

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. Install individual floor-mounted switches and circuit breakers with tops at uniform height, utilizing properly secured channels anchored to floor and ceiling.

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 Division 26 Section "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved 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 sixty (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 eleven (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 as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".

END OF SECTION 262816

SECTION 263600 - TRANSFER SWITCHES

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 and all other sections of Division 26.

1.2 SUMMARY

A. This Section includes transfer switches rated 600 V and less, including the following:

1. Automatic transfer switches.
2. Bypass/isolation switches.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

C. Qualification Data: For manufacturer and testing agency.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Features and operating sequences, both automatic and manual.
2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain automatic transfer switches, bypass/isolation switches through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NEMA ICS 1.

F. Comply with NFPA 70.

G. Comply with NFPA 110.

H. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.5 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service, if needed.

1. Notify UMB no fewer than ten (10) days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without UMB’s written permission.

1.6 COORDINATION

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

1.7 WARRANTY/GUARANTEE

A. See Division 26 Specification Section "Basic Electrical Requirements' for warranty and guarantee requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Contactor Transfer Switches:
   a. Emerson; ASCO Power Technologies, LP.
   b. GE Zenith Controls.
   c. Onan/Cummins Power Generation; Industrial Business Group.
   d. Russelectric, Inc.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 % of switch ampere rating, unless otherwise indicated.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 % or better over an operating temperature range of minus 20^0C to plus 70^0C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. All switches shall be four-pole switches , provide neutral pole switched simultaneously with phase poles.

H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

I. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device. Provide CAT 6E cable in conduit from remote communication.

J. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

K. Enclosures: General-purpose NEMA 250, Type 1], complying with NEMA ICS 6 and UL 508, unless otherwise indicated

2.3 AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from one (1) second to thirty (30) seconds.

E. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

F. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.

G. Automatic Transfer-Switch Features:

1. Maximum operating transfer time of one sixth (1/6) second.
2. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85% to 100 % of nominal, and dropout voltage is adjustable from 75% to 98 %of pickup value. Factory set for pickup at 95 % and dropout at 95 %.
3. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero (0) seconds to six (6) seconds, and factory set for three (3) seconds.
4. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85% to 100 % of nominal. Factory set for pickup at 95 %. Pickup frequency shall be adjustable from 90% to 100% of nominal. Factory set for pickup at 98%.
5. Time delay for Transfer to Emergency: Adjustable from zero (0) minutes to five (5) minutes, and factory set for zero (0) minutes.
6. Time Delay for Retransfer to Normal Source: Adjustable from zero (0) minutes to thirty (30) minutes, and factory set for ten (10) minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
7. Engine Cool Down Time: Adjustable from zero (0) minutes to thirty (30) minutes, and factory set for five (5) minutes.
8. Test Switch: Simulate normal-source failure.
9. Switch-Position Pilot Lights: Indicate source to which load is connected.
10. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

11. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
12. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
13. Engine Starting Contacts: One (1) isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
14. Engine Shutdown Contacts: Time delay adjustable from zero (0) minutes to five (5) minutes, and factory set for five (5) minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
15. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from seven (7) days to thirty (30) days. Running periods are adjustable from ten (10) minutes to thirty (30) minutes. Factory settings are for seven (7) day exercise cycle, thirty (30) minute running period, and five (5) minute cool-down period. Exerciser features include the following:

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

2.4 SOURCE QUALITY CONTROL

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

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Concrete Bases: Four (4) inches high, reinforced, with chamfered edges. Extend base no more than four (4) inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."

B. Identify components according to Division 26 Section "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

D. Where generators serve more than one transfer switch, starting control is governed by the closing of engine start contacts at any one multiple transfer switches. Engines shall not shut down unless all associated transfer switches have transferred back to normal source and all cool-down time delays have expired.

3.2 CONNECTIONS

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

B. Provide CAT 6E cable in conduit from ATS back to BAS main control panel.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
b. Simulate loss of phase-to-ground voltage for each phase of normal source.
c. Verify time-delay settings.
d. Verify pickup and dropout voltages by data readout or inspection of control settings.
e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one (1) pole deviating by more than 50 % from other poles.
g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

a. Verify grounding connections and locations and ratings of sensors.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Remove and replace malfunctioning units and retest as specified above.

F. Infrared Scanning: After Substantial Completion, but not more than sixty (60) days after Substantial Completion, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch eleven (11) months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

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

B. Coordinate this training with that for generator equipment.

3.5 START-UP SERVICES

A. The complete installation shall be initially started and checked for operational compliance by factory trained manufacturer's representative(s).

B. All settings, as specified in this section shall be property set and verified by start-up personnel.

C. Provide a written start-up and testing checklist which verifies all settings and features are properly set and functioning, written report shall indicate final setting of all adjustable features.

3.6 CLEANING

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

END OF SECTION 263600