XAVIER UNIVERSITY

M.H. MALTINSKY, LICENSE #10106
EXPIRATION DATE 12/31/2017

LOGAN HALL RENOVATION

SPECIFICATIONS

BID PACKAGE NO. 3 ISSUED FOR BIDDING AND PERMIT

MARCH 7, 2017

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SECTION 011000 - SUMMARY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Project information.
2. Work under separate contracts.
3. Pre-purchased equipment and services.
4. Specification and drawing conventions.
5. Miscellaneous provisions.

1.2 PROJECT INFORMATION

A. Project Identification: Logan Hall Renovation.

1. Project Location: 3800 Victory Parkway, Cincinnati, Ohio 45207.

B. Owner: Xavier University.

C. Architect: glaserworks, 304 East 8th Street, Cincinnati, Ohio 45202.

1.3 WORK UNDER SEPARATE CONTRACTS

A. General: Cooperate fully with separate contractors so work on those contracts may be carried out smoothly, without interfering with or delaying work under this Contract or other contracts. Coordinate the Work of this Contract with work performed under separate contracts.

B. Concurrent Work: Owner will award separate contract(s) for construction operations at Project site. Those operations will be conducted simultaneously with work under this Contract.

1.4 PRE-PURCHASED EQUIPMENT AND SERVICES

A. Certain equipment and services for this project have been pre-purchased by the Owner in separate bid packages.

B. Pre-purchased equipment and services:

1. Fume hoods, metal laboratory casework, new laboratory countertops and installation of same.
2. Exhaust fans and installation of same.
3. Air handling unit and installation/refurbishment.
4. Variable frequency drives and installation of same.
5. Other HVAC work as described in the Mechanical drawings.

1.5 SPECIFICATION AND DRAWING CONVENTIONS

A. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:

1. Imperative mood and streamlined language are generally used in the Specifications. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.

2. Specification requirements are to be performed by Contractor unless specifically stated otherwise.

B. Division 01 General Requirements: Requirements of Sections in Division 01 apply to the Work of all Sections in the Specifications.

C. Drawing Coordination: Requirements for materials and products identified on Drawings are described in detail in the Specifications. One or more of the following are used on Drawings to identify materials and products:

1. Terminology: Materials and products are identified by the typical generic terms used in the individual Specifications Sections.

2. Abbreviations: Materials and products are identified by abbreviations scheduled on Drawings.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 011000

SECTION 013300 - SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes requirements for the submittal schedule and administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.

1.2 DEFINITIONS

A. Action Submittals: Written and graphic information and physical samples that require Architect's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

B. Informational Submittals: Written and graphic information and physical samples that do not require Architect's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

C. Portable Document Format (PDF): An open standard file format licensed by Adobe Systems used for representing documents in a device-independent and display resolution-independent fixed-layout document format.

1.3 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Initial Review: Allow 15 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Architect will advise Contractor when a submittal being processed must be delayed for coordination.
2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.
3. Resubmittal Review: Allow 15 days for review of each resubmittal.

B. Electronic Submittals: Identify and incorporate information in each electronic submittal file as follows:

1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.
    a. File name shall use project identifier and Specification Section number followed by a decimal point and then a sequential number (e.g., LNHS-061000.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., LNHS-061000.01.A).
3. Provide means for insertion to permanently record Contractor's review and approval markings and action taken by Architect.

C. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.

1. Note date and content of previous submittal.
2. Note date and content of revision in label or title block and clearly indicate extent of revision.

3. Resubmit submittals until they are marked with approval notation from Architect's action stamp.

D. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Architect's action stamp.

PART 2 - PRODUCTS

2.1 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements: Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.

1. Submit electronic submittals via email as PDF electronic files.

a. Architect will return annotated file. Annotate and retain one copy of file as an electronic Project record document file.

2. Certificates and Certifications Submittals: Provide a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.

a. Provide a digital signature with digital certificate on electronically submitted certificates and certifications where indicated.

B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. Submit Product Data in the following format:

a. PDF electronic file.

C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.

1. Submit Shop Drawings in the following format:

a. PDF electronic file.

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

1. Identification: Attach label on unexposed side of Samples that includes the following:

a. Generic description of Sample.

b. Product name and name of manufacturer.

E. Maintenance Data: Comply with requirements specified in Section 017823 "Operation and Maintenance Data."

2.2 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.

B. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally signed PDF electronic file paper copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Architect .

B. Project Closeout and Maintenance Material Submittals: See requirements in Section 017700 "Closeout Procedures."

C. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

3.2 ARCHITECT'S ACTION

A. Action Submittals: Architect will review each submittal, make marks to indicate corrections or revisions required, and return it. Architect will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action.

END OF SECTION 013300

SECTION 016000 - PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for selection of products for use in Project; product delivery, storage, and handling; manufacturers' standard warranties on products; special warranties; and comparable products.

1.2 DEFINITIONS

A. Products: Items obtained for incorporating into the Work, whether purchased for Project or taken from previously purchased stock. The term "product" includes the terms "material," "equipment," "system," and terms of similar intent.

1. Named Products: Items identified by manufacturer's product name, including make or model number or other designation shown or listed in manufacturer's published product literature, that is current as of date of the Contract Documents.

2. New Products: Items that have not previously been incorporated into another project or facility. Products salvaged or recycled from other projects are not considered new products.

3. Comparable Product: Product that is demonstrated and approved through submittal process to have the indicated qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics that equal or exceed those of specified product.

B. Basis-of-Design Product Specification: A specification in which a specific manufacturer's product is named and accompanied by the words "basis-of-design product," including make or model number or other designation, to establish the significant qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics for purposes of evaluating comparable products of additional manufacturers named in the specification.

1.3 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft and vandalism. Comply with manufacturer's written instructions.

B. Delivery and Handling:

1. Schedule delivery to minimize long-term storage at Project site and to prevent overcrowding of construction spaces.

2. Deliver products to Project site in an undamaged condition in manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.

C. Storage:

1. Store materials in a manner that will not endanger Project structure.

2. Store products that are subject to damage by the elements, under cover in a weathertight enclosure above ground, with ventilation adequate to prevent condensation.

3. Comply with product manufacturer's written instructions for temperature, humidity, ventilation, and weather-protection requirements for storage.

4. Protect stored products from damage and liquids from freezing.

1.4 PRODUCT WARRANTIES

A. Warranties specified in other Sections shall be in addition to, and run concurrent with, other warranties required by the Contract Documents. Manufacturer's disclaimers and limitations on product warranties do not relieve Contractor of obligations under requirements of the Contract Documents.

1. Manufacturer's Warranty: Written warranty furnished by individual manufacturer for a particular product and specifically endorsed by manufacturer to Owner.

2. Special Warranty: Written warranty required by the Contract Documents to provide specific rights for Owner.

B. Special Warranties: Prepare a written document that contains appropriate terms and identification, ready for execution.

PART 2 - PRODUCTS

2.1 PRODUCT SELECTION PROCEDURES

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

1. Provide products complete with accessories, trim, finish, fasteners, and other items needed for a complete installation and indicated use and effect.

2. Owner reserves the right to limit selection to products with warranties not in conflict with requirements of the Contract Documents.

3. Where products are accompanied by the term "as selected," Architect will make selection.

4. Descriptive, performance, and reference standard requirements in the Specifications establish salient characteristics of products.

PART 3 - EXECUTION (Not Used)

END OF SECTION 016000

SECTION 017300 - EXECUTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general administrative and procedural requirements governing execution of the Work including, but not limited to, the following:

1. Installation of the Work.
2. Cutting and patching.
3. Progress cleaning.
4. Starting and adjusting.
5. Protection of installed construction.

1.2 DEFINITIONS

A. Cutting: Removal of in-place construction necessary to permit installation or performance of other work.

B. Patching: Fitting and repair work required to restore construction to original conditions after installation of other work.

1.3 QUALITY ASSURANCE

A. Cutting and Patching: Comply with requirements for and limitations on cutting and patching of construction elements.

1. Structural Elements: When cutting and patching structural elements, notify Architect of locations and details of cutting and await directions from Architect before proceeding. Shore, brace, and support structural elements during cutting and patching. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection

B. Manufacturer's Installation Instructions: Obtain and maintain on-site manufacturer's written recommendations and instructions for installation of products and equipment.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Comply with requirements specified in other Sections.

B. In-Place Materials: Use materials for patching identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.

1. If identical materials are unavailable or cannot be used, use materials that, when installed, will provide a match acceptable to Architect for the visual and functional performance of in-place materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Existing Conditions: The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning sitework, investigate and verify the existence and location of underground utilities, mechanical and electrical systems, and other construction affecting the Work.

1. Before construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping; underground electrical services, and other utilities.
2. Furnish location data for work related to Project that must be performed by public utilities serving Project site.

B. Examination and Acceptance of Conditions: Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance. Record observations.

1. Examine roughing-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
2. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.
3. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.

C. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

B. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.

C. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for clarification of the Contract Documents caused by differing field conditions outside the control of Contractor, submit a request for information to Architect.

3.3 INSTALLATION

A. General: Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.

1. Make vertical work plumb and make horizontal work level.
2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
3. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.

B. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.

C. Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.

D. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.

E. Sequence the Work and allow adequate clearances to accommodate movement of construction items on site and placement in permanent locations.

F. Attachment: Provide blocking and attachment plates and anchors and fasteners of adequate size and number to securely anchor each component in place, accurately located and aligned with other portions of the Work. Where size and type of attachments are not indicated, verify size and type required for load conditions.

1. Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by Architect.

G. Joints: Make joints of uniform width. Where joint locations in exposed work are not indicated, arrange joints for the best visual effect. Fit exposed connections together to form hairline joints.

H. Hazardous Materials: Use products, cleaners, and installation materials that are not considered hazardous.

3.4 CUTTING AND PATCHING

A. Cutting and Patching, General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.

1. Cut in-place construction to provide for installation of other components or performance of other construction, and subsequently patch as required to restore surfaces to their original condition.

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

C. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.

1. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots neatly to minimum size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.

2. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.

D. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other work. Patch with durable seams that are as invisible as practicable. Provide materials and comply with installation requirements specified in other Sections, where applicable.

1. Exposed Finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will minimize evidence of patching and refinishing.

a. Clean piping, conduit, and similar features before applying paint or other finishing materials.

b. Restore damaged pipe covering to its original condition.

E. Cleaning: Clean areas and spaces where cutting and patching are performed. Remove paint, mortar, oils, putty, and similar materials from adjacent finished surfaces.

3.5 PROGRESS CLEANING

A. General: Clean Project site and work areas daily, including common areas. Enforce requirements strictly. Dispose of materials lawfully.

3.6 STARTING AND ADJUSTING

A. Start equipment and operating components to confirm proper operation. Remove malfunctioning units, replace with new units, and retest.

B. Adjust equipment for proper operation. Adjust operating components for proper operation without binding.

C. Test each piece of equipment to verify proper operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.7 PROTECTION OF INSTALLED CONSTRUCTION

A. Provide final protection and maintain conditions that ensure installed Work is without damage or deterioration at time of Substantial Completion.

B. Comply with manufacturer's written instructions for temperature and relative humidity.

END OF SECTION 017300

SECTION 017700 - CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

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

1. Substantial Completion procedures.
2. Warranties.
3. Final cleaning.
4. Repair of the Work.

1.2 ACTION SUBMITTALS

A. Contractor's List of Incomplete Items: Initial submittal at Substantial Completion.

1.3 SUBSTANTIAL COMPLETION PROCEDURES

A. Contractor's List of Incomplete Items: Prepare and submit a list of items to be completed and corrected (Contractor's punch list), indicating the value of each item on the list and reasons why the Work is incomplete.

1.4 LIST OF INCOMPLETE ITEMS (PUNCH LIST)

A. Organization of List: Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction.

1. Submit list of incomplete items in the following format:

a. PDF electronic file. Architect will return annotated file.

1.5 SUBMITTAL OF PROJECT WARRANTIES

A. Time of Submittal: Submit written warranties on request of Architect for designated portions of the Work where commencement of warranties other than date of Substantial Completion is indicated, or when delay in submittal of warranties might limit Owner's rights under warranty.

B. Organize warranty documents into an orderly sequence based on the table of contents of Project Manual.

1. Warranty Electronic File: Scan warranties and bonds and assemble complete warranty and bond submittal package into a single indexed electronic PDF file with links enabling navigation to each item. Provide bookmarked table of contents at beginning of document.

C. Provide additional copies of each warranty to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cleaning Agents: Use cleaning materials and agents recommended by 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 3 - EXECUTION

3.1 FINAL CLEANING

A. General: Perform final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.

3.2 REPAIR OF THE WORK

A. Complete repair and restoration operations before requesting inspection for determination of Substantial Completion.

END OF SECTION 017700

SECTION 017823 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SUMMARY

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

1. Operation manuals for systems, subsystems, and equipment.
2. Product maintenance manuals.

1.2 DEFINITIONS

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

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

1.3 CLOSEOUT SUBMITTALS

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

1. PDF electronic file. Assemble each manual into a composite electronically indexed file. Submit on digital media acceptable to Architect.
2. One paper copies. Include a complete operation and maintenance directory. Enclose title pages and directories in clear plastic sleeves.

PART 2 - PRODUCTS

2.1 OPERATION MANUALS

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

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

B. Descriptions: Include the following:

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

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

1. Startup procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.
4. Regulation and control procedures.
5. Instructions on stopping.
6. Normal shutdown instructions.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

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

2.2 PRODUCT MAINTENANCE MANUALS

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

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

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

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

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

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

2.3 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS

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

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

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

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

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

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

1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual, and annual frequencies.

PART 3 - EXECUTION

3.1 MANUAL PREPARATION

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

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

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

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

1. Do not use original project record documents as part of operation and maintenance manuals.

2. Comply with requirements of newly prepared record Drawings in Section 017839 "Project Record Documents."

D. Comply with Section 017700 "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

END OF SECTION 017823

SECTION 017839 - PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for project record documents, including the following:

1. Record Drawings.

1.2 CLOSEOUT SUBMITTALS

A. Record Drawings: Comply with the following:

1. Number of Copies: Submit one set(s) of marked-up record prints.

2. Submit electronic files for shop drawings serving as record drawings.

PART 2 - PRODUCTS

2.1 RECORD DRAWINGS

A. Record Prints: Maintain one set of marked-up paper copies of the Contract Drawings and Shop Drawings, incorporating new and revised drawings as modifications are issued.

1. Preparation: Mark record prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to provide information for preparation of corresponding marked-up record prints.

a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.

b. Accurately record information in an acceptable drawing technique.

c. Record data as soon as possible after obtaining it.

d. Record and check the markup before enclosing concealed installations.

e. Cross-reference record prints to corresponding archive photographic documentation.

2. Content: Types of items requiring marking include, but are not limited to, the following:

a. Dimensional changes to Drawings.

b. Revisions to details shown on Drawings.

c. Revisions to routing of piping and conduits.

d. Revisions to electrical circuitry.

e. Actual equipment locations.

f. Duct size and routing.

g. Locations of concealed internal utilities.

h. Field records for variable and concealed conditions.

i. Record information on the Work that is shown only schematically.

PART 3 - EXECUTION

3.1 RECORDING AND MAINTENANCE

A. Recording: Maintain one copy of each submittal during the construction period for project record document purposes. Post changes and revisions to project record documents as they occur; do not wait until end of Project.

END OF SECTION 017839

SECTION 017900 - DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for instructing Owner's personnel, including the following:

1. Demonstration of operation of systems, subsystems, and equipment.
2. Training in operation and maintenance of systems, subsystems, and equipment.

1.2 COORDINATION

A. Coordinate instruction schedule with Owner's operations. Adjust schedule as required to minimize disrupting Owner's operations and to ensure availability of Owner's personnel.

B. Coordinate instructors, including providing notification of dates, times, length of instruction time, and course content.

C. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by Architect.

PART 2 - PRODUCTS

2.1 INSTRUCTION PROGRAM

A. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following as applicable to the system, equipment, or component:

1. Basis of System Design, Operational Requirements, and Criteria: Include the following:
    a. System, subsystem, and equipment descriptions.
    b. Performance and design criteria if Contractor is delegated design responsibility.
    c. Operating standards.
    d. Regulatory requirements.
    e. Equipment function.
    f. Operating characteristics.
    g. Limiting conditions.
    h. Performance curves.
2. Documentation: Review the following items in detail:
    a. Operations manuals.
    b. Maintenance manuals.

c. Identification systems.

d. Maintenance service agreements and similar continuing commitments.

3. Emergencies: Include the following, as applicable:

a. Instructions on meaning of warnings, trouble indications, and error messages.

b. Instructions on stopping.

c. Shutdown instructions for each type of emergency.

d. Operating instructions for conditions outside of normal operating limits.

e. Sequences for electric or electronic systems.

f. Special operating instructions and procedures.

4. Operations: Include the following, as applicable:

a. Startup procedures.

b. Equipment or system break-in procedures.

c. Routine and normal operating instructions.

d. Regulation and control procedures.

e. Control sequences.

f. Safety procedures.

g. Instructions on stopping.

h. Normal shutdown instructions.

i. Operating procedures for emergencies.

j. Operating procedures for system, subsystem, or equipment failure.

k. Seasonal and weekend operating instructions.

l. Required sequences for electric or electronic systems.

m. Special operating instructions and procedures.

5. Adjustments: Include the following:

a. Alignments.

b. Checking adjustments.

c. Noise and vibration adjustments.

d. Economy and efficiency adjustments.

6. Troubleshooting: Include the following:

a. Diagnostic instructions.

b. Test and inspection procedures.

7. Maintenance: Include the following:

a. Inspection procedures.

b. Types of cleaning agents to be used and methods of cleaning.

c. List of cleaning agents and methods of cleaning detrimental to product.

d. Procedures for routine cleaning

e. Procedures for preventive maintenance.

f. Procedures for routine maintenance.

g. Instruction on use of special tools.

8. Repairs: Include the following:

a. Diagnosis instructions.

b. Repair instructions.

c. Disassembly; component removal, repair, and replacement; and reassembly instructions.

d. Instructions for identifying parts and components.

e. Review of spare parts needed for operation and maintenance.

PART 3 - EXECUTION

3.1 PREPARATION

A. Assemble educational materials necessary for instruction, including documentation and training module. Assemble training modules into a training manual organized in coordination with requirements in Section 017823 "Operation and Maintenance Data."

B. Set up instructional equipment at instruction location.

3.2 INSTRUCTION

A. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

END OF SECTION 017900

SECTION 075423 - THERMOPLASTIC POLYOLEFIN (TPO) ROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Adhered thermoplastic polyolefin (TPO) roofing system.
2. Roof insulation.

B. Related Requirements:

1. Section 076200 "Sheet Metal Flashing and Trim" for metal roof flashings and counterflashings.

1.2 DEFINITIONS

A. Roofing Terminology: Definitions in ASTM D 1079 and glossary in NRCA's "The NRCA Roofing and Waterproofing Manual" apply to work of this Section.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Roofing Conference: Conduct conference at Project site.

1. Meet with Owner, Architect, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
3. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Examine deck substrate conditions and finishes for compliance with requirements, including flatness and fastening.
5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.
7. Review governing regulations and requirements for insurance and certificates if applicable.
8. Review temporary protection requirements for roofing system during and after installation.
9. Review roof observation and repair procedures after roofing installation.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work, including:

1. Base flashings and membrane terminations.
2. Tapered insulation, including slopes.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturer Certificates: Signed by roofing manufacturer certifying that roofing system complies with requirements specified in "Performance Requirements" Article.

B. Field quality-control reports.

C. Sample Warranties: For manufacturer's special warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roofing system to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.

B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.

1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.

C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.

D. Handle and store roofing materials, and place equipment in a manner to avoid permanent deflection of deck.

1.9 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period.

1. Special warranty includes roofing, base flashings, roof insulation, cover boards, and other components of roofing system.
2. Warranty Period: 20 years from date of Substantial Completion.

B. Special Project Warranty: Submit roofing Installer's warranty, on warranty form at end of this Section, signed by Installer, covering the Work of this Section, including all components of roofing system such as roofing, base flashing, roof insulation, fasteners, cover boards, substrate boards, vapor retarders, roof pavers, and walkway products, for the following warranty period:

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Firestone Building Products.

B. Source Limitations: Obtain components including roof insulation for roofing system from same manufacturer as membrane roofing.

2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Installed roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Roofing and base flashings shall remain watertight.

1. Accelerated Weathering: Roofing system shall withstand 2000 hours of exposure when tested according to ASTM G 152, ASTM G 154, or ASTM G 155.

2. Impact Resistance: Roofing system shall resist impact damage when tested according to ASTM D 3746 or ASTM D 4272.

B. Material Compatibility: Roofing materials shall be compatible with one another and adjacent materials under conditions of service and application required, as demonstrated by roofing manufacturer based on testing and field experience.

C. Roofing System Design: Tested by a qualified testing agency to resist the following uplift pressures:

1. Corner Uplift Pressure: 60.0 lbf/sq. ft..

2. Perimeter Uplift Pressure: 39.8 lbf/sq. ft..

3. Field-of-Roof Uplift Pressure: 23.8 lbf/sq. ft..

D. Exterior Fire-Test Exposure: ASTM E 108 or UL 790, Class A; for application and roof slopes indicated; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

2.3 TPO ROOFING

A. Fabric-Reinforced TPO Sheet: ASTM D 6878, internally fabric- or scrim-reinforced, uniform, flexible TPO sheet.

1. Thickness: 80 mils, nominal.

2. Exposed Face Color: White.

2.4 AUXILIARY ROOFING MATERIALS

A. General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with roofing.

1. Liquid-type auxiliary materials shall comply with VOC limits of authorities having jurisdiction.

B. Sheet Flashing: Manufacturer's standard unreinforced TPO sheet flashing, 60 mills thick, minimum, of same color as TPO sheet.

C. Bonding Adhesive: Manufacturer's standard.

D. Metal Termination Bars: Manufacturer's standard, predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch thick; with anchors.

E. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Global 4470, designed for fastening roofing to substrate, and acceptable to roofing system manufacturer.

F. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, lap sealants, termination reglets, and other accessories.

2.5 ROOF INSULATION

A. General: Preformed roof insulation boards manufactured by TPO roofing manufacturer, selected from manufacturer's standard sizes suitable for application, of thicknesses indicated.

B. Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 3, felt or glass-fiber mat facer on both major surfaces.

C. Tapered Insulation: Provide factory-tapered insulation boards fabricated to slope of 1/4 inch per 12 inches unless otherwise indicated.

D. Provide preformed saddles, crickets, tapered edge strips, and other insulation shapes where indicated for sloping to drain. Fabricate to slopes indicated.

2.6 INSULATION ACCESSORIES

A. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with roofing.

B. Insulation Adhesive: Insulation manufacturer's recommended adhesive formulated to attach roof insulation to substrate or to another insulation layer as follows:

1. Bead-applied, low-rise, one-component or multicomponent urethane adhesive.

C. Cover Board: ASTM C 1289, Type II, Class 4, Grade 2, polyisocyanurate insulation board, 1/2 inch thick.

2.7 WALKWAYS

A. Flexible Walkways: Factory-formed, nonporous, heavy-duty, slip-resisting, surface-textured walkway pads .

1. Basis-of-Design Product: Subject to compliance with requirements, provide Firestone Building Products; X-Tred Walkway Pad.

a. Size: 30inches wide by 30 feet long.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work:

1. Verify that roof openings and penetrations are in place, curbs are set and braced, and roof-drain bodies are securely clamped in place.
2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
3. Verify that concrete substrate is visibly dry and free of moisture. Test for capillary moisture by plastic sheet method according to ASTM D 4263.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing installation according to roofing system manufacturer's written instructions. Remove sharp projections.

B. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.

3.3 ROOFING INSTALLATION, GENERAL

A. Install roofing system according to roofing system manufacturer's written instructions.

B. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at the end of the workday or when rain is forecast. Remove and discard temporary seals before beginning work on adjoining roofing.

3.4 INSULATION INSTALLATION

A. Coordinate installing roofing system components so insulation is not exposed to precipitation or left exposed at the end of the workday.

B. Comply with roofing system and insulation manufacturer's written instructions for installing roof insulation.

C. Install tapered insulation under area of roofing to conform to slopes indicated.

D. Install insulation under area of roofing to achieve required thickness. Where overall insulation thickness is 2.7 inches or greater, install two or more layers with joints of each succeeding layer staggered from joints of previous layer a minimum of 6 inches in each direction.

E. Trim surface of insulation where necessary at roof drains so completed surface is flush and does not restrict flow of water.

F. Install insulation with long joints of insulation in a continuous straight line with end joints staggered between rows, abutting edges and ends between boards. Fill gaps exceeding 1/4 inch with insulation.

1. Cut and fit insulation within 1/4 inch of nailers, projections, and penetrations.

G. Adhered Insulation: Install each layer of insulation and adhere to substrate as follows:

1. Set each layer of insulation in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.

H. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches in each direction. Loosely butt cover boards together.

3.5 ADHERED ROOFING INSTALLATION

A. Adhere roofing over area to receive roofing according to roofing system manufacturer's written instructions. Unroll roofing and allow to relax before retaining.

B. Start installation of roofing in presence of roofing system manufacturer's technical personnel.

C. Accurately align roofing, and maintain uniform side and end laps of minimum dimensions required by manufacturer. Stagger end laps.

D. Bonding Adhesive: Apply to substrate and underside of roofing at rate required by manufacturer, and allow to partially dry before installing roofing. Do not apply to splice area of roofing.

E. In addition to adhering, mechanically fasten roofing securely at terminations, penetrations, and perimeter of roofing.

F. Apply roofing with side laps shingled with slope of roof deck where possible.

G. Seams: Clean seam areas, overlap roofing, and hot-air weld side and end laps of roofing and sheet flashings according to manufacturer's written instructions, to ensure a watertight seam installation.

1. Test lap edges with probe to verify seam weld continuity. Apply lap sealant to seal cut edges of sheet.

2. Verify field strength of seams a minimum of twice daily, and repair seam sample areas.

3. Repair tears, voids, and lapped seams in roofing that do not comply with requirements.

H. Spread sealant bed over deck-drain flange at roof drains, and securely seal roofing in place with clamping ring.

3.6 BASE FLASHING INSTALLATION

A. Install sheet flashings and preformed flashing accessories, and adhere to substrates according to roofing system manufacturer's written instructions.

B. Apply bonding adhesive to substrate and underside of sheet flashing at required rate, and allow to partially dry. Do not apply to seam area of flashing.

C. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.

D. Clean seam areas, overlap, and firmly roll sheet flashings into the adhesive. Hot-air weld side and end laps to ensure a watertight seam installation.

E. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

3.7 WALKWAY INSTALLATION

A. Flexible Walkways: Install walkway products in locations indicated. Heat weld to substrate according to roofing system manufacturer's written instructions.

3.8 FIELD QUALITY CONTROL

A. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion.

3.9 PROTECTING AND CLEANING

A. Protect roofing system from damage and wear during remainder of construction period. When remaining construction does not affect or endanger roofing, inspect roofing for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and Owner.

B. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Substantial Completion and according to warranty requirements.

C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

3.10 ROOFING INSTALLER'S WARRANTY

A. WHEREAS _____ of _____, herein called the "Roofing Installer," has performed roofing and associated work ("work") on the following project:

1. Owner: .
2. Address: .
3. Building Name/Type: .
4. Address: .
5. Area of Work: .
6. Acceptance Date: _____.
7. Warranty Period: 2 years.
8. Expiration Date: _____.

B. AND WHEREAS Roofing Installer has contracted (either directly with Owner or indirectly as a subcontractor) to warrant said work against leaks and faulty or defective materials and workmanship for designated Warranty Period,

C. NOW THEREFORE Roofing Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period he will, at his own cost and expense, make or cause to be made such repairs to or replacements of said work as are necessary to correct faulty and defective work and as are necessary to maintain said work in a watertight condition.

D. This Warranty is made subject to the following terms and conditions:

1. Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by:

a. lightning;

b. peak gust wind speed exceeding 105 mph;

c. fire;

d. failure of roofing system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition;

e. faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work;

f. vapor condensation on bottom of roofing; and

g. activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.

2. When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Roofing Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated.

3. Roofing Installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.

4. During Warranty Period, if Owner allows alteration of work by anyone other than Roofing Installer, including cutting, patching, and maintenance in connection with penetrations, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to the extent said alterations affect work covered by this Warranty. If Owner engages Roofing Installer to perform said alterations, Warranty shall not become null and void unless Roofing Installer, before starting said work, shall have notified Owner in writing, showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying a limitation or termination of this Warranty.

5. During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to the extent said change affects work covered by this Warranty.

6. Owner shall promptly notify Roofing Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Roofing Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.

7. This Warranty is recognized to be the only warranty of Roofing Installer on said work and shall not operate to restrict or cut off Owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Roofing Installer of responsibility for performance of original work according to requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner's General Contractor.

E. IN WITNESS THEREOF, this instrument has been duly executed this _____ day of _____, _____.

1. Authorized Signature: _____.

2. Name: _____.

3. Title: _____.

END OF SECTION 075423

SECTION 076200 - SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Formed roof-drainage sheet metal fabrications.
2. Formed low-slope roof sheet metal fabrications.
3. Formed equipment support flashing.

1.2 COORDINATION

A. Coordinate sheet metal flashing and trim layout and seams with sizes and locations of penetrations to be flashed, and joints and seams in adjacent materials.

B. Coordinate sheet metal flashing and trim installation with adjoining roofing and wall materials, joints, and seams to provide leakproof, secure, and noncorrosive installation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each manufactured product and accessory.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage. Store sheet metal flashing and trim materials away from uncured concrete and masonry.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General: Sheet metal flashing and trim assemblies shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim shall not rattle, leak, or loosen, and shall remain watertight.

B. Sheet Metal Standard for Flashing and Trim: Comply with NRCA's "The NRCA Roofing Manual" and SMACNA's "Architectural Sheet Metal Manual" requirements for dimensions and profiles shown unless more stringent requirements are indicated.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes to prevent buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 SHEET METALS

A. Metallic-Coated Steel Sheet: Provide zinc-coated (galvanized) steel sheet according to ASTM A 653/A 653M, G90 coating designation; prepainted by coil-coating process to comply with ASTM A 755/A 755M.

1. Surface: Smooth, flat.
2. Exposed Coil-Coated Finish:
    a. Three-Coat Fluoropolymer: AAMA 621. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
3. Color: As selected by Architect from manufacturer's full range.

2.3 MISCELLANEOUS MATERIALS

A. General: Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and as recommended by manufacturer of primary sheet metal unless otherwise indicated.

B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal.

1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
2. Fasteners for Zinc-Coated (Galvanized) Steel Sheet: Series 300 stainless steel or hot-dip galvanized steel according to ASTM A 153/A 153M or ASTM F 2329.

C. Elastomeric Sealant: ASTM C 920, elastomeric silicone polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

2.4 FABRICATION, GENERAL

A. General: Custom fabricate sheet metal flashing and trim to comply with details shown and recommendations in cited sheet metal standard that apply to design, dimensions, geometry, metal thickness, and other characteristics of item required. Fabricate sheet metal flashing and trim in shop to greatest extent possible.

1. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
2. Obtain field measurements for accurate fit before shop fabrication.
3. Form sheet metal flashing and trim to fit substrates without excessive oil canning, buckling, and tool marks; true to line, levels, and slopes; and with exposed edges folded back to form hems.

B. Expansion Provisions: Form metal for thermal expansion of exposed flashing and trim.

C. Sealant Joints: Where movable, nonexpansion-type joints are required, form metal to provide for proper installation of elastomeric sealant according to cited sheet metal standard.

D. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

E. Fabricate cleats and attachment devices of sizes as recommended by cited sheet metal standard for application, but not less than thickness of metal being secured.

2.5 ROOF-DRAINAGE SHEET METAL FABRICATIONS

A. Downspouts: Fabricate round downspouts to dimensions indicated, complete with mitered elbows. Furnish with metal hangers from same material as downspouts and anchors .

1. Fabricate from the following materials:

a. Galvanized Steel: 0.022 inch thick.

B. Parapet Scuppers: Fabricate scuppers to dimensions required, with closure flange trim to exterior, 4-inch- wide wall flanges to interior, and base extending 4 inches beyond cant or tapered strip into field of roof. Fabricate from the following materials:

1. Galvanized Steel: 0.028 inch thick.

C. Conductor Heads: Fabricate conductor heads with flanged back and stiffened top edge and of dimensions and shape required, complete with outlet tubes, exterior flange trim,. Fabricate from the following materials:

1. Galvanized Steel: 0.028 inch thick.

2.6 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

A. Roof Edge Flashing Fascia Cap: Fabricate in minimum 96-inch- long, but not exceeding 12-foot- long sections. Furnish with 6-inch- wide, joint cover plates. Shop fabricate interior and exterior corners.

1. Joint Style: Butted with expansion space and 6-inch- wide, exposed cover plate.
2. Fabricate from the Following Materials:

a. Galvanized Steel: 0.028 inch thick.

B. Counterflashing: Fabricate from the following materials:

1. Galvanized Steel: 0.022 inch thick.

C. Roof-Penetration Flashing: Fabricate from the following materials:

1. Galvanized Steel: 0.028 inch thick.

2.7 MISCELLANEOUS SHEET METAL FABRICATIONS

A. Equipment Support Flashing: Fabricate from the following materials:

1. Galvanized Steel: 0.028 inch thick.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, substrate, and other conditions affecting performance of the Work.

1. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
2. Verify that air- or water-resistant barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. General: Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement. Use fasteners, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.

1. Install sheet metal flashing and trim true to line, levels, and slopes. Provide uniform, neat seams with minimum exposure of solder, welds, and sealant.
2. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.
3. Space cleats not more than 12 inches apart. Attach each cleat with at least two fasteners. Bend tabs over fasteners.
4. Install exposed sheet metal flashing and trim with limited oil canning, and free of buckling and tool marks.
5. Torch cutting of sheet metal flashing and trim is not permitted.

B. Metal Protection: Where dissimilar metals contact each other, or where metal contacts pressure-treated wood or other corrosive substrates, protect against galvanic action or corrosion by painting contact surfaces with bituminous coating or by other permanent separation as recommended by sheet metal manufacturer or cited sheet metal standard.

1. Underlayment: Where installing sheet metal flashing and trim directly on cementitious or wood substrates, install underlayment and cover with slip sheet.

C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at maximum of 10 feet with no joints within 24 inches of corner or intersection.

1. Form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with sealant concealed within joints.
2. Use lapped expansion joints only where indicated on Drawings.

D. Fasteners: Use fastener sizes that penetrate wood blocking or sheathing not less than 1-1/4 inches for nails and not less than 3/4 inch for wood screws.

E. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.

F. Seal joints as required for watertight construction.

1. Use sealant-filled joints unless otherwise indicated. Embed hooked flanges of joint members not less than 1 inch into sealant. Form joints to completely conceal sealant. When ambient temperature at time of installation is between 40 and 70 deg F, set joint members for 50 percent movement each way. Adjust setting proportionately for installation at higher ambient temperatures. Do not install sealant-type joints at temperatures below 40 deg F.

3.3 ROOF-DRAINAGE SYSTEM INSTALLATION

A. General: Install sheet metal roof-drainage items to produce complete roof-drainage system according to cited sheet metal standard unless otherwise indicated. Coordinate installation of roof perimeter flashing with installation of roof-drainage system.

B. Downspouts: Join sections with 1-1/2-inch telescoping joints.

1. Provide hangers with fasteners designed to hold downspouts securely to walls. Locate hangers at top and bottom and at approximately 60 inches o.c.

2. Provide elbows at base of downspout to direct water away from building.

C. Parapet Scuppers: Continuously support scupper, set to correct elevation, and seal flanges to interior wall face, over cants or tapered edge strips, and under roofing membrane.

1. Anchor scupper closure trim flange to exterior wall and seal with elastomeric sealant to scupper.

2. Loosely lock front edge of scupper with conductor head.

3. seal with elastomeric sealant exterior wall scupper flanges into back of conductor head.

D. Conductor Heads: Anchor securely to wall, with elevation of conductor head rim at minimum of 1 inch below scupper discharge.

3.4 ROOF FLASHING INSTALLATION

A. General: Install sheet metal flashing and trim to comply with performance requirements and cited sheet metal standard. Provide concealed fasteners where possible, and set units true to line, levels, and slopes. Install work with laps, joints, and seams that are permanently watertight and weather resistant.

B. Counterflashing: Coordinate installation of counterflashing with installation of base flashing. Insert counterflashing in reglets or receivers and fit tightly to base flashing. Extend counterflashing 4 inches over base flashing. Lap counterflashing joints minimum of 4 inches . Secure in waterproof manner by means of snap-in installation and sealant or lead wedges and sealant unless otherwise indicated.

3.5 MISCELLANEOUS FLASHING INSTALLATION

A. Equipment Support Flashing: Coordinate installation of equipment support flashing with installation of roofing and equipment. Weld or seal flashing with elastomeric sealant to equipment support member.

3.6 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean off excess sealants.

C. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of sheet metal flashing and trim installation, remove unused materials and clean finished surfaces as recommended by sheet metal flashing and trim manufacturer. Maintain sheet metal flashing and trim in clean condition during construction.

D. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 076200

SECTION 220000 – PLUMBING WORK

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. This Section includes a summary of all Plumbing related work.

B. Related Sections:

1. 220000 – Plumbing Work
2. 220400 – General Plumbing Requirements
3. 220500 – Common Work Results for Plumbing Work
4. 220523 – General-Duty Valves for Plumbing Piping
   220529 – Hangers and Supports for Plumbing Piping and Equipment
5. 220553 – Identification for Plumbing Piping and Equipment
6. 220700 – Pipe Insulation
7. 221116 – Domestic Water Piping
8. 221316 – Sanitary Waste Vent System
9. 221335 – Chemical Waste Piping
10. 221423 – Storm Sewer System
11. 221424 – Natural Gas System
12. 221430 – Plumbing Specialties
13. 221513 – General-Service Compressed-Air Piping

1.3 PROJECT CONDITIONS

A. Alterations of and Additions to Existing Plumbing Systems

1. The contract shall include the installation of the work as shown, specified, or required, and shall include the following principal components:

   a. Furnish and install new roof drains as shown including all necessary piping thereto.

   b. Furnish and install new acid waste piping and all associated accessories.

   c. Furnish and install new compressed air piping and all associated accessories.

   d. Furnish and install natural gas piping.

   e. Provide certain pipe insulation.

   f. All work shall be performed in strict accordance with Greater Cincinnati Water Works rules, regulations, and drawings and the Plumbing Division of the Ohio Health Department.

   g. Provide complete soil, waste, vent, and water piping for Plumbing Fixtures.

   h. Perform start-up for all plumbing systems and commission same in accordance with the commissioning requirement.

i. Provide and/or participate in training of Owner's personnel on the use of all new plumbing systems.

2. The contractor shall exercise adequate protective and safety measures for all persons and property and shall be responsible for any damages or injuries arising from the execution of this work.

3. Alterations and additions to existing work shall include the requisite dismantling of the old equipment, rigging, wrecking, hauling, protections of permanent equipment and the building structures, and cleaning up. Care shall be exercised to keep dust and dirt to a minimum and to confine it to the area where the removal work is being performed. All debris shall be promptly removed.

4. If asbestos insulation is encountered on any existing piping which is to be removed or remodeled, contractor shall immediately notify Owner of the existence of asbestos and Owner will arrange proper removal of same without cost to contractor.

5. Unless otherwise noted, remove all other existing equipment and piping, valves, fittings, etc. which will not be reused in the final arrangement. Plug or cap openings in piping which will remain. Unless otherwise noted, all items which will be removed by this this contractor and not reused shall become the property of the contractor and shall be promptly removed from the site by him.

6. The existing facility will be partially occupied and will remain in operation throughout the period that this work is being performed, and certain new work will be performed during this period. Unscheduled interruptions of the facility will not be tolerated. The contractor shall exercise extreme caution, shall thoroughly inform his workmen and subcontractors of the critical nature of this work, and shall continually review the work procedure being followed in order to prevent accidental interruption of service. Before performing any act which could result in interruption of service, the contractor shall notify the Owner and Engineer of the hazards involved and the contractor shall proceed in a manner and at a time specifically approved by the Owner and Engineer.

7. All work necessitating the temporary turning off or shutting down the operation of existing mechanical and/or electrical facilities shall be done at times specifically approved by the Owner and Engineer in advance of any disruption of existing facilities. Also, refer to Section 22 04 00 – General Plumbing Requirements.

B. Demolition of Work

1. The Plumbing Contractor shall remove some of the existing plumbing fixtures within this building as indicated on the drawings. The contractor shall be responsible to verify the extent of demolition work and shall include in their bid all demolition work affecting their trade.

2. Remove all equipment not used in the final arrangement shown on the drawings including all piping, insulation, hangers, supports, accessories, concrete pads, etc.

C. Installation of Pipe

1. Roughing-in and locations of wastes shall be installed as near like the drawings as possible. Where the drawings indicate that the waste exceeds the code requirements, the roughing-in shall be installed in accordance with the drawings and not only to meet the minimum code requirements. Where unforeseen conditions will not permit the installation as shown, no water, waste, etc. lines shall be relocated without the written approval of the Engineer.

2. All piping located in pipe spaces must be located so as to insure maximum accessibility. Where necessary to cross pipe space, the crossing must be near the floor or 6 feet or more above the floor.

D. Excavation and Backfilling and Restoration of Surfaces

1. Refer to Division 1 and Section 220400.

E. Equipment

1. Any and all costs associated with piping, electric, wiring, conduit, supports, pads, or other modifications to accommodate installation for manufacturer's equipment that differs from equipment layout on drawings shall be included on contractor's bid. The contractor is responsible to insure that the equipment will fit within space allocated with appropriate clearances for maintenance, operation, servicing, and code.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 220000

SECTION 220400 - GENERAL PLUMBING REQUIREMENTS

PART 1 - GENERAL

1.1 PLUMBING WORK

A. The following paragraphs are applicable to Division 22 and are complementary to other sections of specifications. Where items described in other sections of the specifications are repeated herein, it is done to call special attention to or to qualify them, but it is not intended that any part of the documents shall be assumed to be omitted if not re peated herein.

B. Where contradictions occur between this section and Division 1, the more stringent of the two shall apply. Architect/Engineer shall decide which is most stringent.

1.2 DRAWINGS AND SPECIFICATIONS

A. Plumbing drawings are diagrammatic and indicate general arrangement of systems and work included in the contract and shall be adhered to insofar as possible. The drawings and specifications are complementary and are intended, without giving every minute detail, to cover a workable installation complete in every respect including, whether mentioned or not, all material and equipment usually furnished with such systems and/or needed to make a complete operational installation omitting only such parts as are specifically excepted.

B. Consult drawings and details for exact location of fixtures and equipment, and where not definitely indicated, request this information in writing.

C. The specification for each division of the work is written in sectional form for brevity and convenience in reference, without repeating in each section all applicable general clauses and/or pertinent data covered elsewhere in the specification, but it is not intended that any of the documents shall be assumed to be omitted if not repeated in each division.

D. Where specifications are written for brevity, with incomplete sentences, the omission of words or phrases, such as "the contractor shall", "shall be", "provide", "furnish", "all", etc. are intentional and such omitted words or phrases shall be supplied by inference; unless otherwise mentioned, such clauses, lists, and/or directives indicate work to be done by the contractor for that specific division of work.

1.3 VERIFYING CONDITIONS

A. The work under this contract occurs on the site of and within the existing facility. The work under this contract shall be scheduled and performed so as to provide a minimum of interference with the normal operation of the existing facilities.

B. Before submitting a proposal, contractors shall visit the site, and shall also carefully examine all bidding documents including those for other branches of the work, to satisfy themselves as to the nature and scope of all work to be done. Prints showing the original building architectural, structural, mechanical, and electrical work are available at the Engineer's office for contractors' review.

C. The submission of a proposal shall be taken as evidence that such an examination has been made and difficulties, if any, noted. Later claims for labor, work, material, and equipment required for any difficulties encountered which could have been foreseen, shall not be recognized, and all such difficulties shall be properly taken care of by the contractor at no additional expense to the Owner.

1.4 EXISTING WORK AND/OR CONDITIONS

A. The accompanying drawings and specifications illustrate and describe the existing conditions, mechanical utilities, sewers, water mains, pipes, ducts, conduits, etc. that are particularly relevant to the new work insofar as these mains are shown on existing records or evident by field inspections and tests; however, it is not the intent that these documents shall be construed to guarantee to the contractor the exact location of these items. Each contractor shall verify and determine the exact location of these items in the field, and all work under this contract shall be executed to avoid conflict with or damage to existing work. The work shall be planned and executed to avoid interference, as much as possible, with traffic and with the normal use of the existing facility.

B. All work involving hazards to persons shall be suitably barricaded and provided with warning lights or signs, as required.

C. Where necessary for the performance of the contract, existing work shall be cut, altered, removed, or temporarily removed and replaced. Work that is altered or replaced shall match similar existing work and said work shall be performed by trade applicable to the work; if said work is NOT shown or noted the Drawings relating to applicable trade, cost shall be paid by contractor requiring said work. However, unless otherwise provided by the drawings or specifications, no structural members shall be cut or altered without authorization of the Architect and Engineer. Work remaining in place, which is damaged or defaced by reason of work done under this contract, shall be restored in kind equal to its condition at the time of award of the contract by applicable trade as hereinbefore specified.

D. Existing work shall not be disturbed further than necessary for proper installation of new work. New work to be connected or made integral with existing work shall be properly erected to secure solidity and be continuous in finish. Such new work in extension of existing work shall correspond in all respects with that to which it connects, or similar existing sound work, unless otherwise specified.

1.5 EXISTING MECHANICAL FACILITIES

A. Where existing mechanical facilities and/or service lines occur in the area of the work and such facilities or lines are to be abandoned or changed, the contractor for the branch of work or trade involved shall cut off and properly cap the old lines, so as not to interfere with the new construction work. If any portions of such lines are required for the operation of an existing building the lines shall be altered and relocated to clear new construction and shall also be restored into service to provide continued operation of the existing building.

1.6 INTERRUPTION OF SERVICES

A. Work which requires the temporary turning off or shutting down the operation of existing mechanical and/or electrical facilities shall be done at times specifically approved by the Owner or utility company and the work shall be pre-scheduled and executed so there is a minimum outage of such services and/or delay in the new construction work.

1.7 MATERIALS AND EQUIPMENT

A. All materials and equipment entering into the work shall be approved by the Engineer, and must be new, without defects, and of the sizes and capacities shown on the drawings or hereinafter specified. All manufactured materials or equipment shall bear the identification mark of the manufacturer or, if required by the Engineer, shall be certified by an approved testing laboratory. All equipment shall operate within the manufacturer's range of speeds, guaranteed capacities, performance, etc. as indicated by the manufacturer's latest catalog and/or engineering data, shall be of proper size and dimension for the allocated space, and shall be placed in the space allocated in the proper construction sequence.

Special consideration will be given to equipment which has been in successful field use or similar applications for at least three (3) years (exclusive of field tests), and to equipment which has an extended guarantee period in lieu of long use period. The contractor shall submit with his bid complete data on equipment he proposes to use; failure to so submit, or to meet these requirements fully and those of the specifications, shall be grounds for rejecting the items.

B. All electrical materials, apparatus, and equipment shall be new, of the make and characteristics specified, shall conform to NEMA standards, and shall be designed to comply with and be installed in accordance with the latest rules and regulations of the National Electrical Code, and all of the legally constituted public authorities having local jurisdiction. Verify the exact voltage and current characteristics at the building before ordering motors or similar equipment.

C. All motors shall be NEMA frame sizes, heavy duty, 40 degree C. ambient motors with ball or roller bearings and with maximum full load temperature rise not exceeding NEMA limits of temperature rise. All motors shall have adequate starting and protective equipment as specified or required, and shall have a conduit terminal box of size adequate to accommodate conduits and wires as sized on electrical drawings or as specified. The capacity of each motor shall be sufficient to operate associated driven devices under all conditions of operation and load without overloading or overheating and each motor shall be of not less than the horsepower indicated or specified.

D. Conduct such tests and adjustment of equipment as specified or necessary to verify performance requirements. Submit data taken during such tests.

1.8 QUIET OPERATION

A. The work shall be installed in such a manner that under all conditions of load it shall operate without sound or vibration which is objectionable in the occupied spaces, in the opinion of the Engineer.

B. In case of moving machinery, sound or vibration noticeable outside of the room in which it is installed or annoyingly noticeable inside its own room will be considered objectionable. Sound or vibration considered objectionable shall be corrected by the contractor.

1.9 PROTECTION

A. In performing this contract, safeguard workmen and the public and protect the work and equipment until final completion and acceptance. After delivery and before and after installation, protect work against theft, injury, or damage. Carefully store material and equipment received on site which are not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing materials. Protect related or adjacent work and the material of the other trades or the Owner from damage that might be caused by this work and make good any damage thus caused. Provide all safeguards, scaffolding, drop cloths, etc. as required.

B. No welding or soldering shall be done near combustible materials of any kind; all adjoining work, finished surfaces, glass, etc. shall be protected from flames, sparks, hot metal, etc. by metal guards or approved noncombustible drop cloths or barriers.

C. Each contractor shall replace any items or portions thereof wherever removed or damaged, in a manner equal to the original construction and finish, or where directed by the Engineer, he shall pay other trades to perform this work.

D. All mechanical equipment with a factory finish shall be protected during construction and must be free of dust, dirt, cement splatters, etc. when the building is turned over to the Owner. Dents and marred finishes shall be repaired to the satisfaction of the Engineer, or a replacement furnished where necessary.

E. Provide belt drives and rotating machinery with readily removable guards complying with OSHA requirements to enclose the drive completely and consisting of heavy angle iron frames, hinged and latched, with heavy galvanized iron wire crimped mesh or sheet steel securely fastened to frames.

1.10 EXECUTION OF WORK

A. The Plumbing work shall be performed and coordinated with the program of the General Contractor and the other subcontractors. Promptly upon award of the contract, the subcontractors shall confer with the General Contractor and the Engineer and other subcontractors to prepare a time schedule for the completion of the various divisions and details of the work. Each subcontractor shall proceed diligently with the work and shall cooperate with the General Contractor and the other contractors to maintain the approved time schedule to the best of his ability and as conditions permit.

1.11 GENERAL SUPERVISION AND INSTALLATION OF WORK

A. Each contractor shall at all times give the work his best skill and attention, including adequate construction supervision over his work, employees, and subcontractors, and he shall fully cooperate with and confer with the Engineer and other contractors so that the best possible installation shall be obtained. Exact locations and relations are to be determined in the field, subject to the approval of the Engineer, and with preference to the dimensioned and architectural and structural drawings and approved shop and setting drawings.

B. Unless otherwise shown, pipes, ducts, etc. in rooms with finished ceilings, shall be concealed in furred ceilings, shafts, walls, and floors, and all work must be exactly and accurately located to conform with the spaces provided therefor. In general, all other new piping, ducts, etc. in mechanical equipment rooms, telephone rooms, etc. shall be exposed.

C. Install pipes, etc. in a neat and workmanlike manner, close to walls, generally as high as possible, true and square to the building, utilizing standard practices, and properly graded for correct functioning of the system involved; multiple lines in close proximity shall be coordinated and neatly grouped. Install work in proper construction sequence and arranged so as to be readily accessible for operation, maintenance, and repair; minor deviations from drawings may be made to accomplish this, but changes of magnitude or which involve extra cost shall not be made without approval. All fixtures, outlets, etc. shall truly center with the adjacent architectural finish. All work, both exposed and concealed, shall meet the approval of the Engineer regarding neatness of appearance, location, and practicability of installation. The Engineer reserves the right to direct the removal and replacement of any item which, in his opinion, does not present an orderly and reasonably neat and workmanlike appearance.

D. Each contractor shall familiarize himself with the work of the other contractors, shall perform and coordinate his work with the other contractors, shall lay out his work to meet conditions at the building, shall give freedom to and prevent conflict with the work of other contractors, and shall make reasonable modification in locations or arrangement from those indicated on the drawings if required to avoid conflicts or to conform to tile, wood, marble, or other architectural finish. From time to time as the work progresses, the contractor shall examine the work installed by others, insofar as it may affect his work, and he shall, before proceeding with the work, notify the Engineer in writing, if any condition exists which prevents the successful installation of his own work.

E. If the contractor places any work in violation of any of the above mentioned requirements, and conflicting or unworkmanlike conditions result, he shall, without additional charge, remove and reinstall or satisfactorily readjust such portions of his work as may be necessary and as the Engineer may direct. The Engineer's decision regarding such conditions shall be final.

1.12 ENGINEER'S OBSERVATION

A. A periodic inspection of the work by the Engineer, commonly referred to as supervision, is only for the express purpose of verifying compliance by the contractor with the contract documents. Such engineering inspections and services rendered by the Engineer or his representatives shall not be construed as the supervising of construction; nor the assuming by the Engineer of the duties and responsibility of the contractors nor making the Engineer responsible for providing a safe place or procedure for the performance of the work or for the contractor's employees or for subcontractors.

1.13 EXCAVATION AND BACKFILLING OF TRENCHES, ETC.

B. This paragraph is not applicable to this project.

1.14 RESTORATION OF SURFACES AND CONCRETE WORK

A. This paragraph is not applicable to this project.

1.15 SLEEVES, CUTTING, PATCHING, CLEANING, WATERPROOFING, ETC.

A. Provide and accurately set frames and Schedule 40 steel pipe sleeves for required openings in new work to minimize cutting. Perform all cutting, patching, etc. required to install the work. Use approved power operated boring machine for small holes wherever practical. Remove all rubbish incidental to the work. Where any work pierces waterproofing, provide all necessary sleeves, caulking, and flashing required to make openings absolutely watertight.

B. Refer to the ACI Code 381.71, Section 6.3 for limitations and requirements for penetrations and openings.

1.16 PATENTS

A. The contractor shall defend and guarantee the Owner against any expense, claims, litigation, etc. occasioned by the use in this work of any materials, devices, etc. covered by patents not owned by the contractor, or of which he is not a licensed user.

1.17 CONTEMPLATED WORK

A. The work contemplated occurs on the site of and within the existing building.

B. The drawings and specifications for the mechanical and electrical portion of this project have been prepared by Motz Consulting Engineers, Inc., doing business as Motz Engineering.

C. The various items of work necessary for completion of this work are hereinafter specified under the respective section headings or shown on accompanying drawings, and shall be included in any contract or contracts made for completion of respective divisions of the work. Such contracts shall also include necessary details reasonably incidental to the proper execution and completion of such work.

1.18 MOVING MATERIALS

A. If it becomes necessary at any time during the progress of this work to move materials which have been temporarily located and which are to enter into the final construction, the contractor furnishing said materials shall, when so directed by the Engineer, move them or cause them to be moved. Cost of such moving shall be included in the contract price.

1.19 ACCIDENT PREVENTION

A. Precaution shall be exercised at all times for the protection of persons and property. The safety provisions of applicable law, building, and construction codes shall be observed. Machinery, equipment, and other hazards shall be guarded in accordance with safety provisions of the "Manual of Accident Prevention in Construction" published by Associated General Contractors of America to the extent that such provisions are not inconsistent with applicable law or regulations.

1.20 PROPERTY PROTECTION

A. All hoisting shall be done with proper tag lines and buffers to prevent damage to the sides of the building. Where it is necessary to hoist materials to the roof, the parapets at top of the building and the roof where materials are landed from hoists shall be protected with heavy wood covers. Parapet protection shall be placed on both sides and top, and shall extend far enough on either side of landing point to insure adequate cover. The roof, from the landing point at parapet to final location of material, shall be adequately protected by planks laid side by side on roofing and spiked together on outside edges with planks running at right angles to main planking. The roof shall be adequately protected against leaks at all times.

B. Where hoists are erected on the roof for hoisting material up the side of the building, the roof shall be adequately protected against abrasion or other damage. Materials stored on the roof shall be placed on planks or other protection approved by the Engineer and shall be placed only at locations approved by the Engineer.

C. If hoisted materials are taken through windows, the jams, head, and sill shall be adequately protected with wood planking or proper buffers.

D. Any work, equipment, or property damaged during construction of this project and due to operations under this contract shall be repaired or replaced by this contractor, without additional cost to the Owner. Upon completion of the work, the contractor shall remove all protections herein specified.

1.21 REMOVAL OF RUBBISH

A. It shall be each contractor's duty to keep the building and surrounding premises clean, free from rubbish of every description. No rubbish, crating materials, packing, or dirt shall be allowed to accumulate at any time, but shall be removed at once and hauled away.

B. Each trade shall be responsible for its own tools and materials during the periods of rubbish removal but contractors shall use reasonable care in removal of rubbish to protect the tools and materials of others against loss or damage. The Owner reserves the right, in the event that removal of rubbish is not promptly and properly carried out by the Contractors to have rubbish removed and to charge the cost of its removal to the contractor.

C. Also, refer to Division 1.

1.22 MATERIAL SAFETY DATA SHEETS (MSDS)

A. The contractor shall obtain and maintain on-site during the course of the project the Material Safety Data Sheets (MSDS's) for all chemicals or products containing chemicals that may be considered toxic or hazardous. The MSDS's are to be forwarded to the Office of Environmental Health and Safety upon completion of the project.

1.23 INSTRUCTION OF PERSONNEL

A. The Plumbing Sub-Contractor shall provide free on site instruction in the proper use of installed equipment to designated representatives of the Owner, sufficient to ensure safe, secure, efficient, non-failing utilization, and operation of systems. This instruction shall include the following:

1. On Site Training: Provide a minimum of 4 hours of training for Owner's staff. Submit a syllabus to the Engineer prior to the first session.

2. Support: Provide a minimum of 4 hours of support either on site or by telephone to answer operations questions.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 220400

SECTION 220500 – COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Conditions, Special Conditions and Division 1 through Division 32 as set forth in these specifications are hereby incorporated into and shall become a part of the specifications for work under this title, insofar as they apply hereto.

B. Furnish material, labor, tools, accessories and equipment to complete and leave ready for operation of the Plumbing system for this project as described in these specifications and as shown on the drawings, or as required.

1.2 REGULATORY REQUIREMENTS

A. Conform to all utility company regulations.

B. Secure and pay for all necessary permits, fees and inspections and prepare all drawings required by applicable local and state codes.

C. Obtain all inspections or additional permits required by all laws, ordinances, rules, regulations or public authority having jurisdiction and obtain certificates of such inspections and permits and submit same to the Architect. The Contractor shall pay all fees, charges and other expenses in connection therein for Plumbing work including inspection fees, etc. associated with the building permit.

D. Perform all work in strict accordance with all applicable laws, codes, regulations and rulings of State, City, County, Local, Utility Company, EPA and requirements of all authorities having local jurisdiction. In case of conflict between the drawings and/or specifications and the above requirements, the more rigid requirements shall govern.

E. Unless otherwise noted, the following latest enforced Edition shall apply to this work:

1. State and Local Plumbing Code
2. Sewer Department
3. Water department
4. National Fire Protection Association
5. Life Safety Code
6. Fire Code
7. Building Code
8. OSHA Requirements
9. EPA Requirements
10. County Building Requirements
11. City Fire Department Requirements
12. City Building Requirements
13. Public Schools Building Requirements

1.3 QUALIFICATIONS

A. Installer: Company specializing in performing work of this Section with minimum three years documented experience.

1.4 MATERIALS, MANUFACTURERS AND SUBSTITUTIONS

A. Unless otherwise specifically indicated, furnish materials and equipment which are new.

B. When two or more products are named together in the specifications, bids shall be based upon any of the products named upon consideration of the following requirements. The product named first has been used in the design.

C. The bidder shall ascertain that the product upon which he chooses to base his bid has the specific features enumerated and is equal, that it will properly fit the space and the adjacent work. Any additional costs, including cost of work by others, involved in completing the work with said products and the responsibility for its fitting and operating as a part of the system rests solely with the bidder.

D. These specifications permit the bidder to propose for consideration with his bid and must be indicated on the substitution sheet, any one of a like material that is generally considered to be equal to the manufacturers named in the specifications. However, the bidder shall base his bid on the name or make of any article, device, material, form of construction, fixture, etc., named in the specifications.

1.5 WARRANTIES

A. In addition to requirements of Division 1, contractor shall turn over to the Owner all certificates of equipment guarantee and/or warranty covering remaining guarantee and/or warranty period at end of his guarantee period.

B. In addition to requirements of Division 1, provide all services necessary to assure the proper operation of all systems installed under this section of the specifications for one year after final acceptance. Completely inspect the systems at least twice during that time, at the change of seasons, and make any necessary adjustments in system. Two weeks before the date for beginning each of the inspections, inform the Engineer in writing. The requirement for inspections is not intended to, nor is the contractor obligated to perform any work during the one year period which, in the opinion of the Engineer is normal maintenance. However, if faulty or defective parts are found during the inspections repair or replace them in accordance with the guarantee provisions of these specifications.

C. In addition to compliance with the Conditions of the Contract, the Contractor is hereby made aware that certain manufacturer's equipment guarantees are valid only for a period of one year from the date of shipment or installation and will, therefore, not be valid until the date of guarantee set forth herein. The Contractor will, therefore, be responsible for all material, labor, and equipment for the full guarantee period as set forth herein.

D. Furnish labor and material required to fulfill the requirements of this guarantee at no additional cost to the Owner.

E. Owner pre-purchased equipment is not to be included in contractor's warranty. However, pre-purchased equipment installation is to be included in the contractor's warranty.

1.6 QUALITY ASSURANCE

A. The Plumbing Contractor shall be responsible for all costs associated with changes to valve, pipe sizes, sprinkler heads, etc. caused by the change of equipment from the basis of design specified to other named manufacturers. The Contractor is responsible to insure that the other manufacturer named supplied equipment will fit within space allocated, with appropriate clearances for maintenance, operation, service, code requirements, etc. Any contractor utilizing a manufacturer other than basis of design shall be responsible for any additional requirements for electrical service, concrete pad size, physical space limitations, and capacities at no additional cost to Owner. If manufacturers are listed, no other manufacturers except those listed within the Sections of this Division, that are in turn able to comply with the contract document requirements and minimum standards of these specifications, will be acceptable.

B. Work provided or performed by the Contractor shall be guaranteed to be replaced and made good at his own

expense any defects which may develop, within one (1) year after final payment and acceptance by Owner, due to faulty workmanship or material, upon receipt of written notification of the defect from the Owner.

1.7 SUBMITTALS

A. Submit under provisions of Division 1.

B. Proposed Products List: Include Products specified in Sections 22.

C. Submit shop drawings and product data grouped to include complete submittals of related systems, products, and accessories in a single submittal.

D. Mark dimensions and values in units to match those specified.

E. Submit prior to any shop drawing submittals for the Associate Engineer's review: A proposed list of equipment to be submitted 7 days after letter of intent or award of contract, whichever is first.

F. In addition to provisions of Division 1, submit (8 sets) of shop drawings having each sheet (except pages bound in a brochure) and each brochure marked with identification, and containing information described below. To facilitate coordination, submit all

G. Drawings in logical order. Submit mechanical assembly drawings, where possible, complete with all related subassembly drawings, wiring diagrams and necessary data.

H. Identification to Include:

1. Project name.

2. Identification by specification heading number under which equipment or material is described and by name, number, and intended use as designated by contract drawings and specifications.

3. Information: Include the following data:

a) Manufacturer's model number or catalog number, size and performance curves and data. Indicate operating points on curves and tabular data, for each piece of equipment that curves or data represent.

b) Indication of all performance data, construction materials, finishes and modifications to manufacturer's standard design called for in specifications.

c) Roughing in, foundation, and support points dimensions.

d) Electrical information, including elementary diagrams, connection diagrams and nameplate data.

4. Any shop drawings not in compliance with above will be returned, without review, for correction and re submittal.

5. In addition to the above, provide shop drawings for the following items:

a) Coordination drawings.

b) Maintain one copy of approval documents on site.

1.8 COORDINATION DRAWINGS

A. General:

1. The HVAC Contractor shall be in charge of the coordination drawing process and shall be responsible to resolve all conflicts and settle any disputes resulting from the coordination drawing process.

2. Contract drawings are diagrammatic. Included in the base bid shall be all offsets, fittings, etc. for a completed project. Only if major rerouting of piping is required, with significant cost increases, as approved by the Owner's Representative, Architect and Engineer, will additional money be warranted.

3. Field discrepancies shall be resolved by the field foreman. When discrepancies cannot be resolved, the signed-off coordination drawings shall be re-examined for rights.

4. Documented, coordinated, dimensioned work will have precedence. Owner will not pay for rework of a particular trade. Uncoordinated work will not be tolerated.

5. Coordination drawings shall be a phased process with the General Contractor, MEP Contractors, Architect and Engineer determining the sequence of work.

6. Each Contractor shall coordinate the exact location of their work with the work of other trades prior to fabrication or installation of same. Verify all dimensions and elevations. Provide additional offsets and sections of material as may be required to meet the applicable job condition requirements. Coordinate with and review all related Construction Drawings and Shop Drawings of all equipment suppliers prior to start of work.

B. Process

1. The Sheet Metal Sub-contractor shall have precedence for the allotment of available space. Ductwork rerouting for gravity drain lines may be required and shall be approved by the Engineer.

2. The Sheet Metal Contractor shall be responsible for all trades, pre-coordinating their layouts and shop drawings with each other, including the Sheet Metal Contractor.

3. The Sheet Metal Contractor shall prepare a BIM model (Revit or Navisworks). He shall be responsible for the base drawings to be used by all other Contractors. Base drawings shall include architectural, structural and reflected ceiling plan information.

4. The Sheet Metal Contractor shall prepare ductwork drawings, at a minimum scale of 1/4" = 1'-0", in a BIM model (Revit or Navisworks). After he has finished, a CD with base drawing and ductwork shall be circulated in the following order:

   a) Plumbing Contractor

   b) Piping Contractor

   c) Electrical Contractor

   d) General Contractor

5. Each Contractor shall use the diskette for preparation of their installation drawings.

6. After all trades have completed the coordination process, the General Contractor shall hold a coordination meeting to resolve conflicts. Each Contractor shall have available a drawing of his layout to be used with a light table for overlaying purposes. A representative of each Contractor, the Architect and the Engineer shall attend. All conflicts shall be resolved at the coordination meeting. The Architect and Engineer shall resolve all major conflicts as to the degree each Contractor shall alter their layout in order to allow for sufficient space for installation of the work.

7. When all coordination is complete, the Sheet Metal Contractor shall distribute two (2) sets of prints of the coordination drawings to each of the trades involved in the project, one (1) set for the owner's representative and one (1) set for as-built drawings.

C. Plumbing, HVAC Piping, and Electrical Contractors:

1. Piping and conduits shall be located and dimensioned from column center lines. Size, center line elevation and

required pitch shall be clearly noted.

2. Long drain lines shall have center line elevations indicated at 20’ intervals.

D. General Contractor:

1. All furring and holes shall be clearly noted.

2. All ceiling heights shall be clearly noted.

E. Service Areas:

1. Contractors shall indicate service areas for all equipment by shaded areas on drawings.

1.9 OPERATING INSTRUCTIONS

A. Instruct the Owner's personnel in the details of operation and maintenance of all Contractor furnished equipment. Instructions shall be based on operating annuals furnished for the equipment, and shall demonstrate procedures and methods described in manuals.

B. Arrange and pay for the services of qualified personnel from the manufacturer's of various major equipment for instruction. Provide this operating instruction for three working days of not less than eight hours, starting from the time that the entire system (or if sections are to be started at various times, from the time that each section) is in satisfactory operation. Time spent in making trial runs, changes, or major adjustments not to be included in the instruction time.

C. In addition to requirements of Division 1, provide:

D. Mechanical Booklet and Operations Instructions: Submit three (3) manuals, bound in the best grade hardback, loose-leaf, 3-ring binders, of all operating and maintenance instructions presenting full details for care and maintenance of all mechanical and electrical equipment installed, including air conditioning systems and equipment. The operating instructions shall include the following information:

1. Operating Instructions Manuals:

a) Provide written instructions, of the following format, for each system with submittal of invoice for 75% of total contract.

b) Submit one copy for approval before releasing to the Owner.

c) Upon receipt of the approval, submit three copies to the Engineer.

d) Bind the written operating instructions, shop drawings, equipment catalog cuts and manufacturer's instructions into a hard backed binder where they can be accommodated into a size 8-1/2" X 11".

2. Provide multiple binders where one cannot accommodate information.

a) First Page - Title of job, Owner, address, date of submittal, name of Contractor and name of Engineer.

b) Second Page - Index or Table of Contents.

c) Third Page - Introduction to first section containing a complete written description of systems.

d) First Section - Written description of system contents, where actually located in the building, how each part functions individually, and how system works as a whole. Conclude with a list of items requiring service and either state the service needed or refer to the manufacturer's data in the binder that described the proper service.

e) Second Section - A copy of each shop drawing with an index at the beginning of the section.

f) Third Section - A copy of each manufacturer's installation instructions.

g) Fourth Section - A copy of each manufacturer's operating instructions and parts lists along with recommended spare parts lists with index at the beginning of the section.

h) Fifth Section - A copy of each manufacturer's maintenance instructions

i) Sixth Section - A list of all equipment used on the job, Contractor's purchase order numbers, supplier's name and address, date of start-up of each piece of equipment.

j) Seventh Section - Copies of all control wiring and flow diagrams, valve charts, pertaining to the work including automatic temperature control diagrams.

1.10 RECORD DRAWINGS

A. In addition to Division 1, keep on the job one complete set of working drawings on which he shall record any deviation or changes made from contract drawings made during construction. Record drawings shall show changes in:

1. Size, type, capacity, etc. of any materials, device, or piece of equipment.

2. Location of any device or piece of equipment.

3. Location of any outlet or source in building service systems.

4. Routing of any piping, conduit, ducts, sewers, or other building services.

B. These drawings shall also record the location of all concealed water and electric service, water piping, sewers, wastes, vents, ducts, conduit and other piping by identification of measured dimensions to each such line from readily identifiable and accessible walls or corners of the building. Drawings also show invert elevation of sewers and top of water lines.

C. These drawings shall be kept clean and undamaged, and shall not be used for any purpose other than recording deviations from working drawings and exact locations of concealed work.

D. After the job is completed these sets of drawings shall be delivered to the Engineer in good condition, as a permanent record of the installation as actually constructed.

1.11 SPARE PARTS AND MAINTENANCE MATERIALS

A. Provide products, spare parts, maintenance and extra materials in quantities specified in individual specification sections.

B. Deliver to owner to location as directed; obtain receipt prior to final payment.

1.12 DRAWINGS AND SPECIFICATIONS

A. It is intended that work covered by these specifications and drawings include everything requisite and necessary to make the various systems complete and operative, irrespective of whether or not every item is specifically provided for. Any omission of direct reference herein to any essential item shall not excuse contractor from complying with the above intent.

B. Figured dimensions supersede scaled ones. Contractor shall take no advantage of, and shall promptly call the Owner's Representative attention to any error, omission or inconsistency in specifications and drawings.

C. Special attention is directed to requirements that equipment and materials stated in specifications and/or indicated on

drawings shall be furnished, except if otherwise noted, completely installed, adjusted and left in safe and satisfactory operating condition. Accessories, appliances and connections necessary for operation of equipment shall be provided to satisfaction of the Owner's Representative.

D. Materials, apparatus or equipment specified or otherwise provided for on drawings, addenda, or change orders issued subsequent to award of contract shall be same brand, type, quality and character originally specified unless otherwise provided.

E. Layout of equipment, accessories, specialties and suspended, concealed or exposed piping systems are diagrammatic unless dimensioned. In preparing shop drawings, contractor shall check project conditions before installing work. If there are any interferences or conflicts, they shall be called to attention of the Engineer immediately for clarification.

F. The drawings indicate required size and points of termination of pipes and ducts and suggest proper routes to conform to structure avoid obstructions and preserve clearances. However, it is not intended that drawings indicate all necessary offsets, and it shall be the work of this contractor to make the installation in such a manner as to conform to structure, avoid obstructions, preserve headroom and keep openings and passageways clear, without further obstruction or cost to the Owner.

G. Shop drawings shall be furnished by this contractor, indicating all changes to meet space requirements, code requirements and as necessary to resolve all space conflicts. Ductwork shall be fabricated from contractor's shop drawings and cut sheets and not from contract drawings.

H. It is intended that all apparatus be located symmetrical with architectural elements, and shall be installed at exact height and locations as shown on the architectural drawings. Refer to architectural details in completing and correlating work.

I. The contractor shall fully inform himself regarding any and all peculiarities and limitations of the spaces available for the installation of all work and materials furnished and installed under the contract. He shall exercise due and particular caution to determine that all parts of his work are made quickly and easily accessible.

J. The contractor shall carefully examine any existing conditions, existing piping and ducts and premises and compare the drawing with the existing conditions.

K. It cannot be too strongly emphasized that, except for work specifically excluded herein, every system shall be turned over to Owner installed completed, with components, ready for normal operation.

L. Modify existing systems by rerouting for systems to remain or remove for abandoned systems as required to accommodate new general construction, Fire Suppression, electrical and mechanical work.

M. Concealment:

1. Unless otherwise specified, all work aboveground to be above suspended ceilings and in walls except in the Mechanical Equipment Room and areas without ceiling work to be as high as possible.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 PROJECT CONDITIONS

A. Install Work in locations shown on Drawings, unless prevented by Project conditions.

B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission of Owner Representative before proceeding.

C. Drawings indicate desired position of equipment and routing of pipe and ductwork. Coordinate routing of pipes, ductwork and all other installations with installations of other trades prior to making installations.

D. Replace and restore to their original undamaged condition, facilities of every description damaged or disturbed

during progress of work. Such replacement or restoration applies to both surface and subsurface installations and materials. This includes fences for security, access routes, sidewalks, etc.

E. Where cutting of building structure such as floors, walls, roof, or framing is necessary, perform cutting operations only as authorized by the Owner's Representative as specified in Division 2. Cutting and patching of existing and new facilities shall be included in this Contract. Patch and finish all such openings in accordance with the applicable requirements given in other sections of these specifications.

F. Patching shall be done by workmen skilled in the trade involved. Holes cut in structural steel must be drilled or punched, not burnt with torch.

G. Remove existing ceiling and replace after work is tested. Repair and/or replace any damaged materials as directed by the Owner's Representative. Cutting and patching by this contractor to be as specified in Architectural Sections.

H. Patch, close and seal all new and existing openings used by this contractor. Where openings are used by more than one trade, each trade to be responsible for an equal share of patching, closing and sealing openings.

I. Tie-in to existing installations as indicated on the drawings and specified hereinafter. Complete the work to assure proper operation of each system with least possible damage to an interference with surrounding construction and using materials specified or to match existing.

3.2 SEQUENCING AND SCHEDULING

A. Construct Work in sequence under provisions in Division 1.

B. Coordinate completely all phases of and scheduling of work with the Owner’s Representative and with other trades. Obtain approval from the Owner’s Representative prior to execution of any work.

C. The existing facilities will remain in service throughout the construction operation with brief shut down periods permitted for making tie-in connections.

D. Interruption of existing services and facilities will be permitted only when the facilities are not required. The cost of premium time for scheduling interruptions on weekends and during evening hours as required by the Owner’s Representative operating schedule to be included in the bid amount. This means that both the cost of doing the work during the normal working day and the premium charges for weekend and evening hours to be included in the bid amount.

E. Make temporary connections where and when necessary to maintain existing systems in operation and replace temporary connections with permanent connections as soon as possible.

3.3 PRODUCT DELIVERY, STORAGE AND HANDLING

A. In addition to Division 1, protect piping ductwork and equipment at all times against entrance of dirt and injury to pipe joints, sheet metal, sheet metal acoustical lining and equipment surfaces during construction by means of caps, plugs, canvas, mounting
on skids or plastic covers.

B. During shipment and before and during erection, protect materials and equipment from weather damage. Keep materials and equipment off ground by means of wood blocks or skids. Follow manufacturer's suggested procedure for protection of equipment which will be idle for an extended period of time prior to start-up.

3.4 DEMOLITION

A. Disconnect all systems piping, ductwork, equipment, trim and accessories that are to be removed from systems that are to be maintained and used in the existing facility. Cap or plug all systems that are to remain in service. Demolition work to be scheduled as directed by the Owner's Representative. All costs for temporary connection to maintain the existing systems in operation after demolition of portions of the facility to be included in this contract. This contract to do all demolition shown on the drawings. All systems not reused are to be removed from the facility unless indicated otherwise.

B. Building demolition that is to be done by the General Contractor is specified in Division 1. Do all demolition work not done by the General Contractor. This includes abandoned systems in walls, ceilings and chases that remain.

C. Demolition to include all cutting, patching, excavation, backfill, removal and reworking all items in accordance with the applicable requirements given in other sections of these specifications.

D. Patch all walls, floors, roofs, ceilings where mechanical items are removed to provide finished surfaces to match adjacent surfaces.

3.5 EXCAVATION AND BACKFILL

A. Perform all excavation and backfill required to complete the working accordance with Division 2 Earthwork. Protect excavations, barricade walkways and minimize pedestrian disruption.

3.6 CONCRETE WORK

A. Provide all concrete pads and do all concrete work in accordance with Division 3.

3.7 PROTECTION AND DAMAGE

A. In addition to the provisions and stipulation of the General Conditions, provide various types of protection as follows:

1. Protect finished floors from chips and cutting oil by the use of metal drip receiving pan and oil proof floor cover.

2. Protect equipment and finished surfaces from welding and cutting splatters with baffles and splatter blankets.

3. Protect equipment and finished surfaces from paint droppings, insulation adhesive and sizing droppings, etc. by use of drop cloths.

B. All equipment shall be stored at the site with openings, bearings, etc., covered to exclude dust and moisture. All stock piled pipe shall be placed on dun age and protected from weather and from entry of foreign material.

C. Piping and construction openings and excavations required for Plumbing work shall be covered when work is not in progress as follows:

1. Cap pipe openings with fittings or plugs.

2. Cover wall and ceiling openings with plywood, or canvas covered framing.

3. Cover floor openings and excavations with structural material of adequate strength to support traffic.

D. The Owner’s property and the property of other Contractors shall be scrupulously respected at all times (including damage from leaks). Provide drop cloths and visqueen or similar barriers where dust and debris is generated, to protect adjacent area.

E. Contractor shall be held responsible for damage caused by his work or through neglect of his workmen. Repairing of damaged work shall be done by Contractor as directed by the Architect. Cost of repairs shall be paid by Contractor.

F. The Owner reserves the right to make emergency repairs as required to keep equipment in operation without voiding the Contractor’s guarantee bond not relieving the contractor of his responsibilities during the bonding period.

3.8 TESTING AND ADJUSTING

A. Furnish all necessary temporary equipment and instruments required for adjustments and for operating tests. Submit list of instruments which will be used, including data of most recent calibration of each instrument.

B. When a test is to be made, notify the Owner's Representative not less than 48 hours before the test is scheduled to start, so that he may witness the test, or any part of it, if they elect to do so. The start of any test or handling system may also be deferred by not more than two working days if the proposed date conflicts with other commitments of the personnel assigned to witness the tests.

C. Pressure Tests:

1. Test piping and prove tight, at the hydrostatic pressures Test piping which is to be concealed before the installation of concealing construction is started. Disconnect devices, equipment and attached piping which are not designed for the test pressure,

   and install plugs and blind flanges to close openings. listed below for a period of 2 hours for each test:

2. Water piping, Storm, soil, waste, vent and drain piping - test with water or air, prove tight to satisfaction of inspection authorities and architect/engineer. Natural gas piping test to 75 psig with compressed air.

3. Replace work found defective, or repair if so directed.

D. Soil test per Division 2.

E. Equipment:

1. After satisfactory testing and cleaning of all piping as specified herein, placement all equipment in operation. Pressure test equipment to rated pressure for a period of 2 hours.

2. Take all necessary reading to determine that equipment is operating satisfactorily. This includes temperatures in and out as well as ampere readings and voltage readings of all phases.

F. Adjusting and Balancing:

1. After satisfactory testing and cleaning of all piping as specified hereinbefore, place all equipment in operation and adjust as required for proper operation.

2. For starting-up and adjusting of Contractor furnished equipment except as specified hereinafter, which is not within the normal function of the Contractor's personnel, arrange and pay for the services of employees of the manufacturer's of various major items of equipment to supervise such adjustment and initial operation.

3. If the Contractor elects to provide such service for any equipment with his own personnel, and this proves unsatisfactory in the opinion of the Owner's Representative, the Contractor shall, upon notification of such dissatisfaction, arrange immediately for services of manufacturer's employees as specified above.

4. Contractor shall add to systems any devices required for proper balancing.

G. Test Reports:

1. After all tests have been completed, or at intervals during the testing if requested by the Owner's Representative, submit data on motor load readings on each phase and simultaneous voltage readings across each phase with motor nameplate data.

3.9 OPERATION OF SYSTEM

A. After the entire system has been adjusted, operate it for not less than three working days of not less than eight hours each to demonstrate that performance is satisfactory and that each item of equipment has the capacity specified. If the Engineer agrees or directs major portions of the system may be so operated at different times in lieu of operations of the entire system at once. Correct all operating deficiencies observed during the test runs.

B. When excessive vibration of equipment is noted during this operation, have the manufacturer's representative check shafts, motors, motor supports, fan wheels, sheaves, equipment mountings, bearings and couplings and other

components of the equipment which are vibrating.

C. Make all corrections necessary to eliminate the vibration to the satisfaction of the Engineer.

D. When the Engineer deems it to be necessary to do so, make another test after corrective work is completed for the full period specified above.

E. After replacement or repair, test work again as specified. Repeat until satisfactory.

F. Keep complete and accurate record of test data. Submit to the Owner's Representative, in triplicate, typewritten report of all test data.

G. Provide restraints to eliminate all excess pipe movement.

3.10 ACCESS PANELS

A. Provide access panels where required for access to concealed equipment, valves and piping. Location of all access panels shall be approved by the Architect/Engineer.

B. Panel size shall be adequate for service intended. Use fire rated UL listed access panels in fire rated ceilings or walls.

C. Access panels shall be per access panel spec section in division 8.

D. Access panels shall have locks in accordance with division 8.

3.11 FINISH

A. Prime piping and structural and/or supporting steel members or parts that are exposed with one coat of Porter gray primer, or equal, after work is in place.

1. Clean and re-paint any factory or shop painted surfaces that are damaged, scarred or with signs of corrosion. Painting to match original factory paint.

2. Clean surfaces to remove all dirt, oil, grease dust, scale and foreign matter before applying paint. Designate all piping with temporary removal markings for guidance during priming and painting.

3. All primer and paint shall be manufactured by Foy Johnston Porter, Pittsburgh Plate Glass Industries, Martin-Marietta, DuPont or equal.

4. Shop fabricated or Manufactured Equipment and Materials.

5. Unless factory finished is specified, prime, prior to shipment to job. If prior painting is not part of manufacturer's standard procedure, paint equipment and materials immediately after they are put in place, as specified for field painted items.

6. Items not to be painted:

a) Galvanized or similarly treated surfaces unless furnished as part of unitary assembly.

b) Non-ferrous surfaces

c) Non-metallic surfaces

d) Plated surfaces

e) Inside of pipes, conduits and electrical devices

f) Gearing and machine finished surfaces

g) Underground piping, unless otherwise specified.

B. Painting:

1. Refer to Division 1, for requirements.

2. Clean surfaces to remove all dirt, oil, grease, dust, scale and foreign matter before applying paint.

3. Finish painting to be done per Division 9 - Finishes or as specified within individual sections of this specification.

C. Permanent Identification:

1. After piping has been insulated and finish painted identify all exposed piping with painted stencils. See Section - Mechanical Identification.

3.12 FINAL CLEANING

A. In addition to the requirements of Division 1.

B. The Contractor shall provide final cleaning of the work consisting of cleaning each surface or unit of work to normal "clean" condition expected for a first-class building cleaning and maintenance program. Comply with the manufacturer's instructions for cleaning operations. The following are examples, but not by way of limitation, of cleaning levels required:

C. Remove labels which are not required as permanent labels.

D. Clean transparent materials, including mirrors and window/door glass, to a polished condition, removing substances which are noticeable as vision-obscuring materials. Replace broken glass.

E. Clean exposed exterior and interior hard-surfaced finishes, including metals, masonry, concrete, painted surfaces, plastics, tile, wood, special coatings and similar surfaces, to a dirt-free condition, free of dust, stains, films and similar noticeable distracting substances. Except as otherwise indicated, avoid disturbance of natural weathering of exterior surfaces. Restore reflective surfaces to original reflective.

F. Clean concrete floors broom clean.

G. Clean project site, including landscape, development areas, of litter and foreign substances. Sweep paved areas to a broom-clean condition; remove stains, petro chemical spills and other foreign deposits. Rake grounds which are neither planted nor paved, to a smooth, even-textured surface.

H. Remove all debris and clean dirt free all interiors of air handling equipment including coils, fans, dampers and ductwork. Clean to a visible dust and dirt free condition the inside of ductwork and replace filters on all systems that have been used for temporary heat or ventilation during construction.

3.13 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve operation and servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

a) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

b) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

c) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

d) Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast- brass type with polished chrome-plated finish.

e) Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and spring clips.

f) Bare Piping in Equipment Rooms: One-piece, cast-brass type.

g) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

L. Sleeves are not required for core-drilled holes.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

2. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

3. Install sleeves in new walls and slabs as new walls and slabs are constructed.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants" for materials and installation.

N. Aboveground, Exterior-Wall Pipe 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.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and

size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire stop materials. Refer to Division 7 Section "Through-Penetration Fire Stop Systems" for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.14 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.

D. Install equipment to allow right of way for piping installed at required slope.

END OF SECTION 220500

SECTION 220523 - GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Conditions, Special Conditions and Division 1 through Division 32 as set forth in these specifications are hereby incorporated into and shall become a part of the specifications for work under this title, insofar as they apply hereto.

B. Provide valves to facilitate maintenance and isolation of piping systems.

1.2 QUALITY ASSURANCE

A. STANDARDS

1. American National Standards Institute (ANSI), American Society of Mechanical Engineers (ASME), American Society for Testing and Materials (ASTM) and the Manufacturers' Standardization Society of the Valve and Fittings Industry (MSS).

2. MSS SP-70-90 Cast Iron Gate Valves, Flanged or Threaded Ends.

3. MSS SP-78-92 Cast Iron Plug Valves Flanged and Threaded.

4. MSS SP-80-87 Bronze Gate, Globe, and Check Valves.

5. MSS SP-85-85 Cast Iron Globe and Angle Valves, Flanged and Threaded Ends.

6. MSS SP-110-92 Ball Valves Threaded, Socket-Welded, Solder Joint, Grooved and Flared Ends.

1.3 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.

2. EPDM: Ethylene-propylene-diene terpolymer rubber.

3. NBR: Acrylonitrile-butadiene rubber.

4. PTFE: Polytetrafluoroethylene plastic.

5. SWP: Steam working pressure.

6. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Set angle, gate, and globe valves closed to prevent rattling.

4. Set ball and plug valves open to minimize exposure of functional surfaces.

5. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. All similar valves used on the project shall be by the same manufacturer.

B. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 VALVES, GENERAL

A. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

B. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

C. Valve Actuators:

1. Chain wheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.

2. Gear Drive: For quarter-turn valves NPS 6 and larger and on discharge of all pumps without VFD’s.

3. Hand wheel: For valves other than quarter-turn types.

4. Lever Handle: For quarter-turn valves NPS 5 and smaller, except plug valves.

5. Wrench: For plug valves with square heads. Furnish Owner with one (1) wrench for every ten (10) plug valves, for each size square plug head.

D. Extended Valve Stems: On insulated valves.

E. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves; and ASME B16.24 for bronze valves.

F. Valve Grooved Ends: AWWA C606.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.3 BALL VALVES (2-1/2 INCHES AND SMALLER)

A. 400 psi WOG, 150 psi steam, bubble tight against 100 psi, cast bronze body, self-aligning free floating chromium plated bronze or stainless steel ball with full flow port, brass non-rising stem, Teflon seat and body seal, quarter turn operation, solder joint or screwed ends. Valves to include memory stop and stem extensions for insulated piping.

1. Drain valves with hose fitting, dust cover and chain attachment: Apollo No. 78-104

2. All other valves: Apollo No. 77-100/200

3. Manufacturers:

a. Apollo (Basis of Design)

b. Hammond

c. Milwaukee

d. Nibco

e. Watts

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, butterfly or gate valves.

2. Throttling Service: Ball or butterfly.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full stem movement.

F. Provide sufficient space to allow adjustment of balancing values.

G. Install drain valves in piping at low points and trapped areas to provide complete drainage of all systems.

3.4 JOINT CONSTRUCTION

A. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated. Open valves before soldering.

3.5 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Conditions, Special Conditions and Division 1 through Division 32 as set forth in these specifications are hereby incorporated into and shall become a part of the specifications for work under this Section.

1.2 SUMMARY

A. This Section includes hangers and supports for mechanical system piping and equipment.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the valve and fittings industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents and test water.

B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents and test water.

1.5 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support system component and thermal-hanger shield insert indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details.

C. Welding Certificates: Copies of certificates for welding procedures and operators.

1.6 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified:

1. Pipe Hangers:

    a. Grinnell Corp.

    b. Michigan Hanger Co., Inc.

    c. National Pipe Hanger Corp.

    d. PHD Manufacturing, Inc.

2. Channel Support Systems:

    a. Grinnell Corp.; Power-Strut Unit.

    b. Michigan Hanger Co., Inc.; O-Strut Div.

    c. National Pipe Hanger Corp.

    d. Thomas & Betts Corp.

    e. Unistrut Corp.

3. Thermal-Hanger Shield Inserts:

    a. Michigan Hanger Co., Inc

    b. Pipe Shields, Inc.

    c. Rilco Manufacturing Co., Inc.

    d. Value Engineered Products, Inc.

4. Powder-Actuated Fastener Systems:

    a. Gunnebo Fastening Corp.

    b. Hilti, Inc.

    c. ITW Ramset/Red Head.

    d. Masterset Fastening Systems, Inc.

5. Roof Pipe Support

    a. C-Port.

    b. Mifab

    c. Advanced Support Products

    d. Clearline Technologies

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

1. Galvanized, Metallic Coatings: For piping and equipment that will not have field- applied finish.

2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100 psi minimum compressive-strength insulation; encased in sheet metal shield.

1. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier.

2. Material for Hot Piping: ASTM C 552, Type I cellular glass.

3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.

4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.

5. Insert Length: Extend 2" beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.

D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, non-shrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.

2. Properties: Nonstaining, noncorrosive, and nongaseous.

3. Design Mix: 5000-psi 28-day compressive strength.

2.4 ROOF PIPE SUPPORT

A. Molded recycled rubber support, UV resistant, Maximum 500 pound load, accepts screw fasteners thru pipe clamps, 4” high unit, 2 inch and smaller pipe minimum base size 6” x 9”, for 2-1/2 inch and larger pipe minimum base size 6” x 22”, maximum support spacing 8 or 10 foot. Provide rigid pipe clamps and stainless steel screws (pipe clamp to be one size larger than piping)

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger requirements are specified in Sections specifying equipment and systems.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 2 to NPS 30.

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.

3. Carbon-or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.

5. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated stationary pipes, NPS 3/4 to NPS 2.

6. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 2.

7. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 2.

8. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30.

9. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

10. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 , with steel pipe base stanchion support and cast-iron floor flange.

11. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from two (2) rods if longitudinal movement caused by expansion and contraction might occur.

12. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.

13. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

D. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

E. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.

    b. Medium (MSS Type 32):1500 lb.

    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where head room is limited.

F. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

G. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.

2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.

3.2 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-

assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions.

C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

D. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, 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.

E. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Install hangers and supports to allow controlled thermal 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. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

K. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.

b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert. Include steel weight distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

c. Do not exceed pipe stress limits according to ASME B31.9.

2. Shield Dimensions for Pipe: Not less than the following:

a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

b. NPS 4: 12 inches long and 0.06 inch thick..

c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.

d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.

3. Pipes NPS 8 and Larger: Include wood inserts.

4. Insert Material: Length at least as long as protective shield.

5. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

L. Supports from roof decking systems are not permitted.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.4 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes 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 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 contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

A. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 220529

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Conditions, Special Conditions and Division 1 through Division 32 as set forth in these specifications are hereby incorporated into and shall become a part of the specifications for work under this title, insofar as they apply hereto.

B. Identify by labels and tags the following:

1. Piping and valves exposed in equipment rooms and accessible service areas.

2. Piping and valves running above accessible ceiling construction and near access panels in non-accessible construction areas.

C. Install laminated plastic markers and metal stamped nameplates for equipment. Provide color banding, flow arrows and contents identification for piping and ductwork.

1.2 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:

1. Pipe markers.

2. Stencils.

3. Valve tags.

4. Valve schedules.

5. Warning tags.

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish three extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, “Scheme for the Identification of Piping Systems,” for letter size, length of color field, colors and viewing angles of identification devices for piping.

1.5 COORDINATION

A. Coordination 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 location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

D. All trades shall use the same type, style and appearance of identification.

PART 2 - PRODUCTS

2.1 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.

1. Colors: As indicated in specification schedule.

2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

3. Pipes with OD, including insulation, less than 6 inches: Full-band pipe markers extending 360 degrees around pipe at each location.

4. Pipes with OD, including insulation, 6 inches and larger: Either full-band or strip-type pipe markers at least three (3) times letter height and of length required for label.

5. Arrows: A separate unit on each pipe marker to indicate direction of flow.

2.2 VALVE TAGS

A. Valve Tags: 2" diameter tag stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme, approved by Engineer. Provide 5/32-inch hole for fastener.

1. Material: 16 gauge brass.

2. Valve-Tag Fasteners: Brass beaded chain.

2.3 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulation), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.

2. Frame: Extruded aluminum.

3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 22 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

B. Installing Contractor is responsible for valve tagging, equipment markers and pipe identification of all valves,

equipment and piping on packaged pumping skids.

3.2 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service of each piping system. Install with flow indication arrows showing direction of flow.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior non-concealed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and non-accessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings.

C. Pipe Identification

TYPE OF SERVICE	1" BAND COLOR	1/2" BAND COLOR	DESIGNATION
Compressed Air	Blue	Blue	CA
Storm	Yellow	Yellow	STORM
Gas	Yellow	Yellow	GAS

3.3 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves with captions similar to those indicated in the following:

TYPE OF SERVICE	VALVE TAG DESIGNATION
Gas	GAS
Compressed Air	COM. AIR

3.4 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location where directed by Owner. Provide aluminum frame with Plexiglas cover for valve chart.

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to equipment and other items where required.

3.6 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work. Stencils, name tags, etc. must be readable from a standing position.

B. When arrows and letters cannot be stenciled on pipe, stencil identification on 16 gauge aluminum metal panels in correct color and hang panel on piping with key chains.

3.7 CLEANING

A. Clean faces of mechanical identification devices and glass and frames of valve schedules.

END OF SECTION 220553

SECTION 220700 - PIPE INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Conditions, Special Conditions and Division 1 through Division 32 as set forth in these specifications are hereby incorporated into and shall become a part of the specifications for work under this title, insofar as they apply hereto.

1.2 SUMMARY

A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

1.3 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Application of protective shields, saddles, and inserts at pipe hangers for each type of insulation and hanger.

2. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.

3. Removable insulation at piping specialties and equipment connections.

4. Application of field-applied jackets.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less; and smoke-developed rating of 50 or less.

C. ASHRAE Standards: Comply with performance efficiencies prescribed for ASHRAE 90.1, "Energy Efficient Design for New Buildings, Except Low Rise Residential Buildings" for pipe insulation.

D. No damaged or water soaked insulation shall be used.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping installer for insulation application.

1.7 SCHEDULING

A. Schedule insulation application after testing piping systems. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

1. Mineral-Fiber Insulation:

a. CertainTeed Manson.

b. Knauf FiberGlass GmbH.

c. Owens-Corning Fiberglas Corp.

d. Schuller International, Inc.

2.2 INSULATION MATERIALS

A. Cellular-Glass Insulation: Foamed glass rated for 25/50 fire smoke spread, annealed, rigid, hermetically sealed cells, and incombustible. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.

2.3 FIELD-APPLIED JACKETS

A. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps and mechanical joints.

2. Adhesive: As recommended by insulation material manufacturer.

3. Rated for 25/50 fire smoke spread if used in return air ceiling plenums.

B. Glass Cloth Covering: Self-adhesive, mastic impregnated, rewettable cloth on exposed insulation and fittings only.

1. Thickness: 0.028 inches

2. Maximum Service Temperature: 450 degrees F.

3. Density: 14.3 oz/sq yd

4. Surface Burning Characteristic: 25/50 per ASTM E84

2.4 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave pre-sized a minimum of 14.3 oz/sq. yd.

1. Tape Width: 4 inches.

2.5 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

E. Apply multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors:

1. Apply insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound

recommended by the insulation material manufacturer to maintain vapor retarder.

3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.

2. Circumferential Joints: Cover with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches o.c.

3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.

4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.

5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.

P. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.

Q. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

R. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.

1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Fire Stopping."

S. Floor Penetrations: Apply insulation continuously through floor assembly.

1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 CELLULAR-GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.

3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

5. All exposed ends for cellular-glass insulation shall be neatly trimmed and beveled. All exposed insulation material shall be covered with mastic.

3.5 FIELD-APPLIED JACKET APPLICATION

A. Apply aluminum metal jacket for all exterior water piping, with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal joints with weatherproof sealant recommended by insulation cover manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

B. Apply glass-cloth jacket, for piping that is exposed in finished areas and mechanical room areas directly over insulation and fittings with factory-applied jackets.

1. Apply jacket smooth and tight to surface with 1-inch overlap at seams and joints.

2. Embed glass cloth between two (2) 0.062-inch thick coats of jacket manufacturer=s recommended adhesive.

3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

C. Provide PVC fitting covers for all exposed piping that is to be insulated.

3.6 PIPING SYSTEM APPLICATIONS

A. Materials and thicknesses for systems listed below are specified in schedules within this section.

B. Insulate the following piping systems:

1. Insulate hot water supply and return piping with glass fiber insulation.

2. Insulate city water supply piping with glass fiber insulation.

3. Insulate storm piping with glass fiber insulation.

C. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors.

2. Vibration-control devices.

3. Below-grade piping, unless otherwise indicated.

4. Chrome-plated pipes and fittings, unless potential for personnel injury.

5. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

D. Minimum Insulation Thickness For Pipe Sizes:

FLUID PIPING SYSTEM TYPES	TEMPERATURE RANGES (DEG. F)	LESS THAN 1" (INCHES)	1" TO 1-1/4" (INCHES)	1-1/2" TO 3" (INCHES)	4" AND LARGER (INCHES)
Horizontal storm	Any	1.0	1.0	1.0	1.0
Roof Drain sumps	Any	1.0	1.0	1.0	1.0

NOTE: The minimum listed thickness is based on a minimum R valve of 4.6. Thickness to vary if the insulation R value is different than 4.6. In addition, the minimum thickness is to be increased as required to meet ASHRAE 90.1.

E. Insulation at fire walls: All insulated piping penetrating walls with a fire resistive rating shall be insulated with molded foamglass; "ASJ-SSL" covering with a dual purpose fireproof, kraft aluminum foil, laminated white jacket. Insulation to be of same thickness as adjoining insulation.

F. PIPE INSULATING SUPPORT

1. On insulated piping with pipe supports around outside of covering provide galvanized steel formed bearing plates. Plates to be lined with length of foam glass insulation.

   a. 8" and smaller pipe: 12" long, 12 gauge plate

   b. 10" and larger pipe: 24" long, 10 gauge plate

3.7 FIELD QUALITY CONTROL

A. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

END OF SECTION 220700

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Conditions, Special Conditions and Division 1 through Division 32 as set forth in these specifications are hereby incorporated into and shall become a part of the specifications for work under this section.

B. Provide a complete system of hot water and cold water to fixtures.

C. Install and make connection to all faucets.

D. Sterilize complete domestic water system.

1.2 SUBMITTALS

A. Product Data: For pipe, tube, fittings and couplings.

B. Water Samples: Specified in Part 3 "Cleaning" Article.

C. Field quality-control test reports.

1.3 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp or other markings of specified testing agency.

B. Comply with NSF 61, “Drinking Water System Components - Health Effects; Sections 1 through 9,” for potable domestic water piping and components.

C. Standards:

1. American National Standards Institute (ANSI)

2. American Society for Testing and Materials (ASTM)

3. American Water Works Association (AWWA)

4. National Sanitation Foundation (NSF)

5. Plumbing and Drainage Institute (PDI)

PART 2 - PRODUCTS

2.1 WATER PIPING, ABOVE GRADE

A. Copper Tubing: ASTM B88, Type L for sizes 4 inches and smaller.

1. Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.

2. Joints: Solder, lead free, ASTM B32, 95-5 tin- antimony, or tin and silver, with melting range 430 to 435 degrees F.

3. Flanges: Bronze

4. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.2 FLANGES, UNIONS AND COUPLINGS

A. Pipe Size 2 Inches and Under:

1. Ferrous Pipe: 150 psig malleable iron threaded unions.

2. Copper tube and pipe: 150 psig bronze unions with soldered joints.

B. Pipe Size Over 2 Inches:

1. Ferrous Pipe: 150 psig forged steel slip-on flanges; 1/16 inch thick preformed neoprene gaskets.

2. Copper tube and pipe: 150 psig slip-on bronze flanges; 1/16 inch thick preformed neoprene gaskets.

C. Dielectric Connections: Flanges with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.3 BALL VALVES – 150 PSIG

A. Bronze Manufacturers:

1. Watt Model B6001

2. Other acceptable manufacturers offering equivalent products:

a. Hammond Model 8511

b. Apollo Model 70-100/200

c. Nibco 585

B. Up to and including 2 inches: Bronze two piece body, chrome plated brass or stainless ball, teflon seats and stuffing box ring, lever handle, solder or threaded ends with union.

C. Over 2 Inches: Cast steel body, chrome plated steel or stainless ball, Teflon seat and stuffing box seals, lever handle flanged.

2.4 BUTTERFLY VALVES – 150 PSIG

A. Manufacturers:

1. Watt Model DBF03.

2. Other acceptable manufacturers offering equivalent products:

a. Grinnell, LC-8201

b. Keystone, AR2

c. Hammond, 6201

d. Centerline 200

e. Demco NE-C

B. Cast or ductile iron body, chrome or nickel plated ductile iron disc, resilient replaceable EPDM seat, lug ends for dead end service, extended neck, 10 position level handle.

2.5 SWING CHECK VALVES – 150 PSIG

A. Manufacturers:

1. William Powell Model 560Y, 559

2. Other acceptable manufacturers offering equivalent products:

a. Hammond Model IB944, IR1124

b. Stockham Model B-321, G-931

c. Nibco Model S-433-B, F918-B

d. Watts B-5001T, F-511

B. Up to and including 2 inches: Bronze swing disc, solder ends.

C. Over 2 Inches: Iron body, bronze trim, swing disc, renewable disc and seat, flanged ends.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Excavating, trenching, and backfilling are specified in Division 31.

B. Flanges may be used on aboveground piping, unless otherwise indicated.

3.2 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use bronze ball valves for piping NPS 3 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 4 and larger.

2. Throttling Duty: Use balancing valves for piping NPS 2-1/2 and smaller.

3. Drain Duty: Hose-end drain valves.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops.

C. Install drain valves for equipment at base of water riser, at low points in horizontal piping and where required to drain water piping.

1. Install hose-end drain valves at low points in water mains, risers and branches.

2. Install stop-and-waste drain valves where indicated.

3.3 PIPING INSTALLATION

A. Provide piping materials as listed in part 2 of this specification section.

B. Install domestic water piping level.

C. Where water lines drop in outside walls, install piping so that the wall insulation is between the pipe and the outside wall.

D. Coordinate installation height of faucets, hose bibbs, and wall hydrants and Owner's Representative.

E. Unless otherwise noted, install shock absorbers at the end of each main branch and at the end of all water closet and urinal branches.

F. Install dielectric unions between piping of dissimilar metals.

G. Install a union between valves and final connections to all items of equipment.

H. All soldering shall be done with propane torch. Oxy-Actylene is prohibited.

I. Nipples shall be of the material as the pipe with which they are used.

J. Install a check valve on all equipment with a hot and cold mixing valve.

K. Place plugs in ends of uncompleted piping at end of day and when work stops.

L. All pipes to be protected from debris entry.

3.4 JOINT CONSTRUCTION

A. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder and ASTM B 828 procedure, unless otherwise indicated. Open valves before soldering.

3.5 HANGER AND SUPPORT INSTALLATION

A. Pipe hanger and support devices are specified in Division 230529 Section "Hangers and Supports for HVAC Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.

2. Individual, Straight, and Horizontal Piping Runs: According to the following:

   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.

   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced one (1) size for double-rod hangers, to a minimum of 3/8".

D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 and Smaller: 60" with 3/8" rod.
2. NPS 1 and NPS 1-1/4: 72" with 3/8" rod.
3. NPS 1-1/2 and NPS 2: 96" with 3/8" rod.
4. NPS 2-1/2: 108" with 1/2" rod.
5. NPS 3 to NPS 5: 120" with 1/2" rod.
6. NPS 6: 120" with 3/4" rod.

E. Install supports for vertical copper tubing every 10'-0".

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

3.7 FIELD QUALITY CONTROL

A. Inspect domestic water piping as follows:

1. Do not enclose, cover or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
    a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
    b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

B. Test domestic water piping as follows:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping. If testing is performed in segments, submit separate report for each test complete with diagram of portion of piping tested.
3. Leave domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 150 psig above operating pressure, without exceeding

pressure rating of piping system materials. Isolate test source and allow to stand for four (4) hours. Leaks and loss in test pressure constitute defects that must be repaired.

5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

3.8 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants and hose bibbs.

2. Open shutoff valves to fully open position.

3. Open throttling valves to proper setting.

4. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.

5. Remove and clean strainer screens. Close drain valves and replace drain plugs.

6. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.

7. Check plumbing specialties and verify proper settings, adjustments and operation.

3.9 STERILIZATION OF WATER LINES

A. After water piping is complete and fixtures have been installed, flush piping clean and sterilize all new hot and cold water piping. The sterilization shall be done by a Water Testing Laboratory regularly engaged in the service. All fees for testing and use of testing equipment shall be paid by this Contractor.

B. With all outlets closed, fill system to working pressure and close valve on supply main.

C. Open all fixtures slightly and pump a sterilization solution into test tap as follows; 400 minimum to 1000 maximum parts per million chlorine solution made from a sanitation grade of hyperchlorite, 70% available chlorine. Hyperchlorites may be either Pittchlor, H.T.H. or Perclorn.

D. Each outlet, hot or cold, shall be tested during fill to prove the presence of chlorine at that outlet and shall be opened and closed several times. Chlorine shall be present at all outlets.

E. Water piping system shall remain filled for a period of 24 hours and each outlet shall be again tested and shall have at least 100 parts per million of chlorine remaining.

F. All outlets shall be opened wide and the main supply valves opened, flushing system free of chlorine with clean water. Outlets shall be again checked and flushed until free of chlorine. Residual chlorine shall not be greater than 0.2 parts per million or until approved by the State Health Department. Flush main valves and entire system.

G. After final flushing, all aerators shall be removed, cleaned and replaced.

H. Chlorination of the system may be performed at same time the pressure test is conducted.

I. Sterilization procedures shall be witnessed by the Architect, city and health officials and the Owner's Representative.

J. After sterilization of system is complete, provide the Owner with written certification from an outside testing agency certified in this manner of testing of sterility and confirmation that piping is clean and safe to transmit water fro human consumption.

END OF SECTION 221116

SECTION 221316 – SANITARY WASTE VENT SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide a complete system of soil, waste, and vent piping to fixtures, including traps, within building.

1.2 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with the following minimum working-pressure ratings, unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.3 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

1.4 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Flexible Transition Couplings for Underground Non-pressure Piping: ASTM C 1173 with elastomeric sleeve. Include ends of same sizes as piping to be joined and include corrosion-resistant metal band on each end.

2.2 CAST-IRON SOIL PIPING

A. Hub-and-Spigot Pipe and Fittings: ASTM A 74, Service class.

1. Gaskets: ASTM C 564, rubber.

2.3 COPPER TUBING

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.

1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 2 for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.

B. Sanitary soil, waste and vents.

1. Aboveground Soil, Waste and Vents:

a. Soil, NPS 2-1/2 and smaller serving urinals only.

1) Pipe: Type “K” copper.

2) Fittings: Wrought copper DWV fittings with soldered joints.

b. All other soil, waste and vents, NPS 2 and smaller:

1) Pipe: Type L copper

2) Fittings: Wrought copper DWV fittings with soldered joints

c. Soil, waste and vent, NPS 2-1/2 and larger:

1) Pipe: Service weight cast iron no-hub pipe with heavy duty stainless steel couplings

2) Fittings: Cast iron to match pipe

3.3 PIPING INSTALLATION

A. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

B. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight.

C. Install cast-iron soil piping according to CISPI’s "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

D. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two (2) fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 Degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

E. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

F. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary Drain: 2% downward in direction of flow for piping NPS 3 and smaller; 1% downward in direction of flow for piping NPS 4 and larger.

2. Horizontal Sanitary Drainage Piping: 2% downward in direction of flow.

3. Vent Piping: 1% down toward vertical fixture vent or toward vent stack.

G. Minimum size for underground soil, waste and vent piping is 2".

H. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

I. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

A. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.

2. Hubless Joints: Make with rubber gasket and sleeve or clamp.

B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 HANGER AND SUPPORT INSTALLATION

A. Refer to Division 220529 Section "Hangers and Supports For Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.

2. Individual, Straight, Horizontal Piping Runs: According to the following:

a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.

b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support vertical piping at base and at each floor.

C. Rod diameter may be reduced one (1) size for double-rod hangers, with 3/8" minimum rods.

D. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60" with 3/8" rod.

2. NPS 3: 60" with 1/2" rod.

3. NPS 4 and NPS 5: 60" with 5/8" rod.

4. NPS 6: 60" with 3/4" rod.

5. Spacing for 10-foot lengths may be increased to 10'-0". Spacing for fittings is limited to 60".

E. Install supports for vertical cast-iron soil piping every 15'-0".

F. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 72" with 3/8" rod.

G. Install supports for vertical copper tubing every 10'-0".

H. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.

2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.

3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.

3.7 VENTS

A. Install Vents Through Roof As Follows:

1. 3" minimum size and extended a minimum of 12" above the roof.

2. Locate at least 8'-0" away from outside wall of building, 15'-0" away from outside air intakes or operable windows, and 2'-0" away from roof flashing work.

3. Offset vent piping to allow for thermal expansion and contraction.

4. Vent flashing to extend at least 12" from vent pipe, clamp between roofing and extend up, over and turn down inside vent pipe.

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1" wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

3.9 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 221316

SECTION 221335 -CHEMICAL WASTE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The General Conditions, special Conditions and Division 1 through Division 32 as set forth in these specifications are hereby incorporated into and shall become a part of the specifications for work under this project.

1.2 SUMMARY

A. This Section includes piping and specialties for the following systems:

1. Chemical waste and vent, gravity-flow, non-pressure piping system designated "Chemical Waste."

1.3 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Non-pressure Piping Pressure Rating: 10 foot head of water.

1.4 SUBMITTALS

A. Product Data: For chemical-waste piping materials, components, and specialties and for neutralization systems.

B. Maintenance Data: For neutralization systems and tanks to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain pipe, fittings, and joining materials for each piping system through one (1) source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of chemical-waste specialties and are based on the specific system indicated.

` C. Piping materials shall bear label, stamp, or other markings of specified testing laboratory.

D. Comply with ASME B31.3, "Process Piping."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties with sealing plugs in ends or with end protection.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one (1) of the manufacturers specified:

1. George Fischer

2. Orion

3. Schier

4. Spears

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 PIPES, TUBES, AND FITTINGS

A. Polypropylene Drainage Pipe and Fittings: ASTM F 1412, pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions, from polypropylene resin with fire-retardant additive complying with ASTM D 4101. Include fusion and mechanical joint ends.

B. PVDF (Polyvinylidene Fluoride) piping shall conform to ASTM F1673 for pipe extruded and drainage pattern fittings, molded with Schedule 40 dimensions. The PVDF material shall conform to ASTM D-3222. Pipe shall be marked with UL to indicate compliance with UL723 (ASTM E84). Include socket fusion and mechanical joint ends.

C. CPVC (Chlorinated Poly Vinyl Chloride) piping shall conform to ASTM 2618 for pipe and fittings, molded with Schedule 40 dimensions. The pipe and fittings shall also meet or exceed UL723 (ASTM E84) standards.

2.4 JOINING MATERIALS

A. Couplings: Assemblies with combination of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.

B. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.

C. Flanges: Assemblies of companion flanges gasket complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.

D. Socket Fittings and solvent welded in accordance with ASTM 493 and ASTM 2618.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31 for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below, unless otherwise indicated.

B. Above Floor Chemical Waste Piping:

1. Piping: Schedule 40 PVDF drainage piping or CPVC

2. Fittings: Mechanical joints or Solvent welded socket fittings.

3. Fittings in return air plenums: Socket fusion joints or Solvent welded socket fittings.

3.3 SPECIALTY INSTALLATION

A. Install neutralization tank on smooth and level foundation within concrete pit. Include full initial charge of limestone.

3.4 PIPING INSTALLATION

A. Install piping next to equipment, accessories, and specialties to allow service and maintenance.

B. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Install underground fiberglass piping according to ASTM D 3839.

3.5 HANGER AND SUPPORT INSTALLATION

A. Refer to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:

1. Individual, Straight, Horizontal Piping Runs:

a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.

b. Longer than 100 Feet: MSS Type 43, adjustable, roller hangers.

B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

C. Support horizontal piping and tubing within 12" of each fitting and coupling.

D. Rod diameter may be reduced one (1) size for double-rod hangers, with 3/8" minimum rods.

E. Install vinyl-coated hangers for chemical waste piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2: 33" with 3/8" rod.

2. NPS 2-1/2 and NPS 3: 42” with 1/2" rod.

F. Support piping and tubing not listed above according to MSS SP-69 and manufacturer’s written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:

B. Install piping adjacent to equipment to allow service and maintenance.

C. Connect Chemical waste piping to sinks, specialties, accessories, and equipment. Use chemical-resistant coupling, adapter, or fitting as required for materials being joined.

3.7 FIELD QUALITY CONTROL

A. Chemical Waste Piping Inspection:

1. Do not enclose, cover, or put drainage and vent piping into operation until it is inspected and approved by authorities having jurisdiction.

2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

   a. Roughing-in Inspection: Arrange for inspection of piping system before concealing after system roughing-in and before setting fixtures and equipment.

   b. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspections: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

B. Chemical Waste Piping Testing: Test systems according to procedures of authorities having jurisdiction or, in absence of published procedure, according to the following:

1. Test for leaks and defects in piping systems. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of system tested.

2. Leave piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Rough Plumbing Test Procedure: Test piping at completion of piping roughing-in, tightly close all openings in piping system, and fill with water to point of overflow, but not less than 10 foot head of water. From 15 minutes before test starts through completion of test, water level must not drop. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures and equipment have been set stack openings on roof and building drain where it leaves building, and introduce air into system equal to pressure of 1" wg. Use U-tube or manometer inserted in trap of fixture to measure pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest system or portion thereof until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

3.8 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:

1. Purge new piping.

2. Clean piping by flushing with potable water.

3.9 STARTUP SERVICE

A. Verify that neutralization system is installed and connected according to the Contract Documents.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Install neutralizing solutions and limestone.

END OF SECTION 221335

SECTION 221423 - STORM SEWER SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Conditions, Special Conditions and Division 1 through Division 32 as set forth in these specifications are hereby incorporated into and shall become a part of the specifications for work under this project.

1.2 SUMMARY

A. SCOPE OF WORK

1. Provide all storm drainage piping system for interior of the building.

1.3 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with the following minimum working pressure ratings, unless otherwise indicated:

1. Storm Drainage Piping: 10-foot head of water.

1.4 SUBMITTALS

A. Product Data: For pipe, tube, fittings and couplings.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Standard: State Environmental Protection Agency.

PART 2 - PRODUCTS

2.1 STORM WATER PIPING, ABOVE GRADE

A. Cast Iron Pipe: CISPI 301, hubless, service weight.

1. Fittings: Cast iron.

2. Joints: Neoprene gaskets and 304 stainless steel clamp-and wide shield assemblies. Joints bonded with Gilman adhesive lubricant and rodded per CISPI 1994.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31 for excavating, trenching and backfilling.

3.2 PIPING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.

3.3 PIPING INSTALLATION

A. Provide piping materials as listed in part 2 of this specification section.

B. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers.

C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight.

D. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

E. Make changes in direction for storm piping using appropriate branches, bends and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

F. Lay buried building drain piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements and other installation requirements. Maintain swab in piping and pull past each joint as completed.

G. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:

1. Building Storm Drain: 1 percent downward in direction of flow for piping.

2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.

H. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

I. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

A. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings" and manufacturer's recommendations."

1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.

2. Hubless joints: Make with rubber gasket and sleeve or clamp.

3. Grooved End: To be assembled per manufacturer’s instructions.

3.5 HANGER AND SUPPORT INSTALLATION

A. Refer to Division 23 Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.

2. Individual, Straight, Horizontal Piping Runs: According to the following:

a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.

b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

D. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and 2 NPS: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6: 60 inches with 3/4-inch rod.
5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.

E. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

D. Extend storm drainage piping with downspout boots from each downspout, as indicated on drawings.

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping according to procedures of authorities having jurisdiction, or in absence of published procedures, as follows:

1. Test for leaks and defects in piping. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed, storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Test Procedure: Test storm drainage piping except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10 foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

5. Prepare reports for tests and required corrective action.

3.8 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses. Flush lines as required to remove collected debris.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 221413

SECTION 221424 – NATURAL GAS SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Conditions, special Conditions and Division 1 through Division 32 as set forth in these specifications are hereby incorporated into and shall become a part of the specifications for work under this title, insofar as they apply hereto.

B. Provide natural gas piping and valve to new HVAC equipment on roof. Connections per code and equipment by the Plumbing Contractor.

1.2 SUBMITTALS

A. Product Data:

1. Piping Valves: Include pressure rating, capacity and settings.

2. Pressure Regulators: Include pressure rating, capacity and settings of selected models.

B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

C. Maintenance Data: For natural gas specialties and accessories to include in maintenance manuals specified in Division 1.

1.3 QUALITY ASSURANCE

A. Electrical Components and Devices: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AGA Standard: Comply with American Gas Association International Fuel Gas Code.

C. UL Standard: Provide components listed in UL's "Gas and Oil Equipment Directory" if specified to be UL listed.

PART 2 - PRODUCTS

2.1 FUEL GAS PIPING, BURIED WITHIN 5 FEET OF BULDING

A. Steel Pipe: ASTM A53, Schedule 40 black.

1. Fittings: ASTM A234, forged steel welding type, with AWWA C105 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.

2. Joints: ANSI B31.9, welded.

2.2 FUEL GAS PIPING, ABOVE GRADE

A. All gas piping and fittings, 1 psig and greater to be welded.

B. Steel Pipe: ASTM A53 Grade B, Schedule 40 black:

1. Fittings: ASME B16.3, malleable iron, or ASTM A234, forged steel welding type.

2. Joints: NFPA 54, threaded or welded to ANSI B31.9.

3. Unions: 300 pound malleable iron, located downstream of appliance valve only.

4. Flanges: 150 pound forged steel ASTM A105, welded neck or slip-on ANSI B16.5.

5. Gaskets: 1/16 inch thick preformed neoprene gasket.

6. All exterior piping to be primed and epoxy painted per specification section 099113.

2.3 FLANGES, UNIONS, AND COUPLINGS

A. Pipe size 2 inches and under:

1. Ferrous Pipe: 150 psig malleable iron threaded unions.

B. Pipe size over 2 inches:

1. Ferrous Pipe: 150 psig forged steel slip-on flanges; 1/16 inch thick preformed neoprene gaskets.

2.4 PLUG VALVES

A. Manufacturers:

1. Homestead Model 601.

2. Resun

3. Apollo Valves.

4. Grinnell Corp.

5. Milwaukee Valve Company, Inc.

6. Mueller Company; Mueller Gas Products Division

7. Nibco, Inc.

8. Hammond.

9. Rockwell.

B. Iron Body Plug Valve; threaded ends, up to and including 4 inches:

1. Iron body, bronze tapered plug, lubricated, threaded ends.

2. Rated for 200 CWP, AGA and UL listed.

3. Operator: One plug valve wrench for every ten plug valves, minimum of one.

C. Bronze Body Plug Valve; threaded ends, up to and including 4 inches:

1. Bronze body, bronze tapered plug, non-lubricated, Teflon packing, threaded ends.

2. Rated for 200 CWP, AGA and UL listed.

3. Operator: One plug valve wrench for every ten plug valves, minimum of one.

D. Iron Body Plug Valve; flanged ends, over 2 inches:

1. Cast iron body and plug, full port opening, pressure lubricated, Teflon packing, flanged ends.

2. Rated for 200 CWP, AGA and UL listed.

3. Operator: Each plug valve with a wrench with set screw.

E. Iron Body Plug Valve; flanged ends, over 2 inches, Teflon sleeve lined, D.I. body:

1. Cast iron body and plug, non-lubricated, Teflon packing, flanged ends.

2. AGA and UL listed.

3. Operator: Each plug valve with a wrench with set screw.

2.5 BALL VALVES

A. Manufacturers:

1. Homestead Model 601.

2. Resun

3. Apollo Valves.

4. Grinnell Corp.

5. Milwaukee Valve Company, Inc.

6. Mueller Company; Mueller Gas Products Division

7. Nibco, Inc.

8. Hammond.

9. Rockwell.

B. Bronze Ball Valve; threaded ends, up to and including 2 inches:

1. Bronze, two piece body, chrome plated brass ball and brass stem, Teflon seats and stem packing, lever handle, threaded ends.

2. Rated for 600 psi WOG

3. AGA, UL listed for natural gas.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.

C. Route piping in orderly manner and maintain gradient.

D. Install piping to conserve building space and not interfere with use of space.

E. Group piping whenever practical at common elevations.

F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

G. Provide clearance for installation of insulation and access to valves and fittings.

H. Provide access where valves and fittings are not exposed.

I. Provide firm bed for each pipe of minimum of 6 inches of bank run gravel. Support pipe uniformly.

J. Provide steel pipe sleeve for each pipe that passes under each footing or grade beam. Extend sleeve not less than 18 inches from footing with not less than 2 inches clearance around pipe. Backfill with concrete not less than 6 inches around sleeve and up to bottom of footing or grade beam.

K. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

L. Provide support for utility meters in accordance with requirements of utility companies.

M. Prepare pipe, fittings, supports, and accessories not prefinished, ready for finish painting.

N. Install valves with stems upright or horizontal, not inverted.

3.3 PIPING INSTALLATION

A. Concealed Locations: Install gas piping per the following:

1. Vent conduit to outside and terminate with screened vent cap.

2. Above ceiling locations: Welded gas piping may be installed in accessible spaces, subject to approval of authorities having jurisdiction, whether or not such spaces are used as plenums. Do not locate valves or unions above return air ceiling plenums.

3. In partitions: Do not install concealed piping in solid partitions. Exception: Piping passing through partitions or walls.

4. Prohibited Locations: Do not install gas piping in or through circulating air ducts, chutes, chimneys or gas vents (flues), ventilating ducts, and elevator shafts.

5. Install piping under slab (science classrooms), in conduit made of wrought iron, plastic pipe, steel pipe, or other approved conduit material per international fuel gas code. Install conduit at least 2" above finished floor.

B. Drips and Sediment Traps: Install drips at points where condensate may collect. Locate where readily accessible for cleaning and emptying. Do not install where condensate would be subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum length nipple of three (3) pipe diameters, not less than 3" long, and same size as connected pipe. Install with space between bottom of drip and floor for removal of plug or cap.

C. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels, unless indicated to be exposed to view.

D. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

E. Connect branch piping from top or side of horizontal piping.

F. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

G. Install flanges on valves, specialties, and equipment having NPS 2 ½" and larger connections.

H. Install vent piping for gas pressure regulators and gas trains, extend outside building, and vent to atmosphere. Terminate vents with turned down reducing elbow fittings with corrosion resistant insect screens in large end.

3.4 JOINT CONSTRUCTION

A. Use materials suitable for fuel gas.

3.5 HANGER AND SUPPORT INSTALLATION

A. Refer to Division 230529 Section "Hangers and Supports for HVAC Piping and Equipment" for pipe hanger and support devices.

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1.	NPS 1 and Smaller:	96" with 3/8" rod
2.	NPS 1-1/4:	108" with 3/8" rod
3.	NPS 1-1/2 and NPS 2:	108" with 3/8" rod
4.	NPS 2-1/2 to NPS 3-1/2"	120" with 1/2" rod
5.	NPS 4 and NPS 5:	120" with 5/8" rod
6.	NPS 6:	120" 3/4" rod

3.6 CONNECTIONS

A. Drawings indicate general arrangement of fuel gas piping, fittings, and specialties.

B. Install piping adjacent to appliances to allow service and maintenance.

C. Connect piping to appliances using gas with shutoff valves and unions. Install valve upstream from and within 72" of each appliance. Install union downstream from valve.

D. Sediment Traps: Install tee fitting with capped 6" long nipple in bottom to form drip, as close as practical to inlet of each appliance using gas.

E. Ground Equipment:

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

2. Do not use gas pipe as grounding electrode.

3.7 PAINTING

A. Painting by Contractor.

3.8 FIELD QUALITY CONTROL

A. Inspect, test and purge piping according to ANSI Z223.1, Part 4 "Inspection, Testing and Purging" and requirements of the local utilities company or authorities having jurisdiction.

B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

C. Report test results promptly and in writing to Architect and authorities having jurisdiction.

D. Verify capacities and pressure ratings of service meters, pressure regulators, valves and specialties.

E. Verify correct pressure settings for pressure regulators.

F. Verify that specified piping tests are complete.

3.9 ADJUSTING

A. Adjust controls and safety devices. Replace damaged and malfunctioning controls and safety devices.

END OF SECTION 221424

SECTION 221430 – PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Conditions, Special Conditions and Division 1 through Division 32 as set forth in these specifications are hereby incorporated into and shall become a part of the specifications for work under this title, insofar as they apply hereto.

B Provide plumbing piping specialties or accessories as required by either the Equipment Manufacturer or the Local Code Authority.

1.2 QUALITY ASSURANCE

A. STANDARDS

1. Plumbing and Drainage Institute (PDI), American Society of Sanitary Engineering (ASSE), American National Standards Institute (ANSI).

1.3 PERFORMANCE REQUIREMENTS

Provide components and installation capable of producing piping systems with following minimum working-pressure ratings, unless otherwise indicated:

1. Domestic Water Piping: 125 psig.

2. Sanitary Waste and Vent Piping: 10-foot head of water.

1.4 SUBMITTALS

A. Submit per the provisions of section 220500

B. Product Data: Include rated capacities and shipping, installed, and operating weights. Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections for the following:

1. Thermostatic water mixing valves and water tempering valves.

2. Water hammer arresters, air vents, and trap seal primer valves and systems.

3. Cleanouts, floor drains, and roof drains.

C. Maintenance Data: For plumbing specialties to include in maintenance manuals. Include the following:

1. Thermostatic water mixing valves and water tempering valves.

2. Trap seal primer valves and systems.

1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of plumbing specialties and are based on the specific system indicated. Refer to Division 1, Section "Product Requirements."

B. Plumbing specialties shall bear label, stamp, or other markings of specified testing agency.

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. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for piping materials and installation.

E. NSF Compliance:

Comply with NSF 61, "Drinking Water System Components--Health Effects, Sections 1 through 9," for potable domestic water plumbing specialties.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents per the requirements of section 220500.

B. Operating Key Handles: Equal to 100 percent of amount installed for each key operated hose bibb and hydrant installed.

PART 2 – PRODUCTS

2.1 SPECIALTIES SCHEDULED ON THE DRAWINGS

A. Roof Drains

a. Refer to Drawings.

2.2 SHOCK ABSORBERS

A. Shock absorbers shall conform to ASSE Standard 1010. Furnish shock absorbers as shown on the Drawings. Shock absorbers shall be selected by weight in fixture units per manufacturers recommendations.

B. Manufacturers:

1. Amtrol “Diatrol”

2. Josam

3. J.R. Smith

4. Precision Plumbing Products

2.3 TRAPS

A. Exposed Fixture Traps shall be chrome-plated brass.

B. Concealed Fixture Traps

1. 2 Inches and Under: Extra heavy weight brass, recessed drainage type with brass cleanout plug in bottom.

2. 3 Inches and Larger: Cast iron with clean out in the trap inlet or brass plug in bottom or side.

2.4 TRAP PRIMERS (TP)

A. Manufacturers:

1. Mifab

2. Precision Plumbing Products

3. Smith

4. Watts

5. Zurn

B. Single Trap Primer: ½" cast bronze, automatic trap primer, non-liming actuator.

C. Multiple unit trap primer: Diaphragm operated trap primer, capable of supplying eight (8) drain traps, operating range 35 to 75 psig.

D. Trap primers shall comply with ANSI/ASSE standard 1018.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install trap seal primer valves in accessible ceilings or behind access panel with outlet piping pitched down toward drain trap a minimum of 1 percent and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

B. Install flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.

C. Install vent flashing sleeves on stacks passing through roof. Secure over stack flashing according to manufacturer's written instructions.

D. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1" clearance between vent pipe and roof substrate.

E. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

1. Install roof-drain flashing collar or flange so no leakage occurs between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.

2. Position roof drains for easy access and maintenance.

F. Fasten wall-hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated.

G. Fasten recessed-type plumbing specialties to reinforcement built into walls.

H. Install wood-blocking reinforcement for wall-mounting and recessed-type plumbing specialties.

I. Install individual shutoff valve in each water supply to plumbing specialties. Install shutoff valves in accessible locations.

J. Install air vents at piping high points. Include ball valve in inlet and drain piping from outlet to floor drain.

K. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Ground equipment.

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

E. Connect plumbing specialties and devices that require power according to Divisions 26 and 28 Sections.

3.3 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221430

SECTION 221513 - GENERAL-SERVICE COMPRESSED-AIR PIPING

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. This Section includes piping and related specialties for general-service compressed-air systems operating at 200 psig or less.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. CR: Chlorosulfonated polyethylene synthetic rubber.

C. EPDM: Ethylene-propylene-diene terpolymer rubber.

D. HDPE: High-density polyethylene plastic.

E. NBR: Acrylonitrile-butadiene rubber.

F. PE: Polyethylene plastic.

G. PVC: Polyvinyl chloride plastic.

H. Low-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig or less.

1.4 ACTION SUBMITTALS

A. Product Data: For the following:

1. Pipes, fittings, and valves.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For general-service compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

1. Extruded-Tee Outlet Procedure: Qualify operators according to training provided by T-DRILL Industries Inc., for making branch outlets.

2. Pressure-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by Viega; Plumbing and Heating Systems.

3. Pressure-Seal Joining Procedure for Steel Piping. Qualify operators according to training provided by Victaulic Company.

B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or to AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

D. ASME Compliance:

1. Comply with ASME B31.1, "Power Piping," for high-pressure compressed-air piping.

2. Comply with ASME B31.9, "Building Services Piping," for low-pressure compressed-air piping.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Compressed-Air Service: Do not interrupt compressed-air service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary compressed-air service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of compressed-air service.

2. Do not proceed with interruption of compressed-air service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Schedule 40, Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B, black or hot-dip zinc coated with ends threaded according to ASME B1.20.1.

1. Steel Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized seamless steel pipe. Include ends matching joining method.

2. Malleable-Iron Fittings: ASME B16.3, Class 150 or 300, threaded.

3. Malleable-Iron Unions: ASME B16.39, Class 150 or 300, threaded.

4. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel, threaded.

5. Wrought-Steel Butt-Welding Fittings: ASME B16.9, Schedule 40.

6. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel.

B. Copper Tube: ASTM B 88, Type K or L seamless, drawn-temper, water tube.

1. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.

2. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150 or 300.

3. Copper Unions: ASME B16.22 or MSS SP-123.

4. Press-Type Fittings, NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.

C. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.2 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for compressed-air piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.3 VALVES

A. Metal Ball, Butterfly, Check, and Gate Valves: Comply with requirements in Section 220523 “General Duty Valves for Plumbing Piping.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Low-Pressure Compressed-Air Distribution Piping: Use the following piping materials for each size range:

1. NPS 2 and Smaller: Schedule 40, -black-steel pipe; threaded, malleable-iron fittings; and threaded joints.

2. NPS 2 and Smaller: Type K or L, copper tube; wrought-copper fittings; and brazed or soldered joints.

3. NPS 2 and Smaller: Type K or L , copper tube; press-type fittings; and pressure-sealed joints.

3.2 VALVE APPLICATIONS

A. Metal General-Duty Valves: Comply with requirements and use valve types specified in Section 220523 “General Duty Valves for Plumbing Piping." according to the following:

1. Low-Pressure Compressed Air: Valve types specified for low-pressure compressed air.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.

E. Install piping adjacent to equipment and machines to allow service and maintenance.

F. Install air and drain piping with 1 percent slope downward in direction of flow.

G. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.

H. Extended-tee outlets with brazed branch connection may be used for copper tubing, within extruded-tee connection diameter to run tube diameter ratio for tube type, according to Extruded Tee Connections Sizes and Wall Thickness for Copper Tube Table in ASTM F 2014.

I. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install piping to permit valve servicing.

L. Install piping free of sags and bends.

M. Install fittings for changes in direction and branch connections.

N. Install sleeves for piping penetrations of walls, ceilings, and floors.

O. Install sleeve seals for piping penetrations of concrete walls and slabs.

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints for Steel Piping: Join according to AWS D10.12/D10.12M.

E. Brazed Joints for Copper Tubing: Join according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Join according to ASTM B 828 or CDA's "Copper Tube Handbook."

3.5 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Section 220523 “General Duty Valves for Plumbing Piping.

B. Install shutoff valves and unions or flanged joints at compressed-air piping to air compressors.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

B. Vertical Piping: MSS Type 8 or 42, clamps.

C. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet or Less: MSS Type 1, adjustable, steel clevis hangers.

2. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

D. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

E. Base of Vertical Piping: MSS Type 52, spring hangers.

F. Support horizontal piping within 12 inches of each fitting and coupling.

G. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

H. Install hangers for Schedule 40, steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4 to NPS 1/2: 96 inches with 3/8-inch rod.

2. NPS 3/4 to NPS 1-1/4: 84 inches with 3/8-inch rod.

3. NPS 1-1/2: 12 feet with 3/8-inch rod.

4. NPS 2: 13 feet with 3/8-inch rod.

I. Install supports for vertical, Schedule 40, steel piping every 15 feet.

J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4: 60 inches with 3/8-inch rod.

2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.

3. NPS 3/4: 84 inches with 3/8-inch rod.

4. NPS 1: 96 inches with 3/8-inch rod.

5. NPS 1-1/4: 108 inches with 3/8-inch rod.

6. NPS 1-1/2: 10 feet with 3/8-inch rod.

7. NPS 2: 11 feet with 3/8-inch rod.

K. Install supports for vertical copper tubing every 10 feet.

3.7 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

A. Perform field tests and inspections.

B. Tests and Inspections:

1. Piping Leak Tests for Metal Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.

2. Repair leaks and retest until no leaks exist.

C. Prepare test reports.

END OF SECTION 221513

SECTION 230000 - HVAC WORK

PART 1 - GENERAL

1.1 GENERAL

A. Bidding Documents and Form of Proposal apply to this Division.

B. Furnish all materials, equipment, and services herein specified.

C. Coordinate with Installing Contractor for shipping, rigging, installation, start-up, and commissioning procedures.

1.2 SCOPE OF WORK

A. In general, this work includes, but is not limited to, the following principal items:

Section 230000 – HVAC Work
Section 230400 – General Heating, Ventilation, and Air Conditioning (HVAC) Requirements
Section 230500 – Common Work Results for HVAC
Section 230513 – Common Motor Requirements for HVAC Systems
Section 230515 – General Piping Requirements
Section 230517 – Sleeves and Sleeve Seals for HVAC Piping
Section 230518 – Escutcheons for HVAC Piping
Section 230519 – Meters and Gages for HVAC Piping
Section 230523 – General Duty Valves for HVAC Piping
Section 230529 – Hangers and Supports for HVAC Equipment
Section 230548 – Vibration Controls for HVAC Piping and Equipment
Section 230553 – Identification for HVAC Piping and Equipment
Section 230593 – Testing Adjusting and Balancing for HVAC
Section 230700 – Pipe Insulation
Section 230701 – Equipment Insulation
Section 230702 – Duct Insulation
Section 230800 – Commissioning of HVAC
Section 230995 – Laboratory Airflow Control System
Section 232111 – Piping Materials
Section 232113 – Hydronic Piping
Section 232114 – Hot Water Heating System
Section 232115 – Chilled Water System
Section 233113 – Metal Ducts
Section 233300 – Air Duct Accessories
Section 233423 – HVAC Fans
Section 233600 – Air Terminal Units
Section 233713 – Diffusers, Registers and Grilles
Section 233714 – Louvers
Section 237300 – Custom Air Handling Units
Section 237314 – Variable Frequency Motor Controllers
Section 238239 – Unit Heaters

1.3 WORK BY OTHERS

A. The following work will be done by contractors, whose work will be specified later.

1. General Construction Work

2. HVAC and Temperature Control Work

3. Electric Work

1.4 ESPECIAL ATTENTION

A. Especial attention is called to the fact that in order to save time the Owner is requesting quotations for certain air handling units and requisite variable frequency drives herein specified, F.O.B. rigger's yard in Cincinnati, freight allowed, excluding sales and use tax.

B. The Owner shall issue a purchase order to the selected equipment supplier. The Owner shall pay 90% of the purchase order amounts within 30 days of the delivery of equipment to rigger's yard in Cincinnati and the Owner shall pay the final 10% of the purchase order amount within 30 days of the recognized start-up date. The equipment is requested to be delivered to rigger's yard or Xavier University location as stated on the Bid Form; however, receipt of equipment after the grace period shall result in penalties as described in Paragraph 23 00 00 - 1.4D in order to maintain the project schedule. In the event that any penalty is invoked, the penalty amount will be deducted from the “final 10% payment”. Modification of this paragraph in any manner may result in supplier’s bid being deemed non-responsive.

C. The subsequently selected HVAC contractor will exclude the cost of this equipment from his bid; however, installation contractor will include his charges for overhead and profit; and he will receive equipment, transport same from rigger's yard, rig, handle, install and assume the same responsibility as though he had initially invited proposals and made the award on the equipment.

D. The equipment manufacturer shall agree to cooperate with the Installation Contractor designated by the Owner at a later date. Equipment manufacturer shall be responsible for any overtime expediting, and associated costs incurred by the HVAC contractor in order to maintain the project schedule as a result of delivery of equipment after the dates listed on the form of proposal.

E. Prior to shipment, the Manufacturer shall contact the Owner to insure that the Owner is ready to accept the various air handling units. In the event that the Owner is not prepared to accept the various air handling units, the Manufacturer shall store the equipment at their factory for up to two (2) months at no additional charge to the Owner.

1.5 GUARANTEE

A. Variable frequency drive manufacturers shall guarantee the variable frequency drives for five (5) years (parts and labor) and all manufacturers shall guarantee all other workmanship, materials and equipment herein specified for a period of two (2) years (parts and labor), all from date of substantial completion or from the "recognized" start-up date, whichever is later. Should the Owner elect to accept a portion of equipment prior to the date of substantial completion, the guarantee period for the accepted portion of the equipment shall commence on the date of acceptance or on the "recognized" start-up date for that portion of the equipment, whichever is later.

B. The "recognized" start-up date shall be defined as that date on which the manufacturer has successfully completed all phases of his equipment, including the following:

1. Submitted and received approval of three (3) copies of the Instruction Booklets.

2. Completed all on-site training of Owner's personnel. On-site operator training shall consist of three 8 hour sessions (a day per shift) during normal working hours. Air handling unit manufacturers shall be required to

provide this training for which a syllabus shall be submitted to the Engineer for approval prior to the training sessions. Manufacturers shall include providing requisite training manuals, training aides, etc.

3. Completed all testing, cleaning, adjusting and trial run to the satisfaction of the Engineer.

C. In the case where the Owner is accepting a portion of the equipment, the manufacturer shall have completed all phases of that portion of the equipment to be accepted, including Items B.1, B.2, and B.3 above, for that accepted portion of the equipment.

D. Any workmanship, materials or equipment proving to be defective during this guarantee period shall be made good by this manufacturer without additional cost to the Owner.

1.6 COMMISSIONING

A. Supplier shall participate in the commissioning process as herein specified.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION - NOT USED

END OF SECTION 230000

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SECTION 230400 - GENERAL HEATING, VENTILATING, AND AIR CONDITIONING (HVAC) REQUIREMENTS

PART 1 - GENERAL

1.1 HVAC WORK

A. The following paragraphs are applicable to Division 23 and are complementary to other sections of specifications. Where items described in other sections of the specifications are repeated herein, it is done to call special attention to or to qualify them, but it is not intended that any part of the documents shall be assumed to be omitted if not repeated herein.

B. Where contradictions occur between this section and Division 1, the more stringent of the two shall apply. Architect/Engineer shall decide which is most stringent.

1.2 DRAWINGS AND SPECIFICATIONS

A. HVAC drawings are diagrammatic and indicate general arrangement of systems and work included in the contract and shall be adhered to insofar as possible. The drawings and specifications are complementary and are intended, without giving every minute detail, to cover a workable installation complete in every respect including, whether mentioned or not, all material and equipment usually furnished with such systems and/or needed to make a complete operational installation omitting only such parts as are specifically excepted.

B. Consult drawings and details for exact location of fixtures and equipment, and where not definitely indicated, request this information in writing.

C. The specification for each division of the work is written in sectional form for brevity and convenience in reference, without repeating in each section all applicable general clauses and/or pertinent data covered elsewhere in the specification, but it is not intended that any of the documents shall be assumed to be omitted if not repeated in each division.

D. Where specifications are written for brevity, with incomplete sentences, the omission of words or phrases, such as "the contractor shall", "shall be", "provide", "furnish", "all", etc. are intentional and such omitted words or phrases shall be supplied by inference; unless otherwise mentioned, such clauses, lists, and/or directives indicate work to be done by the contractor for that specific division of work.

1.3 VERIFYING CONDITIONS

A. The work under this contract occurs on the site of and within the existing facility. The work under this contract shall be scheduled and performed so as to provide a minimum of interference with the normal operation of the existing facilities.

B. Before submitting a proposal, contractors shall visit the site, and shall also carefully examine all bidding documents including those for other branches of the work, to satisfy themselves as to the nature and scope of all work to be done. Prints showing the original building architectural, structural, mechanical, and electrical work are available at the Engineer's office for contractors' review.

C. The submission of a proposal shall be taken as evidence that such an examination has been made and difficulties, if any, noted. Later claims for labor, work, material, and equipment required for any difficulties encountered which could have been foreseen, shall not be recognized, and all such difficulties shall be properly taken care of by the contractor at no additional expense to the Owner.

1.4 EXISTING WORK AND/OR CONDITIONS

A. The accompanying drawings and specifications illustrate and describe the existing conditions, mechanical utilities, sewers, water mains, pipes, ducts, conduits, etc. that are particularly relevant to the new work insofar as these mains are shown on existing records or evident by field inspections and tests; however, it is not the intent that these documents shall be construed to guarantee to the contractor the exact location of these items. Each contractor shall verify and determine the exact location of these items in the field, and all work under this contract shall be executed to avoid conflict with or damage to existing work. The work shall be planned and executed to avoid interference, as much as possible, with traffic and with the normal use of the existing facility.

B. All work involving hazards to persons shall be suitably barricaded and provided with warning lights or signs, as required.

C. Where necessary for the performance of the contract, existing work shall be cut, altered, removed, or temporarily removed and replaced. Work that is altered or replaced shall match similar existing work and said work shall be performed by trade applicable to the work; if said work is NOT shown or noted the Drawings relating to applicable trade, cost shall be paid by contractor requiring said work. However, unless otherwise provided by the drawings or specifications, no structural members shall be cut or altered without authorization of the Architect and Engineer. Work remaining in place, which is damaged or defaced by reason of work done under this contract, shall be restored in kind equal to its condition at the time of award of the contract by applicable trade as hereinbefore specified.

D. Existing work shall not be disturbed further than necessary for proper installation of new work. New work to be connected or made integral with existing work shall be properly erected to secure solidity and be continuous in finish. Such new work in extension of existing work shall correspond in all respects with that to which it connects, or similar existing sound work, unless otherwise specified.

1.5 EXISTING MECHANICAL FACILITIES

A. Where existing mechanical facilities and/or service lines occur in the area of the work and such facilities or lines are to be abandoned or changed, the contractor for the branch of work or trade involved shall cut off and properly cap the old lines, so as not to interfere with the new construction work. If any portions of such lines are required for the operation of an existing building the lines shall be altered and relocated to clear new construction and shall also be restored into service to provide continued operation of the existing building.

1.6 INTERRUPTION OF SERVICES

A. Work which requires the temporary turning off or shutting down the operation of existing mechanical and/or electrical facilities shall be done at times specifically approved by the Owner or utility company and the work shall be pre-scheduled and executed so there is a minimum outage of such services and/or delay in the new construction work.

B. Unscheduled interruptions of the facility will not be tolerated. The contractor shall exercise extreme caution, shall thoroughly inform his workmen and subcontractors of the critical nature of this work, and shall continually review the work procedure being followed in order to prevent accidental interruption of service. Before performing any act which could result in interruption of service, the contractor shall notify the Owner and Engineer of the hazards involved and the contractor shall proceed in a manner and at a time specifically approved by the Owner and Engineer.

C. All work necessitating the temporary turning off or shutting down the operation of existing mechanical and/or electrical facilities shall be done at times specifically approved by the Owner and Engineer in advance of any disruption of existing facilities.

1.7 MATERIALS AND EQUIPMENT

A. All materials and equipment entering into the work shall be approved by the Engineer, and must be new, without defects, and of the sizes and capacities shown on the drawings or hereinafter specified. All manufactured materials or equipment shall bear the identification mark of the manufacturer or, if required by the Engineer, shall be certified by an approved testing laboratory. All equipment shall operate within the manufacturer's range of speeds, guaranteed capacities, performance, etc. as indicated by the manufacturer's latest catalog and/or engineering data, shall be of proper size and dimension for the allocated space, and shall be placed in the space allocated in the proper construction sequence. Special consideration will be given to equipment which has been in successful field use or similar applications for at least three (3) years (exclusive of field tests), and to equipment which has an extended guarantee period in lieu of long use period. The contractor shall submit with his bid complete data on equipment he proposes to use; failure to so submit, or to meet these requirements fully and those of the specifications, shall be grounds for rejecting the items.

B. All electrical materials, apparatus, and equipment shall be new, of the make and characteristics specified, shall conform to NEMA standards, and shall be designed to comply with and be installed in accordance with the latest rules and regulations of the National Electrical Code, and all of the legally constituted public authorities having local jurisdiction. Verify the exact voltage and current characteristics at the building before ordering motors or similar equipment.

C. All motors shall be NEMA frame sizes, heavy duty, 40 degree C. ambient motors with ball or roller bearings and with maximum full load temperature rise not exceeding NEMA limits of temperature rise. All motors shall have adequate starting and protective equipment as specified or required, and shall have a conduit terminal box of size adequate to accommodate conduits and wires as sized on electrical drawings or as specified. The capacity of each motor shall be sufficient to operate associated driven devices under all conditions of operation and load without overloading or overheating and each motor shall be of not less than the horsepower indicated or specified.

D. Conduct such tests and adjustment of equipment as specified or necessary to verify performance requirements. Submit data taken during such tests.

1.8 QUIET OPERATION

A. The work shall be installed in such a manner that under all conditions of load it shall operate without sound or vibration which is objectionable in the occupied spaces, in the opinion of the Engineer.

B. In case of moving machinery, sound or vibration noticeable outside of the room in which it is installed or annoyingly noticeable inside its own room will be considered objectionable. Sound or vibration considered objectionable shall be corrected by the contractor.

1.5 PROTECTION

A. In performing this contract, safeguard workmen and the public and protect the work and equipment until final completion and acceptance. After delivery and before and after installation, protect work against theft, injury, or damage. Carefully store material and equipment received on site which are not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing materials. Protect related or adjacent work and the material of the other trades or the Owner from damage that might be caused by this work and make good any damage thus caused. Provide all safeguards, scaffolding, drop cloths, etc. as required.

B. No welding or soldering shall be done near combustible materials of any kind; all adjoining work, finished surfaces, glass, etc. shall be protected from flames, sparks, hot metal, etc. by metal guards or approved noncombustible drop cloths or barriers.

C. Each contractor shall replace any items or portions thereof wherever removed or damaged, in a manner equal to the original construction and finish, or where directed by the Engineer, he shall pay other trades to perform this work.

D. All mechanical equipment with a factory finish shall be protected during construction and must be free of dust, dirt, cement splatters, etc. when the building is turned over to the Owner. Dents and marred finishes shall be repaired to the satisfaction of the Engineer, or a replacement furnished where necessary.

E. Provide belt drives and rotating machinery with readily removable guards complying with OSHA requirements to enclose the drive completely and consisting of heavy angle iron frames, hinged and latched, with heavy galvanized iron wire crimped mesh or sheet steel securely fastened to frames.

1.6 EXECUTION OF WORK

A. The HVAC Work shall be performed and coordinated with the program of the General Contractor and the other subcontractors. Promptly upon award of the contracts, the subcontractors shall confer with the General Contractor and the Engineer and other subcontractors to prepare a time schedule for the completion of the various divisions and details of the work. Each subcontractor shall proceed diligently with the work and shall cooperate with the General Contractor and the other contractors to maintain the approved time schedule to the best of his ability and as conditions permit.

1.7 GENERAL SUPERVISION AND INSTALLATION OF WORK

A. Each contractor shall at all times give the work his best skill and attention, including adequate construction supervision over his work, employees, and subcontractors, and he shall fully cooperate with and confer with the Engineer and other contractors so that the best possible installation shall be obtained. Exact locations and relations are to be determined in the field, subject to the approval of the Engineer, and with preference to the dimensioned and architectural and structural drawings and approved shop and setting drawings.

B. Unless otherwise shown, pipes, ducts, etc. in rooms with finished ceilings, shall be concealed in furred ceilings, shafts, walls, and floors, and all work must be exactly and accurately located to conform with the spaces provided therefor. In general, all other new piping, ducts, etc. in mechanical equipment rooms, telephone rooms, etc. shall be exposed.

C. Install pipes, ducts, etc. in a neat and workmanlike manner, close to walls, generally as high as possible, true and square to the building, utilizing standard practices, and properly graded for correct functioning of the system involved; multiple lines in close proximity shall be coordinated and neatly grouped. Install work in proper construction sequence and arranged so as to be readily accessible for operation, maintenance, and repair; minor deviations from drawings may be made to accomplish this, but changes of magnitude or which involve extra cost shall not be made without approval. All fixtures, outlets, etc. shall truly center with the adjacent architectural finish. All work, both exposed and concealed, shall meet the approval of the Engineer regarding neatness of appearance, location, and practicability of installation. The Engineer reserves the right to direct the removal and replacement of any item which, in his opinion, does not present an orderly and reasonably neat and workmanlike appearance.

D. Each contractor shall familiarize himself with the work of the other contractors, shall perform and coordinate his work with the other contractors, shall lay out his work to meet conditions at the building, shall give freedom to and prevent conflict with the work of other contractors, and shall make reasonable modification in locations or arrangement from those indicated on the drawings if required to avoid conflicts or to conform to tile, wood, marble, or other architectural finish. From time to time as the work progresses, the contractor shall examine the work installed by others, insofar as it may affect his work, and he shall, before proceeding with the work, notify the Engineer in writing, if any condition exists which prevents the successful installation of his own work.

E. If the contractor places any work in violation of any of the above mentioned requirements, and conflicting or unworkmanlike conditions result, he shall, without additional charge, remove and reinstall or satisfactorily readjust such portions of his work as may be necessary and as the Engineer may direct. The Engineer's decision regarding such conditions shall be final.

1.8 ENGINEER'S OBSERVATION

A. A periodic inspection of the work by the Engineer, commonly referred to as supervision, is only for the express purpose of verifying compliance by the contractor with the contract documents. Such engineering inspections and services rendered by the Engineer or his representatives shall not be construed as the supervising of construction; nor the assuming by the Engineer of the duties and responsibility of the contractors nor making the Engineer responsible for providing a safe place or procedure for the performance of the work or for the contractor's employees or for subcontractors.

1.9 EXCAVATION AND BACKFILLING OF TRENCHES, ETC.

A. Unless otherwise specified, the HVAC Contractor shall do all excavation of trenches for piping, etc. in connection with his work, and after his work is in place and inspected by the Engineer and Civil Authorities, he shall backfill in layers of not to exceed six inches (6") in depth, thoroughly moistened, thoroughly rammed, tamped, and compacted to a density at least equal to the surrounding earth to minimize after settlement. If, in the opinion of the Engineer, the excavated material is unsuitable for backfilling, the contractor shall backfill with bank run gravel well compacted. The bottom of each sewer trench shall be filled with sand to an elevation of 6" above the top of the sewer. Top of backfill or trench surface shall be level with adjoining ground or surface; furnish additional material if required to fill trenches. All surplus earth shall be moved by this contractor and disposed of as directed by the Engineer. Compact backfill in trenches within building lines the same as specified in architectural branches.

B. Any sheet piling or shoring or pumping necessary shall be done by this contractor at his own expense and all trenches shall be dug in a careful manner, with bottoms properly pitched to insure perfect drainage and to provide uniform bearing and support for each section of pipe on undisturbed soil along its entire length, except where it is necessary to excavate for bell holes and for the proper sealing of pipe joints. The bottoms of all sewer trenches shall be excavated 6" below the bottom elevation of the sewer and backfilled with sand so at least one-third of the circumference of the pipe will rest firmly on tamped sand. These trenches shall be not less than 12" wider, nor more than 16" wider, than the outside diameter of the pipe to be laid therein; this requirement applies to the width at and below the level of the top of the pipe; the width above that level may be wider for proper sheeting and bracing and the proper installation of the work. Shoring, bracing, barricades, etc. shall be provided to protect the workmen and/or public amply; refer to the Ohio Bulletin No. 201 "Specific Safety Requirements Relating to Building and Construction Work".

C. Unless otherwise approved, the following minimum cover shall be provided above the top of underground pipes outside the buildings: Water lines, refer to elevations on plans.

D. Whenever wet or otherwise unstable soil, that is incapable of properly supporting the pipe as determined by the Engineer, is encountered in the trench bottom, such soil shall be removed to a depth required and for the length designated by the Engineer, and the trench backfilled to trench bottom grade with coarse sand, fine gravel, or other suitable materials, properly compacted.

E. Excavation near or under building footings shall be backfilled with concrete installed under the direction of the Engineer.

F. Where contractor elects to have any excavation work performed by a subcontractor, subcontractor must be approved by the Owner prior to commencing any work.

G. Construction Fence

A. Refer to Division 01.

1.10 RESTORATION OF SURFACES AND CONCRETE WORK

A. Unless otherwise specified, all new concrete work for parking lots, driveways, pads, etc. shall be provided by the general contractor. Unless otherwise specified, all new concrete work for pads, and all surfaces such as concrete floors, walls, paving, sidewalks, roof deck, or other surfaces disturbed in the execution of work, and which remain in use, shall be restored in kind by this contractor, or he shall pay the cost of such work.

B. Where this contractor has performed excavation work, this contractor shall backfill as hereinbefore specified in Paragraph 1.16.

C. In Landscaped Areas, such as grass or plantings, the final 6" of backfilling, grading, seeding, mulching, and planting shall be performed by a qualified, competent Landscaping Contractor. The Mechanical Contractor shall include in his bid the cost of such landscaping services and shall warrant same as described under Paragraph 24.

1. This final 6" of backfill provided by the approved Landscaping Contractor shall consist of top soil complying with Ohio DOT 653.02; ph 6.0 to 7.0 or adjusted within these limits, raked to a uniform fineness and free of rock or stones 1" or greater in any dimension.

2. Where grass has been disturbed, the Landscape Contractor shall apply 8/32/16 organic fertilizer at rate of 1 lb. per 5 square yards and seed with 90-95% pure, 85% (minimum) germination seed of a mixture of 20% Rye grass, 40% creeping red fescue, and 40% Kentucky blue grass at a rate of 7 lbs. per 1000 square feet. Cover seeded areas with clean, weed free straw.

3. If shrubbery and plantings must be disturbed, the Landscaping Contractor shall either remove, maintain, and reinstall said plantings or the Landscape Contractor shall furnish healthy new shrubbery and plantings similar in kind to that which was removed. In either case, the Landscape Contractor shall fertilize and provide mulch around said plants.

D. In Blacktop Paved Areas, the work shall be performed by a qualified, competent Blacktop Contractor; bids shall be based on and work shall comply with the following:

1. All materials and workmanship shall comply with the latest edition of the State of Ohio Department of Transportation Construction and Material Specification.

2. Paved areas shall match existing slopes and shall be without dips or low spots. All seams in paving to be flush and tight.

3. Begin rolling when mixture will bear roller weight without excessive displacement. Repair surface defects with hot material as rolling progresses. Cut out and patch defective areas and roll to blend with adjacent satisfactory paving. Continue rolling until maximum density is attained and roller marks eliminated.

4. Protect newly placed material from traffic until mixture has cooled and attained its maximum degree of hardness.

5. Remove and replace mixtures that become contaminated with foreign materials and defective areas and fill with fresh, hot mix properly compacted. Remove deficient areas for full depth of course. Cut sides perpendicular and parallel to direction of traffic with edges vertical. Apply tack coat before placing new mixture.

6. Thickness of Paving shall be as follows:

   a. Base: ODOT-301, compacted thickness 9".

   b. Prime Coat (over base): ODOT-408, 3.0 Gallons/Square Yard.

   c. Wearing Course: ODOT-404, two separate 1-1/2" layers each compacted; total compacted thickness 3".

   d. Tack-coat: ODOT-407, 0.20 Gallons/Square Yard.

7. Restore all parking space lines and space numbers using materials in accordance with Ohio Department of Transportation Section 621 - Pavement Marking.

E. Concrete Work, shall be performed by a qualified, competent, Concrete Contractor, and work shall comply with the following:

1. Sidewalks shall be concrete, Class C, unreinforced, complying with ODOT 608. Width and finish shall match existing adjacent sidewalks. Sidewalks shall be the same depth as the existing adjacent sidewalks or 7" deep whichever is greater.

2. All other concrete for parking lots, driveways, and pads shall be 4000 PSI compressive strength concrete with reinforcing steel. Thickness of concrete for parking lots and driveways shall be not less than 7" thick. Reinforcing steel shall be 6" x 6" 58 pound welded wire fabric (WWF) top and bottom. All welded wire fabric shall be in flat sheets, not rolls.

1.11 SLEEVES, CUTTING, PATCHING, CLEANING, WATERPROOFING, ETC.

A. Provide and accurately set frames and Schedule 40 steel pipe sleeves for required openings in new work to minimize cutting. Perform all cutting, patching, etc. required to install the work. Use approved power operated boring machine for small holes wherever practical. Remove all rubbish incidental to the work. Where any work pierces waterproofing, provide all necessary sleeves, caulking, and flashing required to make openings absolutely watertight.

B. Refer to the ACI Code 381.71, Section 6.3 for limitations and requirements for penetrations and openings.

1.12 PATENTS

A. The contractor shall defend and guarantee the Owner against any expense, claims, litigation, etc. occasioned by the use in this work of any materials, devices, etc. covered by patents not owned by the contractor, or of which he is not a licensed user.

1.13 CONTEMPLATED WORK

A. The work contemplated occurs on the site of and within the existing building.

B. The drawings and specifications for the mechanical and electrical portion of this project have been prepared by Motz Consulting Engineers, Inc., doing business as Motz Engineering.

C. The various items of work necessary for completion of this work are hereinafter specified under the respective section headings or shown on accompanying drawings, and shall be included in any contract or contracts made for completion of respective divisions of the work. Such contracts shall also include necessary details reasonably incidental to the proper execution and completion of such work.

1.14 MOVING MATERIALS

A. If it becomes necessary at any time during the progress of this work to move materials which have been temporarily located and which are to enter into the final construction, the contractor furnishing said materials shall, when so directed by the Engineer, move them or cause them to be moved. Cost of such moving shall be included in the contract price.

1.15 ACCIDENT PREVENTION

A. Precaution shall be exercised at all times for the protection of persons and property. The safety provisions of applicable law, building, and construction codes shall be observed. Machinery, equipment, and other hazards shall be guarded in accordance with safety provisions of the "Manual of Accident Prevention in Construction" published by Associated General Contractors of America to the extent that such provisions are not inconsistent with applicable law or regulations.

1.16 PROPERTY PROTECTION

A. All hoisting shall be done with proper tag lines and buffers to prevent damage to the sides of the building. Where it is necessary to hoist materials to the roof, the parapets at top of the building and the roof where materials are landed from hoists shall be protected with heavy wood covers. Parapet protection shall be placed on both sides and top, and shall extend far enough on either side of landing point to insure adequate cover. The roof, from the landing point at parapet to final location of material, shall be adequately protected by planks laid side by side on roofing and spiked together on outside edges with planks running at right angles to main planking. The roof shall be adequately protected against leaks at all times.

B. Where hoists are erected on the roof for hoisting material up the side of the building, the roof shall be adequately protected against abrasion or other damage. Materials stored on the roof shall be placed on planks or other protection approved by the Engineer and shall be placed only at locations approved by the Engineer.

C. If hoisted materials are taken through windows, the jams, head, and sill shall be adequately protected with wood planking or proper buffers.

D. Any work, equipment, or property damaged during construction of this project and due to operations under this contract shall be repaired or replaced by this contractor, without additional cost to the Owner. Upon completion of the work, the contractor shall remove all protections herein specified.

1.17 REMOVAL OF RUBBISH

A. It shall be each contractor's duty to keep the building and surrounding premises clean, free from rubbish of every description. No rubbish, crating materials, packing, or dirt shall be allowed to accumulate at any time, but shall be removed at once and hauled away.

B. Each trade shall be responsible for its own tools and materials during the periods of rubbish removal but contractors shall use reasonable care in removal of rubbish to protect the tools and materials of others against loss or damage. The Owner reserves the right, in the event that removal of rubbish is not promptly and properly carried out by the Contractors to have rubbish removed and to charge the cost of its removal to the contractor.

C. Also, refer to Division 1.

1.18 MATERIAL SAFETY DATA SHEETS (MSDS)

1.18.1 The contractor shall obtain and maintain on-site during the course of the project the Material Safety Data Sheets (MSDS's) for all chemicals or products containing chemicals that may be considered toxic or hazardous. The MSDS's are to be forwarded to the Office of Environmental Health and Safety upon completion of the project.

1.19 INSTRUCTION OF PERSONNEL

A. The HVAC Subcontractor shall provide free on site instruction in the proper use of installed equipment to designated representatives of the Owner, sufficient to ensure safe, secure, efficient, non-failing utilization, and operation of systems. This instruction shall include the following:

1. One Site Training: Provide a minimum of 24 hours of training for owner's staff. Submit a syllabus to the Engineer prior to the first session.

2. Support: Provide a minimum of 16 hours of support either on site or by telephone to answer operations questions.

PART 2 – (NOT USED)

PART 3 – (NOT USED)

END OF SECTION 230400

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Transition fittings.
3. Dielectric fittings.
4. Mechanical demolition.
5. Equipment installation requirements common to equipment sections.
6. Painting and finishing.
7. Concrete bases.
8. Supports and anchorages.
9. Fire stopping.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.

2. NBR: Acrylonitrile-butadiene rubber.

1.3 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.

2. Dielectric fittings.

3. Roof Curbs

B. Welding certificates.

1.4 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Mechanical Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified, at the expense of the Contractor installing the mechanical equipment. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.6 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for mechanical installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors and Frames."

D. Provide coordination drawings as specified in section 230000.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

a. Custom Curb

b. Pate Co. (Basis of Design)

c. ThyCurb

2.2 ROOF CURBS, PIPE CURBS AND ROOF PIPE SUPPORTS

A. Prefabricated Roof Curbs:

1. Roof Curbs and Equipment Supports:

Minimum 18 gauge galvanized steel, continuous welded seams, mitered corners, wood nailer, strip, 12 inches minimum height and vertical counterflashing with lag screws. Where curb is used for equipment support, provide internal reinforcing as required to support equipment load and integral base plates. Where curb is around a roof penetration, provide 1-1/2 inch thick, 3 lb. density rigid fiberglass insulation. Where curb is installed on a pitched roof, curb shall be sloped to match roof pitch. Provide raised cant to accommodate the roof insulation thickness. Pate Company ES-2.

2. Pipe Curb:

For vents or other piping passing through the roof, use a Pate Company PCA-2 curb with PCC pipe curb cover. Provide 1-1/2 inch thick, 3 lb. density rigid fiberglass insulation. Cover to be complete with graduated neoprene boots with stainless steel clamps.

B. Roof Pipe Supports

1. Roof pipe supports shall be free standing, black, lexan, pillow block pipe stands. Pipe stands shall have a "V" shape cradle, curved base edges and corners, stacking pins for secure stacking for height adjustment, vent tunnels to prevent condensate buildup and guide holes at top of cradle for installation of pipe strap.
2. Treated wood blocking for pipe support is not acceptable.

2.3 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.4 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Grooved Joints: Use lubricant supplied by the coupling manufacturer and suitable for the elastomer and fluid media.

2.5 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

B. Manufacturers:

1. Cascade Waterworks Mfg. Co.

2. Dresser Industries, Inc.; DMD Div.

3. Ford Meter Box Company, Incorporated (The); Pipe Products Div.

4. JCM Industries.

5. Smith-Blair, Inc.

6. Viking Johnson.

7. Victaulic Co. of America

C. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.

D. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.

E. Aboveground Pressure Piping: Pipe fitting.

F. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one (1) end with threaded brass insert, and one solvent-cement-joint end.

G. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one (1) end with threaded brass insert, and one (1) solvent-cement-joint end.

H. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four (4) part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

I. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.6 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250 psig minimum working pressure at 200 deg F.

1. Manufacturers:

a. Capitol Manufacturing Co.

b. Central Plastics Company.

c. Epco Sales, Inc.

d. Hart Industries, International, Inc.

e. Watts Industries, Inc.; Water Products Div.

f. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150 psig minimum working pressure as required to suit system pressures.

1. Manufacturers:

a. Capitol Manufacturing Co.

b. Central Plastics Company.

c. Epco Sales, Inc.

d. Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Central Plastics Company.

d. Pipeline Seal and Insulator, Inc.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

1. Manufacturers:

a. Perfection Corp.

b. Precision Plumbing Products, Inc.

c. Sioux Chief Manufacturing Co., Inc.

d. Victaulic Co. of America.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.

2.7 FIRE STOPPING

A. Description: UL-classified Systems; C-AJ or W-L-7001-7999. Type of fill materials; one or both of the following: Latex sealant or mortar.

PART 3 - EXECUTION

3.1 ROOF WORK

A. The General Contractor shall provide roof openings where indicated on the architectural drawings and where specifically coordinated with the HVAC contractor. All additional steel support framing that is required for roof penetrations shall be provided by HVAC Contractor except where indicated on the structural design drawings.

A. The HVAC Contractor shall coordinate the size and location of all roof curbs.

B. The HVAC Contractor shall install all roof curbs and pipe supports. Secure curbs and supports to roof deck by means of screws bolts and inserts.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

2. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome- plated finish.

3. Insulated Piping: One-piece, stamped-steel type with spring clips.

4. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

5. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

6. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast- brass type with polished chrome-plated finish.

7. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and spring clips.

8. Bare Piping in Equipment Rooms: One-piece, cast-brass type.

9. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

3. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants" for materials and installation.

O. Aboveground, Exterior-Wall Pipe 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.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Piping is to be positioned in the center of the sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 Section "Through-Penetration Firestop Systems" for materials.

R. Verify final equipment locations for roughing-in.

S. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32, wiped smooth.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate Teflon tape or Permatex pipe thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges or mechanically grooved couplings in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.6 PAINTING

A. All general painting of piping, insulation, and equipment, if any, will be performed by the Contractor. Unless otherwise noted, where this contractor has cut finished building surfaces, this contractor shall patch and paint these surfaces.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 5 Sections for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 FIRE STOPPING

A. Provide fire stopping for all mechanical penetrations of all fire rated construction such as walls and floors.

3.10 DRAIN PIPING

A. Extend drain piping from all drains and cooling coil discharge all at new air conditioning units, etc. to spill over the nearest floor drain or janitor's receptor.

B. Provide valved blowoff on all strainers and pipe to floor drain; where no sizes are shown, blowoff shall be full size of strainer connection.

END OF SECTION 230500

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC SYSTEMS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes basic requirements for factory-installed and field-installed motors.

1.3 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.

1.4 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.5 SUBMITTALS

A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

1. Each installed unit's type and details.

2. Nameplate legends.

3. Diagrams of power and control wiring. Provide schematic wiring diagram for each type of motor and for each control scheme.

C. Qualification Data: For testing agency.

D. Test Reports: Written reports specified in Parts 2 and 3.

E. Operation and Maintenance Data: For field-installed motors to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.

B. Source Limitations: Obtain field-installed motors of a single 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 NFPA 70.

1.7 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:

1. Compatible with the following:

a. Magnetic controllers.

b. Multi-speed controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.

3. Matched to torque and horsepower requirements of the load.

4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. Motor requirements apply to factory-installed and field-installed motors except as follows:

1. Different ratings, performance, or characteristics for a motor are specified in another Section.

2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

B. Comply with Energy Independence and Security Act of 2007.

C. Comply with NEMA MG 1 table 12-11 unless otherwise noted.

D. Comply with IEEE 847 for Severe-Duty motors.

2.2 MOTOR CHARACTERISTICS

A. Motor Phase: As indicated on drawings.

B. Frequency Rating: 60 Hz.

C. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

D. Service Factor: 1.15.

E. Duty: Continuous duty at ambient temperature of 105 deg F and at an altitude of 3300 feet above sea level.

F. 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.

G. Enclosure: Open drip proof for interior mounted motors. Totally enclosed fan cooled for exterior mounted motors.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficiency.

C. Stator: Copper windings, unless otherwise indicated.

1. Multi-speed motors shall have separate winding for each speed.

D. Rotor: Squirrel cage, unless otherwise indicated.

E. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating, unless otherwise indicated.

G. Insulation: Class F, unless otherwise indicated.

H. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Designed with critical vibration frequencies outside operating range of controller output.

2. Temperature Rise: Matched to rating for Class B insulation.

3. Insulation: Class H.

4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

5. Motor shall be design for vector or inverter-duty service with design resistant to transient spikes, high frequencies and short time rise pulse produced by inverters.

6. Motor manufacture shall ensure specified motor operational and performance characteristics are suitable for inverter drive operation.

7. Motor shall be provided with minimum of one shaft mounted grounding protection ring to discharge pulse width modulation induced shaft voltages and bearing currents in reducing the effects of bearing pitting and scoring.

8. Motor shall include factory wired internal automatic reset high temperature thermal protector switch wired to over sized motor terminal box.

I. Rugged-Duty Motors: Totally enclosed, with 1.15 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with nonhygroscopic material.

1. Finish: Chemical-resistant paint over corrosion-resistant primer.

2.4 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.

2. Split-phase start, capacitor run.

3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

C. 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.

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, pre-lubricated-sleeve type for other single-phase motors.

E. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.

2. Read no-load current and speed at rated voltage and frequency.

3. Measure locked rotor current at rated frequency.

4. Perform high-potential test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of conduit systems to verify actual locations of conduit connections before motor installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 MOTOR INSTALLATION

A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.

B. Wiring of motor to controller and auxiliary controls and/or safeties shall be in accordance with motor controller manufacture instructions, NFPA 70 and local code requirements.

C. Properly ground all equipment according to controller manufacturer's requirements regarding noise attenuation and electromagnetic interference. Where not specifically specified by motor controller manufacture, ground equipment according to NFPA 70.

D. Requirements of motor T-lead conductors shall comply with Division 26 Specification 260519 "Wires and Cable".

3.3 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.

2. Test interlocks and control features for proper operation.

3. Verify that current in each phase is within nameplate rating.

B. Testing: Perform the following field quality-control testing:

1. Perform each electrical test and visual and mechanical inspection stated in NEMA ATS, Section 7.15.1. 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.

3.4 ADJUSTING

A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.5 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 230513

SECTION 230515 - GENERAL PIPING REQUIREMENTS

PART 1 - GENERAL

1.1 PIPING SYSTEMS - GENERAL

A. The following instructions apply to all piping systems, except where otherwise noted.

1. Provide unions or flanges at each final connection and at each piece of equipment.

2. Make connections to equipment as detailed on the Drawings or per manufacturer's installation instructions.

3. Where connection size is smaller than piping, make reduction at final connection only (Do not reduce size of pipe drop).

4. Provide valves and specialties as required, to complete installation of each piece of equipment, for proper operation.

B. Clean out and flush water piping systems.

C. If other means of draining are not provided, install drain valves at all low points to permit complete draining of each water system.

D. Certified Pipe Welding Bureau. Welds to be stamped at each joint or fitting.

E. Install dielectric unions at all connections of dissimilar metals.

PART 2 - PRODUCTS

2.1 COPPER PIPE

A. Copper pipe to be of type and thickness as specified in Section 232113. Fittings shall be wrought copper fittings with soldered ends designed for 150 psi (steam) and 300 psi (water) pressure. All joints and fittings shall comply with the latest edition of ASME code for pressure piping. 2-1/2 inches and larger equipment and valved connections shall be flanged.

B. In domestic water piping, all soldered joints shall be made with lead-free nickel silver solder for 150 psi, 250 deg F.

2.2 BLACK STEEL PIPE

A. Steel pipe to be of type specified in Section 232113. For welded piping1-1/2 inches and smaller, pipe shall be butt welded steel. Larger pipe shall be seamless steel or electric resistance welded. Pipe thickness shall be as scheduled in the specifications. All joints and fittings shall comply with the latest edition of ASME code for pressure piping.

B. Threaded pipe shall be accurately cut NPT tapered right hand threads. Screwed fittings shall be of the same make and thickness for weight as the pipe used.

C. Butt weld pipe joints shall be butt type, single vee made by fusion welding oxy-acetylene, electric welding using high test welding rod or semi-automatic metal arc welding machines using micro-wire. Branches in straight pipe are to be made with welding tees of same make and thickness of weight as the pipe used. Branches 1/4 the size of the main or less may be made with weld neck flanges, weld-o-let=s or thread-o-let fittings. Elbows shall be long radius.

D. Socket weld pipe joints shall be made using 2000 lb. socket weld steel fittings. All other items shall be per part 2.2, paragraph C this section of specifications.

E. Flanged pipe: Connections to valves, equipment, etc. shall be made with 125 - 150 lb. standard flanges, except for 250 - 300 lb. extra heavy flanges or fitting on valves, equipment, etc. furnished with extra heavy flanges. Flanged joints are to be faced square and true.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Each union or flange be installed to permit east removal of parts and equipment, and in a position permitting the device or equipment to be removed without disconnecting piping. Connections to equipment shall be arranged to facilitate ease of removal and service without dismantling of the run-outs of main piping, and shall be installed by the use of multiple elbows or other similar methods to minimize strain on the equipment connections.

B. Use grooved mechanical couplings and fasteners only in the only heating hot water systems.

1. Grooved joint piping systems shall be installed in accordance with the manufacturer’s guidelines and recommendations.

2. To assure uniformity and compatibility of piping products in grooved end piping systems, grooved joint couplings, fittings, valves and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

3. Grooved ends shall be clean and free from indentations, projections and roll marks in the area from the pipe end to the groove.

4. The gasket style and elastomeric material shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by the grooved coupling manufacturer.

5. Grooved coupling manufacturer’s factory trained field representative shall provide on-site training for the Contractor’s field personnel in the proper use of grooving tools’ application of groove and installation of grooved piping products. The factory trained representative shall periodically inspect the product installation. The Contractor shall remove and replace any improperly installed products.

C. Make reductions in piping lines with reducing coupling or weld fitting reducer.

D. Install piping to provide clearance for personnel passage, headroom, operation of doors or windows, equipment, lighting outlets, or with Owner's apparatus and equipment.

E. In pipe spaces to be entered for servicing, piping shall be offset so that all lateral runs are located either near floor or 6'-0" above floor and all vertical piping is held close to the wall through that height. Keep all piping to side of chase wherever possible.

F. Piping containing liquids shall not be installed over electrical equipment.

G. Install pipes, valves, fittings, etc. to be insulated with a minimum of l/2-inch clearance between the finished covering and other work and between the finished covering of parallel, adjacent pipes.

H. Make changes in pipe line direction with fittings only.

I. Offset lines around columns, beams and other obstructions as required. Where special conditions are encountered in field, arrangement and alignment of piping shall be decided by the Owner's Representative.

J. At time of erection, piping components shall be cleaned of loose material. After erection, and prior to putting in service, lines shall be blown or flushed free of loose materials. Clean strainer screens and sediment pockets prior to putting lines in service.

K. Install valves at service connections to equipment and branch lines from main lines. All valves and unions to be installed so as to be accessible through ceiling or wall access panel.

L. Contractor is responsible for conformance with all applicable requirements for welding and burning. Contractor shall obtain all necessary permits.

M. SECURELY SUPPORT all piping from structure with approved hangers, rods, brackets and accessories.

N. Where piping is installed in new masonry block walls, coordinate with General Contractor so piping extends out through a masonry joint where possible.

O. Bullhead fittings are not allowed.

P. Where exposed pipes pass through walls, floors or ceilings of finished rooms, provide chrome-plated escutcheons. Prime-coated black iron escutcheons may be used in unfinished rooms. Protect escutcheons from tool marks.

Q. Keep pipe level except where a slope is required. Use eccentric reducers to keep top of pipe level.

R. Avoid trapping of piping.

S. Use transition fittings as recommended by manufacturers to change from one pipe material or type to another.

T. All new piping during the installation period shall have openings protected with temporary caps or protective covers as required to keep the inside of the piping system clean from all dirt, debris and foreign material.

U. At completion of project, thoroughly flush each of the various HVAC hydronic circulating systems with a cleaning solution as recommended by the chemical supplier and the various material manufacturers, so as to remove any oil, rust, dirt, scale or grease that may be present.

V. Do not obstruct passageways, headroom, door and window operation, and similar areas with the installation of piping.

3.2 PIPING PROHIBITIONS

A. Contractor shall not run piping over electrical panels, across windows, door openings, access panels, lighting fixture or within 36 inches in front of electrical panels. Obtain instructions from the Architect if a conflict occurs.

B. On any given system, the Contractor will not be permitted to mix and joint different types of pipe material. For example, if a hot water heating system uses copper and steel, the Contractor may change from one to the other only once, the line may not be changed back to the first material further downstream.

C. Drain lines shall be continuously sloped; trapping is expressly prohibited.

END OF SECTION 230515

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SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

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. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

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. Smith, Jay R. Mfg. Co.
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

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. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Presealed Systems.

C. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi , 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

D. Cut sleeves to length for mounting flush with both surfaces.

1. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

E. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.

2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."

F. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves, Galvanized-steel wall sleeves, or Galvanized-steel-pipe sleeves.

   b. Piping NPS 6 and Larger: Cast-iron wall sleeves, Galvanized-steel wall sleeves, or Galvanized-steel-pipe sleeves.

2. Exterior Concrete Walls below Grade:

   a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system, or Galvanized-steel-pipe sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

   b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system, Galvanized-steel wall sleeves with sleeve-seal system, or Galvanized-steel-pipe sleeves with sleeve-seal system.

      1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs above Grade:

   a. Piping Smaller Than NPS 6 Galvanized-steel-pipe sleeves, Stack-sleeve fittings, Sleeve-seal fittings

   b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves, Stack-sleeve fittings.

4. Interior Partitions:

   a. Piping Smaller Than NPS 6 Galvanized-steel-pipe sleeves,

   b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

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. Escutcheons.

2. Floor plates.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With rough brass finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With rough-brass finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

A. One-Piece Floor Plates: Cast-iron flange.

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

b. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.

c. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with rough brass finish.

d. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.

e. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.

2. Escutcheons for Existing Piping:

a. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.

b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with rough brass finish.

c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with rough brass finish.

d. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge.

e. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with concealed hinge.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 230518

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SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following meters and gages for mechanical systems:

1. Thermometers.

2. Gages.

3. Test plugs.

1.2 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers:

1. Palmer - Wahl Instruments Inc.

2. Trerice, H. O. Co.

3. Weiss Instruments, Inc.

4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Type: Liquid-in-glass type, 9 inch long of chrome plated brass construction or self-powered digital type with glass passivated thermistor and internal potentiometer.

C. Tube: Red reading, liquid filled, with magnifying lens. The use of mercury shall be prohibited.

D. Tube Background: Satin-faced, non-reflective aluminum with permanently etched scale markings.

E. Window: Clear acrylic held in place with removable stainless steel cap.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 scale division to maximum of 1.5 percent of range.

2.3 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Pressure-tight, socket-type brass or stainless steel fitting made for insertion into piping and of type, diameter, and length required to hold thermometer. Thermowell to have a two inch extension with threaded cap nut and cap for all insulated piping.

2.4 PRESSURE GAGES

A. Manufacturers:

1. Palmer - Wahl Instruments Inc.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: Dry or Glycerine filled type,4-1/2 inch diameter.
2. Pressure-Element Assembly: Stainless Steel, Bourdon tube.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Black metal.
7. Window: Glass.
8. Ring: Stainless Steel.
9. Accuracy: Grade 2A, plus or minus 0.5 percent of scale range.
10. Range for Fluids under Pressure: Two (2) times operating pressure.
11. Provide gauges without back mounting plate.
12. Vacuum Range: 30 inches HG of vacuum to 15 PSIG of pressure.

2.5 TEST PLUGS

A. Manufacturers:

1. Peterson Equipment Co., Inc.

2. Sisco Manufacturing Co.

3. Trerice, H. O. Co.

4. Watts Industries, Inc.; Water Products Div.

B. Description: 1/2 inch NPT, Corrosion-resistant brass body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 1000 psi at 350 deg F.

D. Core Inserts: Two (2) self-sealing rubber valves.

1. Insert material for air, water, oil, or gas service at 20 to 350 deg F shall be Nordel.

E. Test Kit: Furnish one (1) test kit containing one (1) pressure gage and adaptor, two (2) thermometers, and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3- inch diameter dial and probe. Dial range shall be 0 to 200 psig.

2. Low Range Thermometer: Small bimetallic insertion type with 2 inch diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.

3. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install liquid-in-glass thermometers in the following locations:

1. Where indicated on the design drawing piping diagrams.

2 Inlet and outlet of each hydronic boiler and chiller.

3. Inlet and outlet of air handling unit heating & cooling coils.

B. Provide the following temperature ranges for thermometers:

1. Heating Hot Water: 30 to 200 deg F, with 2-degree scale divisions.

2. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.

B. Install liquid-filled-case-type pressure gages at chilled water inlet and outlet of chiller and boiler.

C. Install liquid-filled-case-type pressure gages at suction and discharge of each pump.

3.3 TEST PLUG APPLICATIONS

A. Inlet and outlet of each heating and cooling coil.

B. Inlet and outlet of each strainer on coils.

C. Inlet and outlet of each temperature regulating valve.

D. Inlet and outlet of each pressure reducing valve.

E. Both inlets to differential pressure transmitters.

3.4 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.

C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

D. Install needle-valve and snubber fitting in piping for each pressure gage for fluids.

E. Install test plugs in tees in piping. Install test plugs with sufficient clearance to permit installation of test gauges and thermometers.

3.5 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines and equipment.

3.6 ADJUSTING

A. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 230519

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SECTION 230523 – GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide valves to facilitate maintenance and isolation of piping systems.

1.2 QUALITY ASSURANCE

A. STANDARDS

1. American National Standards Institute (ANSI), American Society of Mechanical Engineers (ASME), American Society for Testing and Materials (ASTM) and the Manufacturers' Standardization Society of the Valve and Fittings Industry (MSS).

2. ANSI B16.10, MSS SP0-67-90 Butterfly Valves.

3. MSS SP-70-90 Cast Iron Gate Valves, Flanged or Threaded Ends.

4. MSS SP-78-92 Cast Iron Plug Valves Flanged and Threaded.

5. MSS SP-80-87 Bronze Gate, Globe, and Check Valves.

6. MSS SP-85-85 Cast Iron Globe and Angle Valves, Flanged and Threaded Ends.

7. MSS SP-110-92 Ball Valves Threaded, Socket-Welded, Solder Joint, Grooved and Flared Ends.

B. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by the same manufacturer.

1.3 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.

2. EPDM: Ethylene-propylene-diene terpolymer rubber.

3. NBR: Acrylonitrile-butadiene rubber.

4. PTFE: Polytetrafluoroethylene plastic.

5. OS & Y: Outside screw and yoke.

6. RS: Rising stem.

7. SWP: Steam working pressure.

8. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Set angle, gate, and globe valves closed to prevent rattling.

4. Set ball and plug valves open to minimize exposure of functional surfaces.

5. Set butterfly valves closed or slightly open.

6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. All similar valves used on the project shall be by the same manufacturer.

B. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 VALVES, GENERAL

A. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

B. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

C. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.

2. Gear Drive: For quarter-turn valves NPS 6 and larger and on discharge of all pumps without VFD=s.

3. Handwheel: For valves other than quarter-turn types.

4. Lever Handle: For quarter-turn valves NPS 5 and smaller, except plug valves.

5. Wrench: For plug valves with square heads. Furnish Owner with one (1) wrench for every ten (10) plug valves, for each size square plug head.

D. Extended Valve Stems: On insulated valves.

E. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves and ASME B16.24 for bronze valves.

F. Valve Grooved Ends: AWWA C606.

G. Solder Joint: With sockets according to ASME B16.18. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.

H. Threaded Joint: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.3 GATE VALVES (USED ONLY WHERE INDICATED)

A. Four inches and larger gate valves in steel pipe shall be iron body, bronze mounted, outside screw and yoke, flanged bonnet, rising stem, solid wedge. Rated at 200 psi WOG; 125 psi steam: Powell Fig 1793.

B. Manufacturers:

1. Powell (Basis of Design)

2. Milwaukee

3. Lunkenheimer

4. Nibco

5. Hammond

2.4 BALL VALVES (2-1/2 INCHES AND SMALLER)

A. 400 psi WOG, 150 psi steam, bubble-tight against 100 psi, cast bronze body, self-aligning free floating stainless steel ball and stem with full flow port, non-rising stem, Teflon seat and body seal, quarter turn operation, solder joint or screwed ends. Valves to include memory stop and stem extensions for insulated piping.

1. Drain valves with hose fitting, dust cover and chain attachment: Apollo No. 78-144

2. All other valves: Apollo No. 77-140/240

3. Manufacturers:

    a. Apollo (Basis of Design)

    b. Hammond

    c. Milwaukee

    d. Nibco

    e. Watts

    f. Victaulic Co. of America

B. Two-Piece Standard Port Ductile Iron Ball Valve, (Sizes 2 inch to 2-1/2 inch):

1. Manufacturer:

    a. Victaulic Company Series 726

2. Description:

    a. Standard: MSS SP-72.

    b. CWP Rating: 800 psig

    c. Body Material: ASTM A 536 Ductile Iron

    d. Ends: Grooved.

    e. Seats: TFE.

    f. Stem: Stainless steel.

    g. Ball: Stainless Steel.

    h. Port: Full port to match pipe size.

2.5 BUTTERFLY VALVES – HOT AND CHILLED

A. Butterfly valves shall be Keystone K-Lok Figure 362, DeZurick, Norris, Demco, Crane, Watts, Ginnell, or approved equal high performance butterfly valves suitable for 200° F at a system shutoff pressure of 740 PSI.

1. Valves shall have carbon steel body with full lug type body with holes drilled and tapped for 150 PSI flanges, stainless steel shaft and disc, stainless steel/nitride bearings, and with EPDM seat.
2. Valves 6” and larger at valves at pump discharge shall be equipped with enclosed gear operators; smaller valves shall be equipped with notched plate and rotary handle.

2.6 BUTTERFLY VALVES (3 INCHES AND LARGER)

A. 225 psi line pressure, bubble-tight bi-directionally against 225 psi differential pressure, 250 psi dead end pressure, cast iron lugged type body, double-seated, stainless steel disc, with EPDM seat, stainless steel shaft, bronze bushings, 200^{o} F maximum water temperature.

1. 12 inches and smaller: Keystone Fig. 22

2. 14 inches and larger : Keystone Fig. AR2

B. Manufacturers:

1. DeZurik
2. Keystone (Basis of Design)
3. Milwaukee
4. Nibco
5. Norris
6. Watts

2.7 CHECK VALVES

A. Pump discharge and vertical piping

1. Semi-steel body, bronze mounted, anti-water hammer type
    a. 2-1/2 inches and smaller: Williams No. 329
    b. 3 inches and larger: Williams No. 636
    c. Manufacturers:
        1) McAlear
        2) Mission
        3) Mueller
        4) Williams (Basis of Design)
        5) Victaulic Co. of America

B. 2 inches and smaller: 200 psi WOG, bronze swing check, solder joint tubing ends or threaded ends with replaceable composition disc and integral seat.

1. 2 inches and smaller in copper pipe: Powell Fig. 1825
2. 2 inches and smaller in steel pipe: Powell Fig. 560

C. 2-1/2 inches and larger: 200 psi WOG, iron body bronze trim, renewable disc; Powell Fig. 559.

D. Manufacturers:

1. Hammond
2. Lunkenheimer
3. Powell (Basis of Design)
4. Victaulic Co. of America

2.9 CALIBRATED BALANCING VALVES

A. Bell & Gossett Circuit Setter Plus or equal by Armstrong, Taco, Tour & Andersson, Flowset with positive shut-off, memory stop screw or 4-turn digital readout handwheel, drain connection, read-out valves with EPT insert and check valve, insulated cover, bronze or Ametal brass body, brass ball or globe type, carbon filled TFE or Ametal seats, calibrated name plate. Balancing valves to be 30 PSIT/250 Deg, F rated for 1/2" to 3" NPT connections, 200 PSIG/250 Deg, F rated for 1/2" to 3/4" sweat or grooved connections and 125 PSIG/250 Deg, F rated for 4" flanged or grooved connections.

B. Furnish a portable flow measuring instrument for verifying and determining flow. Furnish carrying case, gage, valve block and color coded hoses for low and high pressure connections, and connectors for connection to read-out valves.

2.10 CHAINWHEEL ACTUATORS

A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Sprocket Rim with Chain Guides: Cast iron, of type and size required for valve.

2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.

3. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

2.11 AUTOMATIC BALACING VALVE

A. Valve with cartridges that automatically control flow rates with plus or minimum 5% accuracy over an operating pressure differential range of at least 14 times the minimum required for control. Valve internal control mechanism shall consist of a stainless steel one-piece cartridge with segmented port design and full travel linear coil spring or equivalent. Body design shall allow inspection or removal of cartridge or strainer without disturbing piping connections. Provide isolation valves on both inlet and outlet side of the balancing valves that permit removal of balancing valve without drain down of piping. Valves 2-1/2 inch and smaller shall be solder or screwed ends, valves 3 inch and larger shall be flanged. Extra cartridges shall be provided as required for a 2 year to adjust system flows to meet demand.

B. Automatic balancing valves shall not be used where modulating temperature control valves are installed.

C. Manufacturers:

1. Griswald

2. Automatic Flow Control

3. Armstrong

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Examine grooved ends for conditions that might cause leakage. Ends should be free from indentations or projections in the area from the valve end to the groove.

G. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball valves for size 2-1/2" and less; butterfly valves for sizes 3" and larger.

2. Throttling Service: Ball valves for size 2-1/2" and less; butterfly valves for sizes 3" and larger.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions, grooved couplings or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full stem movement.

F. Install chain wheel operators on valves NPS 3 and larger and more than 96 inches above floor. Extend chains to 78 inches above finished floor elevation.

G. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.

3. Lift Check Valves: With stem upright and plumb.

H. Provide sufficient space to allow adjustment of balancing values.

I. Install drain valves in piping at low points and trapped areas to provide complete drainage of all systems.

3.4 JOINT CONSTRUCTION

A. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated. Open valves before soldering.

3.5 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 230523

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SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes hangers and supports for mechanical system equipment.

1.2 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 PERFORMANCE REQUIREMENTS

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

1.4 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details.

C. Welding Certificates: Copies of certificates for welding procedures and operators.

1.5 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified:

1. Channel Support Systems:

    a. Grinnell Corp.; Power-Strut Unit.

    b. Michigan Hanger Co., Inc.; O-Strut Div.

    c. National Pipe Hanger Corp.

d. Thomas & Betts Corp.

e. Unistrut Corp.

2. Thermal-Hanger Shield Inserts:

a. Michigan Hanger Co., Inc

b. Pipe Shields, Inc.

c. Rilco Manufacturing Co., Inc.

d. Value Engineered Products, Inc.

3. Powder-Actuated Fastener Systems:

a. Gunnebo Fastening Corp.

b. Hilti, Inc.

c. ITW Ramset/Red Head.

d. Masterset Fastening Systems, Inc.

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.

2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100 psi minimum compressive-strength insulation, encased in sheet metal shield.

1. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier.

2. Material for Hot Piping: ASTM C 552, Type I cellular glass.

3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.

4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.

5. Insert Length: Extend 2" beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.

D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.

2. Properties: Nonstaining, noncorrosive, and nongaseous.

3. Design Mix: 5000-psi 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger requirements are specified in Sections specifying equipment and systems.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

3.2 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.3 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes 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 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 contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

A. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 230529

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SECTION 230548 - VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Elastomeric isolation pads.
2. Freestanding and restrained spring isolators.
3. Housed spring mounts.
4. Elastomeric hangers.
5. Spring hangers.

1.2 SUBMITTALS

A. Product Data: Include load deflection curves for each vibration isolation device.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

1. Amber/Booth Company, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Vibration Eliminator Co., Inc.
5. Vibration Mountings & Controls/Korfund.

B. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene.

C. Elastomeric Mounts: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-Code or otherwise identify to indicate capacity range.

D. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 100 psig.

6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4 inch thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

F. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.

2. Base: Factory drilled for bolting to structure.

3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch travel before contacting a resilient collar.

4. Static deflection: 2 inches.

G. Elastomeric Hangers: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range. Static deflection: 0.5 inches.

H. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

2.2 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.

2. All hardware shall be electro-galvanized. Hot-dip galvanized metal components for exterior use.

3. Baked enamel for metal components on isolators for interior use.

4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Provide vibration isolators for equipment and piping as indicated on the design drawings and as required by other sections of Division 23.

B. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers. At trapeze anchor locations, shackle piping to trapeze. Requirements apply equally to hanging equipment. Do not weld angles to rods.

C. Install resilient bolt isolation washers on equipment anchor bolts.

3.3 QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. Isolator deflection.

2. Snubber minimum clearances.

3.4 ADJUSTING

A. Adjust isolators after piping systems have been filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust snubbers according to manufacturer=s written recommendations.

D. Torque anchor bolts according to equipment manufacturer=s written recommendations to resist seismic forces.

3.5 CLEANING

A. After completing equipment installation, inspect vibration isolation devices. Remove paint splatters and other spots, dirt, and debris.

END OF SECTION 230548

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SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. IDENTIFY BY LABELS AND TAGS THE FOLLOWING ITEMS

1. Equipment such as exhaust fans, air handling units, control cabinets, VAV boxes, etc.

2. Piping, valves and ductwork exposed in equipment rooms and accessible service areas.

3. Piping, valves and ductwork running above accessible ceiling construction and near access panels in non-accessible construction areas.

4. All temperature control valves and automatic control dampers.

B. Install laminated plastic markers and metal stamped nameplates for equipment. Provide color banding, flow arrows and contents identification for piping and ductwork.

1.2 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.

2. Equipment markers.

3. Pipe markers.

4. Duct markers.

5. Stencils.

6. Valve tags.

7. Valve Schedules.

8. Warning tags.

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish three extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, “Scheme for the Identification of Piping Systems,” for letter size, length of color field, colors and viewing angles of identification devices for piping.

1.5 COORDINATION

A. Coordination 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 location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

D. All trades shall use the same type, style and appearance of identification.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

a. Manufacturer, product name, model number, and serial number.

b. Capacity, operating and power characteristics, and essential data.

c. Labels of tested compliances.

2. Location: Accessible and visible.

3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, laminated plastic, white lettering on black background. Markers shall be screw on, except where screws might damage equipment, use a contact-type permanent adhesive.

1. Terminology: Match schedules as closely as possible.

2. Size: Sized for 3/4-inch lettering.

2.2 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.

1. Colors: As indicated in specification schedule.

2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

3. Pipes with OD, including insulation, less than 6 inches: Full-band pipe markers extending 360 degrees around pipe at each location.

4. Pipes with OD, including insulation, 6 inches and larger: Either full-band or strip-type pipe markers at least three (3) times letter height and of length required for label.

5. Arrows: A separate unit on each pipe marker to indicate direction of flow.

2.3 DUCT IDENTIFICATION DEVICES

A. Stencils: Prepared with minimum letter height of 1-1/4 inches for ducts.

1. Stencil Paint: Exterior, gloss, alkyd enamel black, unless otherwise indicated. Paint may be in pressurized spray-can form.

2. Identification Paint: Exterior alkyd enamel in colors as indicated in specification schedule.

B. Manual dampers: Wrap duct with red plastic ribbon with 12" long tail at each manual damper.

2.4 VALVE TAGS

A. Valve Tags: 2" diameter tag stamped or engraved with ¼-inch letters for piping system abbreviation and ½-inch numbers, with numbering scheme, approved by Engineer. Provide 5/32-inch hole for fastener.

1. Material: 16 gauge brass.

2. Valve-Tag Fasteners: Brass beaded chain.

2.5 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulation), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.

2. Frame: Extruded aluminum.

3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.

2. Fasteners: Brass grommet and wire.

3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.

4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 15 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer=s option.

B. Installing Contractor is responsible for valve tagging, equipment markers and pipe identification of all valves, equipment and piping on packaged pumping skids.

3.2 EQUIPMENT IDENTIFICATION

A. Install equipment markers with screws, or, if screws might damage equipment, use permanent adhesive on or near each major item of mechanical equipment.

1. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

    a. Main control and operating valves, including safety devices.

    b. Terminal VAV units.

    c. Boilers

    d. Pumps, chillers and similar motor-driven units.

    e. Coils, heat recovery units and similar equipment.

    f. Fans, blowers, primary balancing dampers, and mixing boxes.

    g. Packaged HVAC central-station and air handling units.

    h. Tanks and pressure vessels.

    i. Water-treatment systems and similar equipment.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service of each piping system. Install with flow indication arrows showing direction of flow.

B. All underground pipe shall be marked with a continuous, underground-type plastic line marker. Confirm location of markers with the Engineer.

C. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior non-concealed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and non-accessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings.

D. Pipe Identification:

TYPE OF SERVICE	1" BAND COLOR	½" BAND COLOR	DESIGNATION
Refrigerated Liquid	Yellow	Black	LIQ
Refrigerated Suction	Yellow	Black	SUCT
Chilled Water Supply	Blue	Black	CHWS
Chilled Water Return	Blue	Black	CHWR
Condensing Water Supply	Purple	Purple	CWS
Condensing Water Return	Purple	Purple	CWR
Heating Water Supply	Lime Green	Lime Green	HWS
Heating Water Return	Lime Green	Lime Green	HWR
Mechanical City Water	Blue	Blue	MCW

3.4 DUCT IDENTIFICATION

A. Stenciled Duct Markers: Stenciled markers, showing service and direction of flow. Stencil only after ductwork is painted.

B. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system and at access doors in concealed spaces.

C. Duct Identification:

TYPE OF SERVICE	1" BAND COLOR	DESIGNATION
Supply Air	Green	SUPPLY
Return Air	Blue	RETURN
Exhaust Air	Blue	EXH
Outdoor Air	Blue	OA

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves with captions as indicated in the following:

TYPE OF SERVICE	VALVE TAG DESIGNATION
Heating Water Supply	HWS
Heating Water Return	HWR
Chilled Water Supply	CHWS
Chilled Water Return	CHWR
Condensing Water Supply	CWS
Condensing Water Return	CWR
Mechanical City Water	MCW

3.6 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location where directed by Owner. Provide aluminum frame with plexiglass cover for valve chart.

3.7 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to equipment and other items where required.

3.8 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work. Stencils, name tags, etc. must be readable from a standing position.

A. When arrows and letters cannot be stenciled on pipe, stencil identification on 16 gauge aluminum metal panels in correct color and hang panel on piping with key chains.

3.9 CLEANING

A. Clean faces of mechanical identification devices and glass and frames of valve schedules.

3.10 UNDERGROUND UTILITIES

A. The following underground utility shall have a 3M ball marker or full-range marker, each having a distinct color and frequency, for locating underground utilities. The marker shall be used only when the utility will be 8 feet or less below the future finished grade. The marker shall be placed in the trench, on top of the utility. A marker shall be placed every 25 feet. A marker shall be placed at every direction change. There shall be a minimum of two markers for each utility trench. Each marker shall be as follows:

1. The 1253 full-range green marker for chilled water and hot water piping.

B. Note, all underground utilities and proposed areas of excavation shall be marked in strict accordance with Ohio's Universal Marketing Standards.

END OF SECTION 230553

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SECTION 230593 – TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. The testing, adjusting and balancing work as specified in this section is to be performed by a certified balancing contractor that is hired by the HVAC Contractor. All final tab work will be completed at the end of the final phase of work. The HVAC Contractor is to provide all necessary assistance and coordination with the testing, adjusting and balancing, (TAB) contractor as required to complete the balancing work and generate the balancing report as specified in this section. The HVAC Contractor is to provide all system start-up procedures and commissioning tasks that are required prior to balancing work as specified in the other sections of this specification.

B. This Section includes testing, adjusting and balancing to produce design objectives for the following:

1. Air Systems:

   a. Constant-volume air systems.

   b. Variable-air-volume systems.

2. Hydronic Piping Systems:

   a. Chilled water systems.

   b. Hot water heating systems.

   c. Condensing water systems.

3. HVAC equipment quantitative-performance settings.

4. Verifying that automatic control devices are functioning properly.

5. Reporting results of activities and procedures specified in this Section.

6. In general, the Balancing Work will occur at the end of the last phase of this project.

1.2 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including sub-mains, branches, and terminals, according to indicated quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

J. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

K. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

L. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

M. TAB: Testing, adjusting, and balancing.

N. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

O. Test: A procedure to determine quantitative performance of systems or equipment.

P. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.3 SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit two (2) copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days from Contractor's Notice to Proceed, submit two (2) copies of the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 90 days from Contractor's Notice to Proceed, submit two (2) copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. Certified TAB Reports: Submit two (2) copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Sample Report Forms: Submit two (2) sets of sample TAB report forms.

F. Warranties specified in this Section.

1.4 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.

B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven (7) days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:

a. Submittal distribution requirements.

b. The Contract Documents examination report.

c. TAB plan.

d. Work schedule and Project-site access requirements.

e. Coordination and cooperation of trades and subcontractors.

f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems@, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing", or TAB firm's forms approved by Engineer.

E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

F. Instrumentation Calibration: Calibrate instruments at least every six (6) months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.5 PROJECT CONDITIONS

A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.6 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven (7) days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.7 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents or provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.

2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 – PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 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.

1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 1 Section "Project Record Documents."

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 and pump curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

I. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

K. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

L. Examine strainers for clean screens and proper perforations.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine equipment for installation and for properly operating safety interlocks and controls.

P. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.

2. Dampers and valves are in the position indicated by the controller.

3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in variable-air-volume terminals.

4. Automatic modulating and shutoff valves, including two-way valves, are properly connected.

5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.

6. Sensors are located to sense only the intended conditions.

7. Sequence of operation for control modes is according to the Contract Documents.

8. Controller set points are set at indicated values.

9. Interlocked systems are operating.

10. Changeover from heating to cooling mode occurs according to indicated values.

Q. 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.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.

2. Hydronic systems are filled, clean, and free of air.

3. Automatic temperature control systems are operational.

4. Equipment and duct access doors are securely closed.

5. Balance and fire dampers are open.

6. Isolating and balancing valves are open and control valves are operational.

7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling unit components.

L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR CONSTANT VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.

b. Measure static pressure directly at the fan outlet or through the flexible connection.

c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.

d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each component that makes up a rooftop unit.

a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps and heat recovery equipment, under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, belt, sheaves, motor sizes, and electrical connections to accommodate fan-speed changes including changing of belts, pulleys and sheaves.
6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in; full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, sub-main ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

a. Where sufficient space in sub-main and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-main and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE AIR VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.

2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.

3. Measure total system airflow. Adjust to within indicated airflow.

4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.

8. Record the final fan performance data.

9. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, belt. sheaves, motor sizes, and electrical connections to accommodate fan-speed changes including changing of belts, pulleys and sheaves.

10. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in; full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pup flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.

2. Check expansion tank liquid level.

3. Check makeup-water station pressure gage for adequate pressure for highest vent.

4. Check flow-control valves for specified sequence of operation and set at indicated flow.

5. Set differential-pressure control valves at the specified differential pressure.

6. Set system controls so automatic valves are wide open to hear exchangers.

7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.

8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

9. Check ethylene glycol percent by volume in chilled water system.

3.8 PROCEDURES FOR HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.

4. Report flow rates that are not within plus or minus 5% of design.

B. Verify flow rate through automatic flow control valves

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.

D. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

E. Measuring the differential-pressure control valve settings existing at the conclusions of balancing.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

3.11 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate measured voltage and amperage for each phase.
6. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Record observations, including: controller manufacturer, model and serial numbers, and nameplate data.

3.12 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.

5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.

6. Capacity: Calculate in tons of cooling.

7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.13 PROCEDURES FOR COOLING TOWERS

A. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:

1. Measure condenser-water flow to each cell of the cooling tower.

2. Measure entering- and leaving-water temperatures.

3. Measure wet- and dry-bulb temperatures of entering air.

4. Measure wet- and dry-bulb temperatures of leaving air.

5. Measure condenser-water flow rate recirculating through the cooling tower.

6. Measure cooling-tower spray pump discharge pressure.

7. Adjust water level and feed rate of makeup water system.

8. Measure flow through bypass.

3.14 PROCEDURES FOR HEAT TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering and leaving water temperature.

2. Water flow rate.

3. Water pressure drop

4. Dry-bulb temperature of entering and leaving air.

5. Wet-bulb temperature of entering and leaving air for cooling coils.

6. Airflow.

7. Air pressure drop.

B. Refrigerant Coils: Measure the following data for each coil:

1. Dry-bulb temperature of entering and leaving air.

2. Wet-bulb temperature of entering and leaving air.

3. Airflow.

4. Air pressure drop.

5. Refrigerant suction pressure and temperature.

3.15 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet and dry bulb temperatures every other hour for a period of two (2) successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside air, wet and dry-bulb temperatures.

3.16 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high and low temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or non-grounded power supply.

J. Note operation of electric actuators using spring return for proper fail-safe operations.

3.17 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and exhaust Fans and Equipment with Fans: Plus 5% to plus 10%.
2. Air Outlets and Inlets: 0 to minus 10%.
3. Heating-Water Flow Rate: 0 to minus 10%.
4. Cooling-Water Flow Rate: 0 to minus 5%.

3.18 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: As Work progresses, prepare 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.

3.19 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.

1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:

1. Pump curves.

2. Fan curves.

3. Manufacturers' test data.

4. Field test reports prepared by system and equipment installers.

5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.

2. Name and address of TAB firm.

3. Project name.

4. Project location.

5. Architect's name and address.

6. Engineer's name and address.

7. Contractor's name and address.

8. Report date.

9. Signature of TAB firm who certifies the report.

10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents including the following:

a. Indicated versus final performance.

b. Notable characteristics of systems.

c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.

13. Data for terminal units, including manufacturer, type size, and fittings.

14. Notes to explain why certain final data in the body of reports varies from indicated values.

15. Test conditions for fans and pump performance forms including the following:

a. Settings for outside, return, and exhaust air dampers.

b. Conditions of filters.

c. Cooling coil, wet and dry bulb conditions.

d. Face and bypass damper settings at coils.

e. Fan drive settings including settings and percentage of maximum pitch diameter.

f. Settings for supply air, static pressure controller.

g. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.

2. Water and steam flow rates.

3. Duct, outlet, and inlet sizes.

4. Pipe and valve sizes and locations.

5. Terminal units.

6. Balancing stations.

7. Position of balancing devices.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:

a. Unit identification.

b. Location.

c. Make and type.

d. Model number and unit size.

e. Manufacturer's serial number.

f. Unit arrangement and class.

g. Discharge arrangement.

h. Sheave make, size in inches, and bore.

i. Sheave dimensions, center-to-center, and amount of adjustments in inches.

j. Number of belts, make, and size.

k. Number of filters, type, and size.

2. Motor Data:

a. Make and frame type and size.

b. Horsepower and rpm.

c. Volts, phase, and hertz.

d. Full-load amperage and service factor.

e. Sheave make, size in inches, and bore.

f. Sheave dimensions, center-to-center, and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.

b. Total system static pressure in inches wg.

c. Fan rpm.

d. Discharge static pressure in inches wg.

e. Filter static pressure differential in inches wg.

f. Preheat coil static pressure differential in inches wg.

g. Cooling coil static pressure differential in inches wg.

h. Heating coil static pressure differential in inches wg.

i. Outside airflow in cfm.

j. Return airflow in cfm.

k. Outside air damper position.

l. Return air damper position.

G. Apparatus-Coil Test Reports:

1. Coil Data:

   a. System identification.

   b. Location.

   c. Coil type.

   d. Number of rows.

   e. Fin spacing in fins per inch o.c.

   f. Make and model number.

   g. Face area in sq. ft.

   h. Tube size in NPS.

   i. Tube and fin materials.

   j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

   a. Airflow rate in cfm.

   b. Average face velocity in fpm.

   c. Air pressure drop in inches wg.

   d. Outside air, wet and dry bulb temperatures in deg F.

   e. Return air, wet and dry bulb temperatures in deg F.

   f. Entering air, wet and dry bulb temperatures in deg F.

   g. Leaving air, wet and dry bulb temperatures in deg F.

   h. Water flow rate in gpm.

   i. Water pressure differential in feet of head or psig.

   j. Entering water temperature in deg F.

   k. Leaving water temperature in deg F.

H. Fan Test Reports: For supply fans, include the following:

1. Fan Data:

a. System identification.

b. Location.

c. Make and type.

d. Model number and size.

e. Manufacturer's serial number.

f. Arrangement and class.

g. Sheave make, size in inches, and bore.

h. Sheave dimensions, center-to-center, and amount of adjustments in inches.

2. Motor Data:

a. Make and frame type and size.

b. Horsepower and rpm.

c. Volts, phase, and hertz.

d. Full load amperage and service factor.

e. Sheave make, size in inches, and bore.

f. Sheave dimensions, center-to-center, and amount of adjustments in inches.

g. Number of belts, make, and size.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.

b. Total system static pressure in inches wg.

c. Fan rpm.

d. Discharge static pressure in inches wg.

e. Suction static pressure in inches wg.

I. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling unit number.

b. Location and zone.

c. Duct static pressure in inches wg.

d. Duct size in inches.

e. Duct area in sq. ft.

f. Indicated airflow rate in cfm.

g. Indicated velocity in fpm.

h. Actual airflow rate in cfm.

i. Actual average velocity in fpm.

J. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.

b. Location and zone.

c. Test apparatus used.

d. Area served.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Air velocity in fpm.

c. Preliminary airflow rate as needed in cfm.

d. Preliminary velocity as needed in fpm.

e. Final airflow rate in cfm.

f. Final velocity in fpm.

g. Space temperature in deg F.

K. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air handling unit identification.

b. Location and zone.

c. Room or riser served.

d. Coil make and size.

e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

b. Entering water temperature in deg F.

c. Leaving water temperature in deg. F.

d. Water pressure drop in feet of head or psig.

e. Entering air temperature in deg F.

f. Leaving air temperature in deg F.

L. Pump Test Reports:

1. Unit Data:

a. Unit identification

b. Location.

c. Service.

d. Make and size.

e. Model and serial numbers.

f. Water flow rate in gpm.

g. Water pressure differential in feet of head or psig.

h. Required net positive suction head in feet of head or psig.

i. Pump rpm.

j. Impeller diameter in inches.

k. Motor make and frame size.

l. Motor horsepower and rpm.

m. Voltage at each connection.

n. Amperage for each phase.

o. Full load amperage and service factor.

p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.

b. Pump shutoff pressure in feet of head or psig.

c. Actual impeller size in inches.

d. Full open flow rate in gpm.

e. Full open pressure in feet of head or psig.

f. Final discharge pressure in feet of head or psig.

g. Final suction pressure in feet of head or psig.

h. Final total pressure in feet of head or psig.

i. Final water flow rate in gpm.

j. Voltage at each connection.

k. Amperage for each phase.

M. Air to Air Heat-Recovery Unit Reports:

1. Unit Data:

a. Unit identification.

b. Location.

c. Service.

d. Make and type.

e. Model and serial numbers.

2. Test Data (Indicated and Actual Values):

a. Total exhaust airflow rate in cfm.

b. Outside airflow rate in cfm.

c. Total exhaust fan static pressure in inches wg.

d. Total outside air fan static pressure in inches wg.

e. Pressure drop on each side of heat exchanger in inches wg.

f. Exhaust air temperature humidity entering in deg F and % RH.

g. Exhaust air temperature humidity leaving in deg F and % RH.

h. Outside air temperature humidity entering in deg F and % RH.

i. Outside air temperature humidity leaving in deg F and % RH.

j. Calculate sensible and total heat capacity of each airstream in MBh

N. Combustion Test:

1. Unit Data

a. Boiler manufacturer.

b. Model number.

c. Serial number.

d. Firing rate.

e. Overfire draft

f. Gas meter timing dial size.

g. Gas meter time per revolution.

h. Gas pressure at meter outlet.

i. Gas flow rate.

j. Heat input.

k. Burner manifold gas pressure.

l. Percent carbon monoxide (CO).

m. Percent carbon dioxide (CO2).

n. Percent oxygen (O2).

o. Percent excess air.

p. Flue gas temperature at outlet.

q. Ambient temperature.

r. Net stack temperature.

s. Percent stack loss.

t. Percent combustion efficiency.

u. Heat output.

O. Cooling Towers:

1. Unit Data

a. Identification/number.

b. Location.

c. Manufacturer.

d. Model number.

e. Serial number.

f. Entering DB and WB air temperature, design and actual.

g. Leaving DB and WB air temperature, design and actual.

h. Water flow rate.

P. Chillers:

1. Unit Data

a. Identification/number.

b. Manufacturer.

c. Capacity.

d. Model number.

e. Serial number.

f. Evaporator entering water temperature, design and actual.

g. Evaporator leaving water temperature, design and actual.

h. Evaporator pressure drop, design and actual.

i. Evaporator water flow rate, design and actual.

j. Condenser entering water temperature, design and actual.

k. Condenser pressure drop, design and actual.

l. Condenser water flow rate, design and actual.

Q. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.

b. Serial number.

c. Application.

d. Dates of use.

e. Dates of calibration.

3.20 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.

2. Randomly check the following for each system:

   a. Measure airflow of at least 10% of air outlets.

   b. Measure water flow of at least 5% of terminals.

   c. Measure room temperature at each thermostat/temperature sensor.

      Compare the reading to the set point.

   d. Verify that balancing devices are marked with final balance position.

   e. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.

2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect.

3. Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10% of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8 hour business day.

4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

5. If the number of "FAILED" measurements is greater than 10% of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.

7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.21 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 230593

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SECTION 230700 - PIPE INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

1.2 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Application of protective shields, saddles, and inserts at pipe hangers for each type of insulation and hanger.

2. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.

3. Removable insulation at piping specialties and equipment connections.

4. Application of field-applied jackets.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

C. ASHRAE Standards: Comply with performance efficiencies prescribed for ASHRAE 90.1, "Energy Efficient Design for New Buildings, Except Low Rise Residential Buildings" for pipe insulation.

D. No damaged or water soaked insulation shall be used.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.5 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping installer for insulation application.

1.6 SCHEDULING

A. Schedule insulation application after testing piping systems. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

1. Mineral-Fiber Insulation:

a. CertainTeed Manson.

b. Knauf FiberGlass GmbH.

c. Owens-Corning Fiberglas Corp.

d. Schuller International, Inc.

e. Armacell

2.2 INSULATION MATERIALS

A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:

1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.

2. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:

a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.

b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.

3. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.

4. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.

5. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

B. Cellular-Glass Insulation: Foamed glass, annealed, rigid, hermetically sealed cells, incombustible. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.

C. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Adhesive: As recommended by insulation material manufacturer.

D. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves.

2.3 FIELD APPLIED JACKETS

A. General: ASTM C 921, Type 1, unless otherwise indicated.

B. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps and mechanical joints.

2. Adhesive: As recommended by insulation material manufacturer.

C. PVC Jacket: High-impact-resistant, UV resistant PVC complying with ASTM D1784, Class 16354-C; 30 mils thick; roll stock ready for shop or field cutting and forming. Finish color to be white.

D. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209, 3003 alloy, H-14 temper

1. Finish and Thickness: Stucco-embossed finish, 0.020-inch thick.

2. Moisture Barrier: 1-mil thick, heat-bonded polyethylene and kraft paper.

3. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

E. Glass Cloth Covering: Self-adhesive, mastic impregnated, rewettable cloth.

1. Thickness: 0.028 inches

2. Maximum Service Temperature: 450 degrees F.

3. Density: 14.3 oz/sq yd

4. Surface Burning Characteristic: 25/50 per ASTM E84

2.4 ACCESSORIES AND ATTACHMENTS

A. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:

1. Aluminum: 0.007 inch thick.

B. Wire: 0.080 inch, nickel-copper alloy; 0.062 inch, soft-annealed, stainless steel; or 0.062 inch soft-

annealed, galvanized steel.

C. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave presized a minimum of 14.3 oz./sq. yd.

1. Tape Width: 4 inches.

2.5 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

E. Apply multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors:

1. Apply insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.

2. Circumferential Joints: Cover with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches o.c.

3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.

a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.

4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.

5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.

P. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.

Q. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

R. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.

1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Firestopping."

S. Floor Penetrations: Apply insulation continuously through floor assembly.

1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.

3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches on center.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

5. All exposed ends for mineral fiber insulation shall be neatly trimmed and beveled. All exposed insulation material shall be covered with mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions and cover with insulating cement trowelled smooth.

2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with tape and cover with insulating cement trowelled smooth.

3. Cover fittings with standard PVC fitting covers.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.

3.5 CELLULAR GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.

3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

5. All exposed ends for mineral fiber insulation shall be neatly trimmed and beveled. All exposed insulation material shall be covered with mastic.

3.6 FIELD APPLIED JACKET APPLICATION

A. Apply aluminum metal jacket for all exterior above ground chilled water piping, with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal joints with weatherproof sealant recommended by insulation cover manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

B. Apply glass cloth or PVC jacket, for piping that is exposed in all areas including mechanical rooms, directly over insulation with factory-applied jackets.

1. Apply jacket smooth and tight to surface with 1-inch overlap at seams and joints.

2. Embed glass cloth between two (2) 0.062-inch thick coats of jacket manufacturer=s recommended adhesive.

3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

C. Provide PVC fitting covers for all exposed piping that is to be insulated. For Victaulic piping, provide PVC fitting covers for all fittings and couplings.

3.7 PIPING SYSTEM APPLICATIONS

A. Materials and thicknesses for systems listed below are specified in schedules within this section.

B. Insulate the following piping systems:

1. Insulate heating hot water supply and return piping with glass fiber insulation

2. Insulate indoor chilled water supply and return piping with glass fiber insulation.

3. Insulate outdoor chilled water supply and return piping with closed cell elastomeric insulation.

4. Insulate indoor condensing water supply and return piping with glass fiber insulation.

5. Insulate make up mechanical city water piping with glass fiber insulation.

C. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors and Vibration-control devices.

2. Vibration-control devices.

3. Fire-suppression piping.

4. Below-grade piping, unless otherwise indicated.

5. Chrome-plated pipes and fittings, unless potential for personnel injury.

6. Hot water air chambers, unions, strainers, check valves, plug valves, and flow regulators.

D. MINIMUM INSULATION THICKNESS FOR PIPE SIZES

Hot water piping insulation shall be 1-1/2” thick and Chilled Water piping insulation shall be 1-1/2” thick on piping 4” and smaller and 2” thick on piping 5” and larger.

PIPING SYSTEM TYPES	FLUID TEMPERATURE RANGES (DEG. F)	LESS THAN 1" (INCHES)	1" TO 1-1/4" (INCHES)	1-1/2" TO 3" (INCHES)	4" AND LARGER (INCHES)
Make-up Water	40°-55°F	0.5	0.5	1.0	1.0
Chilled Water	38°-60°F	1.5	1.5	1.5	2.0
Hot Water	55°-200°F	1.0	1.0	1.5	1.5
Condensing Water	40°-105°F	0.5	0.5	1.0	1.0

NOTE: The minimum listed thickness is based on a minimum R valve of 4.6. Thickness to vary if the insulation R value is different than 4.6. In addition, the minimum thickness is to be increased as required to meet ASHRAE 90.1.

E. Insulation at fire walls: All insulated piping penetrating walls with a fire resistive rating shall be insulated with molded foam glass; “ASJ-SSL” covering with a dual purpose fireproof, kraft aluminum foil, laminated white jacket. Insulation to be of same thickness as adjoining insulation.

F. SUCTION REFRIGERANT AND CONDENSATE DRAIN PIPING

1. Pipe Insulation: 3/4 inch thick, fire retardant, flexible elastomeric thermal insulation.

2. Exposed Exterior Insulation: Cover with two coats of the insulation manufacturer's coating that is recommended for UV protection.

G. PIPE INSULATING SUPPORT

1. On insulated piping with pipe supports around outside of covering provide galvanized steel formed bearing plates. Plates to be lined with length of foam glass insulation.

   a. 8" and smaller pipe: 12" long, 12 gauge plate

   b. 10" and larger pipe: 24" long, 10 gauge plate

3.8 FIELD QUALITY CONTROL

A. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

END OF SECTION 230700

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SECTION 230701 - EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes blanket insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

1.2 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Field application for each equipment type.

2. Removable insulation sections at access panels.

3. Application of field-applied jackets.

4. Special shapes for cellular-glass insulation.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

1.4 DELIVERY, STORAGE AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.5 COORDINATION

A. Coordinate clearance requirements with equipment installer for insulation.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.

1. Adhesive: As recommended by insulation material manufacturer.

2.2 FIELD APPLIED JACKETS

A. General: ASTM C 921, Type 1, unless otherwise indicated.

B. Glass Cloth Covering: Self-adhesive, mastic impregnated, rewettable cloth.

1. Thickness: 0.028 inches

2. Maximum Service Temperature: 450 degrees F.

3. Density: 14.3 oz/sq yd

4. Surface Burning Characteristic: 25/50 per ASTM E84

2.2 ACCESSORIES AND ATTACHMENTS

A. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:

1. Aluminum: 0.007 inch thick.

B. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for Cloth and Type II for Tape. Woven glass-fiber fabrics, plain weave presized a minimum of 14.3 oz/sq. yd.

1. Tape width: 4 inches

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

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 APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of equipment.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each

equipment system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either the wet or dry state.

D. Apply multiple layers of insulation with longitudinal and end seams staggered.

E. Keep insulation materials dry during application and finishing.

F. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

G. Apply insulation with the least number of joints practical.

H. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

I. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

3.4 EQUIPMENT APPLICATIONS

A. Materials and thicknesses for equipment listed below are specified in this Section.

B. Insulate the following indoor equipment:

1. Chilled water centrifugal pump housings.

2. Chilled Water Air Separator.

C. Omit insulation from the following hot water system and provide removable insulation segments for chilled water system:

1. Vibration-control devices.

2. Testing agency labels and stamps.

3. Nameplates and data plates.

D. Equipment Insulation Type:

1. Operating Temperature: 20 to 70 deg. F.

2. Insulation Material: Flexible Elastomeric.

3. Insulation Thickness: 1 inch.

3.5 FIELD QUALITY CONTROL

A. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

END OF SECTION 230701

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SECTION 230702 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes semi-rigid and flexible duct and plenum insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

1.2 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Removable insulation sections at access panels.

2. Application of field-applied jackets.

3. Applications at linkages for control devices.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less and smoke-developed rating of 50 or less.

C. ASHRAE Standards: Comply with performance efficiencies prescribed for ASHRAE 90.1, "Energy Efficient Design for New Buildings, Except Low Rise Residential Buildings" for duct insulation.

D. No damaged or water soaked insulation shall be used.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade and maximum use temperature.

1.5 COORDINATION

A. Coordinate clearance requirements with duct Installer for insulation application.

1.6 SCHEDULING

A. Schedule insulation application after testing duct systems. Insulation application may begin on segments of ducts that have satisfactory test results.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified:

1. Mineral-Fiber Insulation:

a. CertainTeed Manson.

b. Knauf FiberGlass GmbH.

c. Owens-Corning Fiberglas Corp.

d. Schuller International, Inc.

e. Aeroflex USA Inc.; Aerocel.

f. Armacell LLC; AP Armaflex.

g. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2.2 INSULATION MATERIALS

A. Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from aluminum foil, skrim kraft, vapor seal.

B. Mineral-Fiber Blanket Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from aluminum foil, skrim kraft, vapor seal.

C. Glass Fiber Duct Liner

1. Insulation ASTM C553; flexible noncombustible with erosion resistant and mold resistant coating.

a. 'K' value: ASTM C518 and C177, 024 at 75 degrees F.

b. Maximum Service Temperature: 250 degrees F.

c. Maximum Moisture Absorption: 0.5 percent per volume.

d. Density: 3.0 1l/cu ft.

D. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

E. Fire-Rated Blanket: High temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

2.3 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type 1, unless otherwise indicated.

B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.

C. Glass Cloth Covering: Self-adhesive, mastic impregnated, rewettable cloth.

1. Thickness: 0.028 inches

2. Maximum Service Temperature: 450 degrees F.

3. Density: 14.3 pz/sq yd

4. Surface Burning Characteristic: 25/50 per ASTM E84

D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

1. Sheet and roll stock ready for shop or field sizing.

2. Finish and thickness are indicated in field-applied jacket schedules.

3. Factory-Fabricated Fitting Covers:

a. Same material, finish, and thickness as jacket.

b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.

c. Tee covers.

d. Flange and union covers.

e. End caps.

f. Beveled collars.

g. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.4 ACCESSORIES AND ATTACHMENTS

A. Wire: 0.062-inch, soft-annealed, galvanized steel.

B. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of ducts and plenums; and to achieve a holding capacity of 100 lb for direct pull perpendicular to the adhered surface.

C. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

D. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 14.3 oz./sq. yd.

1. Tape Width: 4 inches

E. Aluminum Jacket strapping and seals: All jacketing shall be secured on not greater than 18 inch centers with aluminum straps not less than 0.20 inch thickness. All jacketing shall have 0.75 inch wide aluminum wing seals not less than 0.32 inch thickness.

2.5 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets and substrates.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.

2. Fire – and water – resistant, flexible, elastomeric sealant.

3. Service Temperature Range: Minus 40 to plus 250 °F.

4. Color: Aluminum.

5. 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).

6. 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".

2.7 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Width: 3 inched (75 mm).

2. Thickness: 6.5 mils (0.16 mm).

3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.

4. Elongation: 2 percent.

5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.

6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

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 APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

B. Refer to schedules at the end of this Section for materials, forms, jackets and thicknesses required for each duct system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften or otherwise attack insulation or jacket in either wet or dry state.

D. Apply multiple layers of insulation with longitudinal and end seams staggered.

E. Keep insulation materials dry during application and finishing.

F. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

G. Apply insulation with the least number of joints practical.

H. Apply insulation over fittings and specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

I. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.

2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.

J. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

K. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

L. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations.

M. Provide weld pins located a maximum of 18 inches on center for all insulation serving ductwork that has a width or height dimension that exceeds 20 inches.

N. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.

1. For insulation indicated to have vapor retarders, taper termination and seal insulation ends with vapor-retarder mastic.

3.4 MINERAL FIBER INSULATION APPLICATION

A. Blanket or Board Applications for Ducts and Plenums: Secure blanket insulation with adhesive, anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per square foot for 100 percent coverage of duct and plenum surfaces.

2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install anchor pins and speed washers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints and locate 16 inches on center.

b. On duct sides with dimensions larger than 18 inches. Space 16 inches on center each way and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.

c. Anchor pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not over-compress insulation during installation.

4. Impale insulation over anchors and attach speed washers.

5. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

6. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1 inch on center and cover with pressure-sensitive tape having same facing as insulation.

7. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Apply insulation on round duct elbows with individually mitered gores cut to fit the elbow.

8. Insulate duct stiffeners, hangers and flanges that protrude beyond the insulation surface with 6-inch wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger and flange with anchor pins spaced 6 inches on center.

3.5 FIELD APPLIED JACKET APPLICATION

A. Apply glass cloth jacket directly over insulation with factory applied jackets for all exposed insulation for all exposed insulation in finished, occupied rooms and mechanical rooms.

1. Apply jacket smooth and tight to surface with 2-inch overlap at seams and joints.

2. Embed glass cloth between two (2) 0.062-inch thick coats of jacket manufacturer=s recommended adhesive.

3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

B. Apply aluminum jacket directly over flexible elastomeric insulation located exterior to the building.

1. Apply aluminum jacket as recommended by the manufacture.

2. Completely encapsulate insulation with jacket leaving no exposed raw insulation.

3. Seal watertight.

3.6 DUCT SYSTEM APPLICATIONS

A. Materials and thicknesses for systems listed below are specified in schedules at the end of this Section.

B. Insulate the following plenums and duct systems:

1. Indoor concealed supply and outside air ductwork.

2. Indoor exposed supply and outside air ductwork.

3. Indoor outside air plenums connected to louvers.

4. Indoor exhaust air ductwork and plenums from exhaust louver or discharge hood to the discharge of the exhaust fan or air handling unit.

5. Indoor exhaust air ductwork located within 10 feet of roof mounted exhaust fan with backdraft damper.

6. Indoor exhaust air ductwork serving Type 1 kitchen hood

7. Insulate indoor return air ductwork and plenums only where specifically indicated on the design drawings.

8. Exterior supply and return ductwork.

C. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials and equipment:

1. Metal ducts with duct liner.

2. Manufactured double wall, insulated duct systems.

3. Factory-insulated flexible ducts.

4. Factory-insulated plenums, casings, terminal boxes, filter boxes and sections.

5. Flexible connectors.

6. Vibration-control devices.

7. Testing agency labels and stamps.

8. Nameplates and data plates.

9. Access panels and doors in air-distribution systems.

3.7 INDOOR DUCT AND PLENUM APPLICATION SCHEDULE

A. Service: Round supply, exhaust and outdoor air ducts; concealed.

1. Material: Mineral-fiber blanket.

2. Thickness: 1-1/2 inches.

3. Minimum R value: 3.5.

4. Number of Layers: One.

B. Service: Rectangular supply, exhaust and outdoor air ducts; concealed.

1. Material: Mineral-fiber blanket.

2. Thickness: 1-1/2 inches.

3. Minimum R value: 3.5.

4. Number of Layers: One.

C. Service: Round supply, exhaust and outdoor air ducts; exposed.

1. Material: Mineral-fiber board.

2. Thickness: 1-1/2 inches.

3. Minimum R Value: 3.5.

4. Number of Layers: One.

D. Service: Rectangular supply, exhaust and outdoor air ducts; exposed.

1. Material: Mineral-fiber board.

2. Thickness:1-1/2 inches.

3. Minimum R Value: 3.5.

4. Number of Layers: One.

E. Service: Rectangular transfer air ducts; concealed and rectangular return air ducts where specifically indicated on the drawings to be internally lined.

1. Material: Fiberglass Duct Liner

2. Thickness: 1 inch

F. Service: Rectangular and round supply and return air ducts in spaces not tempered.

1. Insulation Material: Mineral fiber blanket.

2. Thickness: 2 inches.

3. Minimum R Value: 8

G. Thermal Insulation for all Ductwork on the Roof (Exterior of Ductwork)

1. Duct Insulation:

a. Duct: Insulation shall be ¾" thick Armstrong "FR-Armaflex", Rubatex, or IMCOA Polyolefin flexible foamed plastic, fire-retardant, closed cell, ozone resistant duct insulation. At hangers, insulation shall be installed as detailed on drawing, shall be properly coordinated with paragraph heading "Duct Hangers and Supports", and shall be continuous through hanger rings and supports. Adjoining sections and any longitudinal joints shall be butted firmly together and cemented with Armstrong No. 520 adhesive.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping".

END OF SECTION 230702

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SECTION 230800 – COMMISSIONING OF HVAC

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.

B. Refer to Section 019113 “Commissioning” for all specific requirements required associated with the commissioning process that will be required as part of this work. As part of this project, participation in the commissioning process as described in Section 01 91 13 shall be required.

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. DDC: Direct Digital Controls.

E. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 ALLOWANCES

A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Division 01 Section "Allowances."

1.5 UNIT PRICES

A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Division 01 Section "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

1.6 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase HVAC and Integrated Automation coordination meetings.

C. Attend testing, adjusting, and balancing review and coordination meetings.

D. Participate in HVAC systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.7 CxA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.8 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.

2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.

3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC systems, assemblies, equipment, and components to be verified and tested.

4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.

5. Certificate of readiness certifying that HVAC systems, subsystems, equipment, and associated controls are ready for testing.

6. Test and inspection reports and certificates.

7. Corrective action documents.

8. Verification of testing, adjusting, and balancing reports.

1.9 SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

1.10 COMMISSIONING AUTHORITY

A. Motz Engineering acting in conjunction with the Owner’s Maintenance Personnel will take the role of the Commissioning Authority for this project. The Commissioning Authority will respond to all issues directly to the Owner and shall have the authority to grant final acceptance of each system commissioned.

1.11 COMMISSIONING PLAN

A. This section and sections in other Divisions shall outline the work required for the project, consistent with the Commissioning Plan. Any discrepancies between the Commissioning Plan and the Project Manual sections shall be brought to the attention of the Commissioning Agent for clarification.

1.12 COORDINATION

A. The General Contractor and appropriate Subcontractors shall be responsible for cooperating and coordinating their work during the installation and commissioning process. Refer to the specific requirements and other sections for required work associated with coordination of installation work and preparation of Coordination Construction Drawings by the contractors.

B. The Commissioning Authority will participate in the coordination of installation work as necessary to insure the installation of system components meet the Owner's project requirements and will provide a facility that has appropriate access and means for future maintenance and service by Owner.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify 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 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. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

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 TESTING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC systems at the direction of the CxA.

1. The CxA will notify testing and balancing Subcontractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.

2. The testing and balancing 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 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.

4. 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.

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. Tests will be performed using design conditions whenever possible.

E. 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.

F. The CxA may direct that set points be altered when simulating conditions is not practical.

G. 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.

H. 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.

I. 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. The following systems shall be commissioned:

1. HVAC systems including:

a. Direct digital automatic temperature control system.

b. Air distribution systems.

c. Exhaust systems.

d. Unitary equipment.

END OF SECTION 230800

SECTION 23 09 95.00
LABORATORY AIRFLOW CONTROL SYSTEM

PART 1 - GENERAL

1.01 SUMMARY.

A Laboratory Airflow Control System (LACS) shall be furnished and installed under this section. The LACS shall be capable of operating as a standalone system or as a system integrated with the Building Management System (BMS) or Building Automation System (BAS).

1.02 REFERENCES.

A. Abbreviations and Acronyms
   1. ATC – Advanced Temperature Control
   2. BMS – Building Management System
   3. BAS – Building Automation System
   4. LACS – Laboratory Airflow Control System
   5. UBC – Usage Based Controls
   6. VAV – Variable Air Volume
   7. TTW – Through The Wall (sensor)
   8. ZPS – Zone Presence Sensor
   9. PIN – Personal Identification Number

B. Reference Standards
   1. Air Conditioning and Refrigeration Institute
      ARI 880 Performance Rating of Air Terminals
   2. American Society of Heating, Refrigeration, and Air Conditioning Engineers / American National Standards Institute
      ASHRAE/ANSI Standard 130, Methods for Testing Air Terminal Units
   3. American National Standards Institute / American Society of Heating, Refrigeration, and Air Conditioning Engineers
      ANSI/ASHRAE 135-2012: BACnet® - A Data Communication Protocol for Building Automation Systems (including Standard and all published Addenda)

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination
   1. The LACS representative shall coordinate all details of the installation with the successful mechanical contractor. This effort shall include complete coordination of the sheet metal layout drawings to assure that the ductwork layout and sizing is based on the actual sizes of the airflow control valves for this project.

B. Pre-installation Meetings
   1. The LACS representative shall review the proper installation of the system with the sheet metal contractor and the building management system (BMS) contractor.
   2. Project Installation Phase – The LACS representative shall make periodic visits to the project jobsite to assure that the system is being installed properly to assure optimal performance and that the location and orientation of the control valves is consistent for proper operation and future owner maintenance. Any discrepancies shall first be brought to the attention of the appropriate subcontractor. If no action is taken by said contractor, the representative shall bring these issues to the project manager, engineer or owner's representative for resolution.

1.04 SUBMITTALS

A. General: Submit listed Submittals in accordance with Conditions of the General Contract and Division 1 Submittal Procedures Section. LACS submittals shall contain, at a minimum, the following information:
   1. Product Data Sheets

2. Equipment Schedule Sheets containing Room#, Tag#, Min/Max flows, Catalog# and other configuration data as required to provide a fully engineered LACS.
3. Installation Instructions
4. Project-specific Wiring Diagrams
5. Points Lists

1.05 CLOSEOUT SUBMITTALS

A. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided as closeout submittals.

B. Integration checklists are encouraged; once the integration to the BMS or BAS is completed, it is recommended that the Controls Representative Partner meet with the BMS or BAS contractor to do a final acceptance test of the integration. This testing should include:
   1. Testing points to ensure communication
   2. Testing setpoints such as temperature, occupancy, room offset, etc
   3. Testing various alarms in different parts of the system
   4. Testing to ensure that equipment will cycle after a power loss

1.06 QUALITY ASSURANCE

A. Certifications
   1. The laboratory airflow system provider shall be an entity that designs, develops, manufactures and sells products and services to control the environment and airflow of critical spaces using a Quality Management System registered to ISO 9001:2008.
   2. The Laboratory airflow system provider shall be ROHS compliant in all its products
   3. The Venturi valves shall be calibrated using NIST traceable equipment AND NVLAP accredited air stations.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements
   1. Prior to installation, the LACS shall be stored in dry conditions within an environment complying with LACS product specifications as shown on product data sheets within the submittals.
   2. The LACS products shall be handled and transported in a manner consistent trade practices for control systems and instruments.

1.08 SITE CONDITIONS

A. The ambient environmental conditions during installation and operation shall comply with LACS product specifications as shown on the product data sheets within the submittals.

1.09 WARRANTY

A. The Warranty shall commence upon the date of shipment and extend for a period of 60 months for all airflow control devices and 36 months for all other control system components.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

A. Phoenix (Basis of Design)
B. Price
C. Tek-Air
D. Triatek
E. No substitutions without prior owner approval

2.02 LABORATORY AIRFLOW CONTROL SYSTEMS

A LACS shall be furnished and installed to control the airflow into and out of laboratory rooms. The exhaust flow rate of a laboratory fume hood shall be controlled precisely to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on an operator's presence in front of the fume hood. The laboratory control system shall vary the amount of make-up/supply air into the room to operate the laboratories at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates and maintain laboratory pressurization in relation to adjacent spaces (positive or negative). The LACS shall be capable of operating as a standalone system or as a system integrated with the Building

Management System (BMS). An optional locally mounted user interface terminal shall be available to allow room-level control variables to be displayed, and where appropriate, edited to adjust control operation.

2.03 COMPONENTS

A. VAV SASH CONTROLLER EQUIPMENT

1. For variable air volume (VAV) systems, a sash sensor shall be provided to measure the height of each vertically moving fume hood sash.
3. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow set points to maintain a constant face velocity throughout this range. A minimum volume flow shall be set to assure flow through the fume hood even with the sash fully closed.

B. AIRFLOW CONTROL DEVICE - GENERAL

1. The airflow control device shall be a pressure independent venturi valve.
2. The valve assembly manufacturer's Quality Management System shall be registered to ISO 9001:2008.
3. Airflow control device shall be OSHPD tested and certified per 2013 CBC, 2012, IBC, ASCE 7-10, and ICC-ES-AC-156.
4. All Components of the valve, its controllers, and wiring shall be ROHS compliant.
5. The airflow control device shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change (within product specifications) or quantity of airflow controllers on a manifolded system.
6. The airflow control device shall maintain accuracy within ±5% of signal over an airflow turndown range of no less than:
   a. 12.5 to 1 (medium pressure all valve sizes)
   b. 16 to 1 (medium pressure w/o 14" valve)
   c. 7 to 1 (low pressure all valve sizes)
   d. 11 to 1 (low pressure w/o 14" valve)
   e. 8 to 1 (medium pressure shut-off all valve sizes)
   f. 14 to 1 (medium pressure shut-off w/o 14" valve)
   g. 5 to 1 (low pressure shut-off all valve sizes)
   h. 9 to 1 (low pressure shut-off w/o 14" valve)
7. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.
8. No rotational/axial orientation requirements shall be required to ensure accuracy and/or pressure independence.
9. The airflow control device shall maintain pressure independence regardless of loss of power.
10. The airflow control device shall be constructed of one of the following four types:
    a. Class A—The airflow control device for non-corrosive airstreams, such as supply and general exhaust, shall be constructed of 16-gauge aluminum. The device's shaft and internal "S" link shall be made of 316 stainless steel. The shaft support brackets shall be made of galvaneal (non shutoff valves) or 316 stainless steel (shutoff valves). The pivot arm shall be made of aluminum (for non shutoff valves) and 303/304 stainless (for shut off valves). The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a PP (polypropylene) or PPS (polyphenylene sulfide) composite. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.
    b. Class B—The airflow control device for corrosive airstreams, such as fume hoods and biosafety cabinets, shall have a baked-on, corrosion-resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal "S" link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring-grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of PP (polypropylene) or PPS (polyphenylene sulfide) composite.

11. Actuation
    a. For high speed electrically actuated VAV operation, a CE certified, UL Listed, IP56 rated for dust and water, electronic actuator shall be factory mounted to the valve. Loss of main power shall cause the valve to position itself in an appropriate failsafe state. Options for these failsafe states include: normally open-maximum position, normally closed-minimum position and fail-to-last position. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).

       During normal operation the high speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 1 second or less.

    b. For Standard Speed electrically actuated VAV operation, a CSA certified, UL recognized (IP54 rating and CE certification optional on single valves, standard on dual valves) electronic actuator shall be factory mounted to the valve. The failsafe state for standard speed operation valves shall be fail to last position unless otherwise noted.

       During normal operation the standard speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 60 seconds.

       i. Standard speed actuation should not be used for valves that are connected to VAV fume hoods.
       ii. Constant volume valves do not require actuators.
12. The controller for the airflow control devices shall be microprocessor based and operate using peer-to-peer control architecture. The room-level airflow control devices shall function as a standalone network.
13. The room-level control network shall utilize a LonTalk communications protocol.
14. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each laboratory control system shall have the capability of performing fume hood control, pressurization control, standard and advanced temperature control, humidity control, and implement occupancy and emergency mode control schemes.
15. The LACS shall have the option of digital integration with the BMS or BAS.
16. NVLAP Accreditation (Lab Code 200992-0)
    a. Each airflow control device shall be factory characterized on air stations NVLAP Accredited (a program administered by NIST) to ISO/IEC 17025:2005 standards.
    b. Each airflow control device shall be factory characterized to the job specific airflows as detailed on the plans and specifications using NVLAP Accredited air stations and instrumentation having a combined accuracy of no more than ±1% of signal (5,000 to 250cfm), ±2% of signal (249 to 100cfm) and ±3% of signal (199 to 35cfm). Electronic airflow control devices shall be further characterized and their accuracy verified to ±5% of signal at a minimum of 48 different airflows across the full operating range of the device.
    c. Each airflow control device shall be marked with device-specific factory characterization data. At a minimum, it should include the room number, tag number, serial number, model number, eight-point characterization information (for electronic devices), date of manufacture and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation. Characterization data shall be stored indefinitely by the manufacturer and backed up off site for catastrophic event recovery.
17. Airflow control devices that are not venturi valves and are airflow measuring devices (e.g., pitot tube, flow cross, air bar, orifice ring, vortex shedder, etc.) shall only be acceptable, provided these meet all the performance and construction characteristics as stated throughout this specification and:
    a. The airflow control device employs transducers manufactured by Rosemount, Bailey, Bristol, or Foxboro. Accuracy shall be no less than ±0.15% of span (to equal ±5% of signal with a 15 to 1 turndown) over the appropriate full-scale range, including the combined effects of nonlinearity,

hysteresis, repeatability, drift over a one-year period, and temperature effect. 316L stainless steel materials shall be provided for all exhaust applications. The use of 304 stainless steel or aluminum materials shall be provided for all supply air applications.

b. Airflow sensors shall be of a multi-point averaging type, 304 stainless steel for all supply and general exhaust applications, 316L stainless steel for all fume hood, canopy, snorkel, and biosafety cabinet applications. Single point sensors are not acceptable.

C. EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER

1. The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.
2. During normal operation the airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within:
   a. 1 second or less with high speed actuation
   b. 60 seconds for standard speed actuation
3. The airflow control device shall store its control algorithms in non-volatile, re-writeable memory. The device shall be able to stand-alone or to be networked with other room-level digital airflow control devices using an industry standard protocol.
4. Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed control architecture. Critical control functions shall be implemented locally; no separate room-level controller shall be required.
5. The airflow control device shall use industry standard 24 VAC power.
6. The airflow control device shall have provisions to connect a Controls Workbench commissioning tool and every node on the network shall be accessible from any point in the system.
7. The airflow control device shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control occupancy control, emergency control, and non-network sensors switches and control devices. At a minimum, the airflow controller shall have:
   a. Three universal inputs capable of accepting 0 to 10 VAC, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.
   b. One digital input capable of accepting a dry contact or logic level signal input.
   c. Two analog outputs capable of developing either a 0 to 10 VAC @ 1 mA (10Kohm min) or 4 to 20 mA (500 ohm max) linear control signal.
   d. One Form C (SPDT) relay output capable of driving up to 1 A @ 24 VAC/VAC.
8. The airflow control device shall meet FCC Part 15 Subpart J Class A, CE, and CSA Listed per file #228219.
9. The airflow control device shall be ROHS compliant

D. SHUT-OFF AIRFLOW CONTROL DEVICE

1. Two types of shut-off air flow devices shall be available; standard shut-off (no gasket) and low leakage shut-off (with gasket).
2. The shut-off airflow control device shall have shut-off leakage and casing leakage of no greater than the following (with 5.0" WC static pressure):

Shut-off Valve Type and Airflow Range	Shut-off Leakage	Casing Leakage
Standard shut-off devices up to 1600 CFM (472 l/s)	6 CFM	0.060 CFM
Low leakage shut-off devices up to 850 CFM (472 l/s)	0.005 CFM	
Low leakage shut-off devices up to 1,300 CFM (708 l/s)	0.010 CFM	

3. Manufacturer shall provide comprehensive leakage charts generated from ASME N510 pressure decay testing. Standard shut-off devices shall be tested up to and including 5" WC static pressure. Low-leakage shut-off devices shall be tested up to and including 30" WC static pressure.

E. TWO-POSITION EXHAUST AIRFLOW CONTROL DEVICE

The airflow control device shall maintain a factory characterized fixed maximum and minimum flow set point based on a remote contact/sash switch for electronic valves or a switched 0 to 20 psi pneumatic signal for pneumatic valves. Two-position devices requiring feedback shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow. All two-position devices shall be either networked or hard-wired into the room-level network so as to be considered under pressurization control.

F. LABORATORY OFFICE AIRFLOW CONTROL DEVICE

The airflow control device shall maintain a temperature set point by controlling the airflow and the reheat valve (if required) in response to a room temperature sensor. An additional output shall be provided for supplementary cooling or heating of the office space. If the office airflow supply device is not required for make-up airflow control for fume hoods, then the one-second speed of response and fail-safe conditions required of the LACS shall not apply.

G. CONSTANT VOLUME AIRFLOW CONTROL DEVICE

1. The airflow control device shall maintain a constant airflow set point. It shall be factory characterized and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow.
2. LACS suppliers not employing constant volume venturi airflow control valves shall provide pneumatic tubing or electrical wiring as required for their devices.

H. LOCAL DISPLAY UNIT

1. The control system shall have an optional local display option that allows monitoring and control of system variables to be displayed on a user interface terminal device.
2. The display unit shall be a touch screen monitor that shall connect to the room level devices through a Controls Room Controller or Room Integrator.
3. The display unit shall be powered by 24 VAC.
4. The Local Display Unit shall have the provisions of being flush mounted or surface mounted directly to a standard electrical enclosure. Electrical conductors shall terminate inside the display module housing to a pluggable terminal block.
5. The enclosure shall be made from material that is resistant to chemicals that are typically used in the lab for wipe down and general cleaning agents.
6. The unit's exposed surfaces shall be chemically resistant to vaporized hydrogen peroxide (VHP), formaldehyde, chloride dioxide (clidox), percholoric acid, sodium hypochloride/ hypochlorite 3-6% (bleach), and quaternary ammonium 7% in 1:128 tap water (ammonia).
7. The display unit shall be rated for use in areas where IP54 rating is required.
8. The display unit shall utilize a touchscreen display with optional color schemes to adapt the display to various lighting conditions.
9. The display unit shall provide a means of entering and displaying a unique location descriptor (device ID)
10. The display unit shall allow access to pertinent flow, temperature, humidity, pressure data, as well as occupancy and emergency mode control status, and current device or system alarm status. Data shall be viewable in units of measure appropriate for users of the system.
11. The display unit shall have the ability to display up to 48 parameters, on two screens organized into display screens of up to 6 tiles, and up to 4 points per tile (24 parameters per page and up to 2 pages).
    a. Present value, which may be read directly off the network, or conditioned with a fixed multiplier and/or offset to scale the value for the desired units of measure.
    b. Units of measure, which are configurable based on local user conventions.
12. Set points and editable control parameters shall be viewable on the View. The user shall have the ability to provide four levels of access. There will be three levels of PIN code access to prevent unauthorized changes to set points and editable control parameters.
13. Monitor shall have the ability to locally display alarms for:
    a. Numeric High and Low limits
    b. Binary inputs (alarm selectable for True or False state)
    c. Multistate alarms (alarmable on all but one state)
14. Alarms shall have adjustable volume and the ability to be muted for situations where a visual alarm is acceptable or an audible alarm is not desired.

I. FUME HOOD DISPLAY

1. The display screen shall be a LCD resistive touch screen.
2. The touch screen shall support input configurations for fume hood operational parameters done at the touch panel and at a minimum including:
   a. Sash Dimensions
   b. Hood ID

c. Hood Certification Reminder
d. Hood Occupancy Status
e. Stopwatch/Timer
f. Message Display

3. Hood configuration for the following properties shall be viewable and editable from the touch display:
   a. Sash Dimensions
   b. Hood ID
   c. Hood Certification Reminder
   d. Hood Occupancy Status
   e. Stopwatch/Timer
   f. Message Display

4. The enclosure shall be made from material that is resistant to chemicals that are typically used in the lab for wipe down and general cleaning agents.
5. The unit's exposed surfaces shall be chemically resistant to vaporized hydrogen peroxide (VHP), formaldehyde, chloride dioxide (clidox), percholoric acid, sodium hypochloride/ hypochlorite 3-6% (bleach), and quaternary ammonium 7% in 1:128 tap water (ammonia).
6. Two mechanical membrane buttons shall be provided at the front panel of the display to enable users to quickly activate emergency exhaust mode and mute without having to remove protective gloves.
7. Flush mount or recess mount shall be installation options.
8. A USB port shall be provided to support firmware and software upgrades and shall be covered to protect against moisture or corrosion.
9. A timer feature shall be provided to enable users to set specific time to time the duration for experiments and provide visual and audible alarms when the set time is expired.
10. The fume hood display shall have an available I/O at its associated controller which may be used to receive a 0 – 10 volt signal from a Through-The-Wall (TTW) sensor. The TTW shall not control the valve but provide a drift alert to indicate when the TTW sensor reading is out of range relative to the sash position face velocity value.

11. POWER
    a. The device shall be powered by 24 VAC $\pm$ 15% at 10VA, 50/60 Hz.

12. CONFIGURATION
    a. Configuration shall be performed from the touch display and/or manufacturer's software tools.
    b. The device shall be capable of being added to an existing LON communication network.
    c. The device shall display fume hood performance data based on control logics embedded inside the valve controller.

13. COMMUNICATION
    a. The fume hood display unit shall connect to LON communication and link directly to a specific valve controller associated with the hood it is mounted on.
    b. The device shall display fume hood performance data based on the valve controller performance and sash movements over LON.

14. INFORMATION DISPLAY
    a. The device shall have the ability to indicate when the fume hood face velocity is within the normal operating range, energy saving, hood certification, hood ID, timer, and hood occupancy status.
    b. The device shall be configurable to display one of the following measurement units: cubic feet per minute (CFM), meters cubed per hour (m^3/h), liters per second (l/s), feet per minute (fpm), or meters per second (m/s).
    c. The device shall have the ability to display system errors caused by the airflow valve or sash travel.
    d. The device shall have the ability to indicate to users that the hood is due for recertification and shall provide a visible notification at the LCD display stating "Fume Hood Certification is due or expired."

15. EMERGENCY (PURGE) EXHAUST
    a. The display shall have a mechanical membrane button on the lower portion that when pressed will initiate an emergency (purge) exhaust mode in the attached fume hood valve(s).
        1) Button shall be mechanical so that users with rubber, nitrile, vinyl, latex, or other gloves can operate the emergency exhaust button
    b. The emergency (purge) exhaust mode, when initiated, will send the attached fume hood exhaust valves to either the maximum flow of the valve, or other predefined flow (as configured in the fume hood valve)

16. ALARMS
    a. The device shall have the ability to show alarms on the main screen using visual and audible alerts.
    b. The main screen background color shall change to flashing red with text stating the type of alarm.
    c. In alarm state, the enunciator shall remain active until the event that triggered the alarm is removed or fixed.
    d. The device shall have the ability to show Diversity alarm.
        1) Diversity alarm shall be generated by the valve or from the BMS system.
        2) No audible tone for diversity alarm shall be generated at the fume hood display.
    e. The device shall have the ability to have customizable audible alarms levels and customizable mute duration.
    f. Users shall have the ability to change the volume of the alarm tone to low, medium, or high.
    g. The device shall have an Alarm Muting option, which silences the audible alarm for an adjustable time period when the mute button is pushed. If another alarm is generated during the mute period, the new alarm shall override the mute delay and the alarm shall sound again.
    h. The alarm tone shall be cleared only when the event that triggered the alarm is removed or fixed.

17. ENERGY CONSERVATION
    a. The device shall have the ability to enable fume hood hibernation mode.
        1) When activated the exhaust flow through the fume hood goes to the minimum allowed by the exhaust valve (or shut-off where available) when the sash is fully closed and no chemicals are present in the hood.
        2) The mode shall be initiated by a sequence including entering the menu and a password on the touch display, an external momentary switch input to the fume hood controller, or a network command via BMS or BAS.
        3) When activated, the LCD display shall show “Hood in Hibernation,” and the exhaust valve shall move to its minimum position or shutoff position.
        4) Safety shall be built into the hibernation mode, whereby opening the fume hood sash shall automatically return the fume hood exhaust to an in-use operating volume as determined by the sash sensor. Fume hood hibernation shall be a point that can be integrated to the BMS or BAS system.
    b. The device shall provide night time energy waste alarming to generate a visual and audible alarm to indicate that the fume hood sash is open beyond its minimum flow position and the lights in the room are off.
        1) When activated, the LCD display shall show “Energy Waste Close Sash” and the audible alarm shall sound until the sash is closed.
        2) The light levels at which the alarm is both initiated and cancelled shall be configurable.
    c. The device shall provide sash energy waste alarming, which generates a visual and audible alert to notify when the fume hood sash is open beyond a configurable set position and no one is in front of the fume hood.
        1) When activated, the LCD display shall show “Energy Waste Close Sash” and remain until the sash is closed.

18. SECURITY
    End users shall have the ability to enable a PIN pass code to prevent unauthorized changes to sash heights, air flow settings and other editable parameters.

19. COMPLIANCE
    a. The unit shall be certified as meeting regulatory compliance with CE, CUL, and RoHS.
    b. The unit shall be suitable for use with non-solvent wipe down and is designed to meet IP44 test standards.
    c. The device shall comply with part 15 of the FCC Rules. Operation is subject to the following two conditions:
    d. This device shall not cause harmful interference.
    e. This device shall accept any interference received, including interference that may cause undesired operation.

20. ENVIRONMENT
    The operating temperature range shall be between 32 – 122°F (0 – 50°C).

2.03 ACCEPTABLE MANUFACTURERS

A. Manufacturer List
   1. Phoenix (Basis of Design)
   2. Price
   3. Tek-Air
   4. Triatek
   5. No substitutions without prior owner approval

B. Substitute Limitations
   1. In strict accordance with this specification, alternative LACS and equipment shall only be considered for approval provided that the equipment be equal in every respect to the operational characteristics, capacities and intent of control sequences specified herein. Approval to bid does not relieve the LACS supplier from complying with the minimum requirements or intent of this specification.
   2. The engineer and owner shall be the sole judges of quality and equivalence of equipment, materials, methods and life cycle cost.
   3. Only those systems specifically named in this specification or by addendum shall be considered for approval. Other systems submitted after the bid opening will be returned without review.
   4. Compliance Schedule
      a. Any alternate LACS supplier shall provide a separate compliance schedule, which shall include the section, paragraph and subparagraph of these specifications, and a direct statement to indicate compliance or noncompliance with the requirements. For all areas of noncompliance, the supplier shall describe what specific and alternative approach or approaches has been taken and document the impact this will have on the sizing of the air delivery systems, the required cooling and heating capacities, energy costs and maintenance of the building.
      b. The alternate LACS supplier shall furnish a letter of compliance to the engineer, signed by a corporate officer of the laboratory system manufacturer, certifying the compliance and noncompliance items as stated above 10 days prior to the bid.
   5. Technical Proposal
      Any alternate LACS supplier shall submit a detailed technical proposal for the owner's evaluation at the time of bid. The proposal shall describe the manner of compliance with this minimum performance specification, with particular emphasis on the following areas: diversity and energy analysis, proposed equipment, experience and performance verification. Proposed Equipment
      The alternate LACS supplier shall provide a detailed proposal describing all elements of the laboratory control system. A schematic laboratory layout shall be provided, showing relations of these elements and a description of how they interact.
      Technical specification data sheets shall be provided for all proposed system components and devices.
      All proposed airflow control devices shall include discharge, exhaust and radiated sound power level performance obtained from testing in accordance with ARI Standard 880.
      a. Experience
      The LACS supplier shall provide a list of at least three similar LACS installed in the state or province as part of this proposal.

The LACS supplier shall provide the names, addresses and telephone numbers of the consulting engineer and the owner's representative for each of these installations. It is understood that these individuals may be contacted regarding timely delivery, the quality of installation, the operation and performance of the equipment and the service requirements for each installation. Unsatisfactory performance or inability to provide references shall be grounds for rejection.

b. Performance Variation
If desired and upon request by owner, the LACS supplier shall demonstrate a typical laboratory space that includes multiple fume hoods, a general exhaust and a supply airflow control device for the purpose of verifying the LACS's ability to meet the performance requirements indicated in this specification. All travel and lodging costs to witness the performance verification shall be the responsibility of the LACS supplier.

The LACS supplier shall provide at no additional cost to the owner during and after the warranty period five years of required preventive maintenance on all airflow sensors (e.g., pitot tube, flow cross, orifice ring, air bar, hot wire, vortex shedder, etc.) and flow transducers provided under this section. Airflow sensors shall be removed, inspected, and cleaned annually during the five-year period to prevent inaccuracies due to long-term buildup from corrosion, lab tissues, wet or sticky particles, or other materials that foul the sensor. If impractical to remove the airflow sensors, the LACS supplier shall include in the proposal the cost of supplying and installing duct access doors, one for each sensor. The transducer shall be checked and recalibrated annually to ensure long-term accuracy. Note that auto-zero recalibration of transducers is not acceptable as a substitute for annual recalibration.

c. The LACS supplier shall provide the total system cost of proposed equal to Phoenix Controls system. This will include:
   i. Cost to commission the equipment
   ii. Cost to integrate the components to the BMS or BAS system
   iii. Cost of wiring for equal controls sequences of equipment
   iv. Cost to balance equipment
   v. Costs associated with commissioning agents and final acceptance tests

2.04 PERFORMANCE/DESIGN CRITERIA

A. Each laboratory shall have a dedicated LACS. Each dedicated LACS shall support a minimum of 20 network controlled airflow devices.

B. The LACS shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood's exhaust airflow to maintain a constant face velocity over a minimum range of 20% to 100% of sash travel. The corresponding minimum hood exhaust flow turndown ratio shall be 5 to 1. Use of Sidewall Sensors or Through The Wall (TTW) sensors to control the face velocity are unacceptable.

C. The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90% of its commanded value within one second of the sash reaching 90% of its final position (with no more than 5% overshoot/undershoot) of required airflow. Rate of sash movement shall be from one to one and one-half feet per second.

D. The hood exhaust airflow control device shall be switched automatically between in-use and standby levels based on the operator's presence immediately in front of the hood. A presence and motion sensor shall activate the switching. The airflow control device shall achieve the required in-use commanded value in less than one second from the moment of detection with no more than a 5% overshoot or undershoot.

E. The LACS shall maintain specific airflow (±5% of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change, airflow change or quantity of airflow control devices on the manifold (within 0.6" to 3.0" wc).

F. The LACS shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions, such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure. Systems using differential pressure measurement or velocity measurement to control room pressurization are unacceptable.

G. The LACS shall maintain specific airflow (±5% of signal) with a minimum turndown as specified in 2.2.B.4 to ensure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

H. Airflow Control Sound Specification

1. The LACS manufacturer shall provide comprehensive sound power level data for each size airflow control device. All data shall be obtained from testing in accordance with ASHRAE/ANSI Standard 130, Methods of Testing Air Terminal Units.
2. All proposed airflow control devices shall include discharge, exhaust and radiated sound power level performance.
3. If the airflow control device cannot meet the sound power levels required to achieve the sound criteria appropriate for the space, as determined by the engineer, a properly sized sound attenuator must be used. All sound attenuators must be of a packless design (constructed of at least 18 gauge 316L stainless steel when used with fume hood exhaust) with a maximum pressure drop at the device's maximum rated flow rate not to exceed 0.20 inches of water.

2.05 OPERATION SEQUENCES

A. The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Master-slave control schemes shall not be acceptable. Control functions shall include, at a minimum, volumetric offset pressurization, temperature, humidity control, as well as respond to hood flow demands, occupancy, and emergency control commands.

B. Volumetric Offset Pressurization Control

The laboratory control system shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure (within specified range for medium or low pressure valves). This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.

The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. The offset shall be adjustable as a configurable parameter in the LACS as set by startup technician or BMS/BAS.

The pressurization control algorithm shall consider both networked devices, as well as:
Up to three non-networked devices providing a linear analog flow signal.
Any number of constant volume devices where the total of supply devices and the total of exhaust devices may be factored into the pressurization control algorithm.

Volumetric offset shall be the only acceptable means of controlling room pressurization. Systems that rely on differential pressure as a means of control shall provide documentation to demonstrate that space pressurization can be maintained if fume hood sashes are changed at the same time a door to the space is opened.

The volumetric offset control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.

C. Temperature Control

1. Standard Primary Temperature Control

The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The laboratory control system shall support up to four separate temperature zones for each pressurization zone. Each zone shall have provisions for monitoring up to five temperature inputs and calculating a straight-line average to be used for control purposes. Separate cooling and heating set points shall be writeable from the BMS, with the option of a local offset adjustment.
Temperature control shall be implemented through the use of independent primary cooling and heating control functions. Primary heating shall be provided through modulating control of a properly sized reheat coil. Primary cooling shall be provided as a function of volumetric override or through auxiliary modulating control of a chilled water valve. Volumetric override will command both supply and

general exhaust valves to maintain desired offset as a high select zone control. Volumetric cooling override may be staged before or after chilled water control valve.

2. Advanced Temperature Control (ATC) or Cascade Control
   The primary temperature control loop for the lab is based on a comparison between the discharge air temperature and the set point for the discharge air. The space temperature measured by a wall sensor is used to reset the set point for discharge air. The set point may be calculated automatically by using "Adaptive Set Point Range". Another method enabling "Exhaust Air Temperature Adjustment" will calculate the difference between space temperature and exhaust temperature (within 2.7 degrees F) to reset the set point for the discharge air. The reset schedule for the set point is driven by a small window of temperature above and below the desired room temperature in the space.
3. Thermal Anticipatory Control (BTU Compensation)Thermal
   Anticipatory Control monitors discharge air temperature sensors, space temperature sensors, and discharge air flow to respond to significant (programmable) changes in air flow to immediately adjust temperature control.

D. Humidity Control
   The laboratory control system shall have an embedded humidity control function, which allows the monitoring and control of the relative humidity level in the pressurized zone. Using peer-to-peer control, the airflow devices shall have the ability to monitor the relative humidity level of the space and, based on a BMS writeable set point, develop a control signal to drive one or the other humidification or dehumidification control circuits.
   The humidity control loop(s) shall share a common set point, with a configurable deadband adjustment to prevent the humidification and dehumidification control functions to operate at the same time. A Dew Point Sensor contact can be used to manually reset or disable humidification/dehumidification output as "Humidity PID Reset". The contact can reset automatically, use a timed latch, or BMS command to reset.

E. Occupancy Control
   The laboratory control system shall have the ability to change the minimum ventilation and/or temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state may be set by either the BMS as a scheduled event or through the use of a local occupancy sensor or switch. The laboratory control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied for a predetermined interval. The override interval shall be configurable from one to 1440 minutes. The local occupancy sensor/switch or bypass button shall be given priority over a BMS command.

F. Emergency Mode Control
   The laboratory control system shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists, and airflow control devices are to be driven to a specific flow set point. The system shall support up to four emergency control modes (zone or valve level). The emergency control modes may be initiated either by a local contact input or BMS command. Valve level emergency modes can be individually programmed on each valve as one of four emergency control modes. Zone level emergency modes will drive supply and exhaust valves to maintain or ignore zone offset (excludes control of hood valves).
   Once an emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.

G. Local Alarm Control
   The laboratory control system shall provide the means of summing selective alarm activity at the room-level network and generating a local alarm signal. The local alarm signal may be directed to any available output, as well as to the BMS. The alarm mask may be configured differently for each room-level system.

H. Shut-off Control (Standard and Low Leakage Shut-off Valves Only)
   The laboratory control systems shall provide means of commanding air flow devices to shut-off sequence in one of four modes.
   1. Emergency Mode Control: The shut-off sequence can be initiated locally through a universal input or remotely from the BMS or other controller such as Local Display Unit (LDU) using emergency mode(s). Fume hood air flow devices cannot be controlled locally using a universal input (See mode 2 below).

2. Hibernation Mode Control: The shut-off sequence can be initiated on a fume hood air flow device using hibernation mode in conjunction with a FHM631 fume hood monitor in one of three methods: local contact closure, pushbutton sequence using faceplate of fume hood monitor, or remotely via BMS.
3. Auto Gex Shut-off Mode Control: The shut-off sequence can be initiated on a general exhaust (Gex) air flow device in a lab environment when the total non-Gex exhaust air flow satisfies minimum air change rate and cooling demand for a period greater than 60 seconds. Shut-off must be enabled on the general exhaust air flow device.
4. IAQ Mode Control: The shut-off sequence can be initiated when exhaust air flow is distributed between a general exhaust and return air flow device. If shut-off is enabled, the general exhaust air flow device will shut when return ratio is 100% and the return air flow device will shut when the return ratio is 0%.

I. Diversity Alarm

The laboratory control system shall have the ability of monitoring the airflow values for the pressurized space and generating an alarm signal in the event the total exhaust flow exceeds a predetermined threshold. The diversity alarm is intended to allow the user to take diversity in the design and generate an alarm condition in the event the diversity threshold is compromised. This function must be available in either an integrated or standalone system.

J. Fume Hood Control

Airflow devices intended to control the face velocity of a fume hood shall have the ability to interface directly with the fume hood monitoring device. The airflow control device shall:

1. Accept command inputs to regulate the flow accordingly and make this command value available to the BMS.
2. Accept a sash position signal and make this value available to the BMS.
3. Accept a Zone Presence Sensor (ZPS) Usage Based Control signal to indicate user presence and make this signal available to the BMS.
4. Provide a flow feedback signal to the fume hood monitor, which may be used for calculating face velocity or to confirm the airflow device has achieved the proper flow rate and make this value available to the BMS.
5. Provide alarm signals to the fume hood monitor in the event the airflow device is unable to achieve the proper flow rate, there is a loss of static pressure indicating improper fan operation, or there is a loss of power to the airflow control device, in order to provide a local alarm indication.

   The fume hood airflow control device shall respond to changes in sash position and user presence within one second without hunting, in order to provide a constant 100-feet-per-minute face velocity when the fume hood is in use.

K. The laboratory control system shall be segregated into subnets to isolate network communications to ensure room-level control functions and BMS communications are carried out reliably. Each laboratory space or pressurization zone shall be on a single subnet. Controls supplied Room Controllers or Room Integrators shall be used to isolate the subnets in a facility where BMS or BAS system is used, providing a maximum of 20 devices per subnet.

L. The LACS shall support at least 20 networked devices in each pressurized zone.

M. All points shall be available through the interface to the BMS for trending, archiving, graphics, alarm notification and status reports. LACS performance (speed, stability and accuracy) shall be unaffected by the quantity of points being monitored, processed or controlled.

N. Refer to the BMS or BAS specification for the required input/output summary for the necessary points to be monitored and/or controlled.

2.06 INTERFACE TO BUILDING MANAGEMENT SYSTEMS

A. The LACS network shall have the capability of digitally interfacing with the BMS. The required software interface drivers shall be developed and housed in a dedicated interface device furnished by the LACS supplier.

B. All room-level points shall be available to the BMS for monitoring or trending as shown in Table 1. The LACS Room Controller, Room Integrator, Room Manager, or Supervisor shall maintain a cache of all points to be monitored by the BMS. The room-level airflow control devices shall update this cache continually.

C. The Room-level network shall be LonTalk FTT-10A communications protocol.
D. Room Level Integration:
The room Level Integration device shall be a Controls Room Integrator or equivalent. Room Level Integration device shall be a standalone piece of hardware with embedded Power PC platform (@400MHz or greater), operating on QNX Real-time Operating system and will be used for commissioning and configuration of Venturi valves and ancillary components such as Fume Hood Displays, and Input Output (I/O) modules when connected to a Controls Workbench, Room Manager, or Supervisor.

After the Room Level Interface is commissioned it shall provide a web based user interface for device, network, and platform diagnostics as well as a Test and Balance web application for zone balance and airflow validation. Room Level interface will also provide a means of integrating on an open BACnet network via IP, Ethernet, or MS/TP to be field selectable at time of commissioning.

Room Level Integration device shall operate with the following platform and Operating system:

Platform

- Power PC 405EX 400MHz or greater processor
- 256 MB SDRAM & 128 MB or greater Flash Memory
- Data Recovery Services with SRAM
- Real-time clock

Operating System

- QNX RTOS
- Oracle Hotspot JAVA VM
- Niagara AX 3.7.106 or later
- Niagara 4.0 Ready

Room Level Integration device shall support a combination of the following network connection ports and communication protocols as standard or orderable options:

- 2 Ethernet Ports (RJ-45 Connectors) – 10/100 Mbps
- 1 RS-232 Port (9 pin D-shell connector)
- 1 RS-485 on board port (3 Screw Connector on base board)
- 2 Dual port RS-485 expansion adapters
- 2 LON adapters 78 Kbps FTT 10
- BAS protocol: BACnet over Ethernet, or BACnet over IP, or BACnet over MS/TP
- BAS Implementation: Conformance Class 3 BIBBS-BBC (BACnet Building Controller)
- BAS data transfer rates (points per second): Read requests – 50 sustained, 100 peak; Write commands – 30 maximum
- Room network: ANSI 709.1 LonTalk protocol

If the room level integration device drops off the network or loses power, it shall not cause the zone balance, temperature control, or fume hood devices to lose control. The room level valve devices should operate independently of the room level integration device.

Room Level Integrator shall be able to integrate to BAS shall be through BACnet/IP, BACnet/Ethernet, BACnet MS/TP, or LON through on board communication adapters and shall be field configurable/upgradable.

Room Manager:

For buildings that require a single IP address to interface to the Building Management system (BMS) or Building Automation system (BAS) or where a local access point for all the Controls Room Integrators, Room Controllers, Valves and Ancillary components is necessary, a Controls Room Manager shall be used. The Room Manager shall house the database wherein all the Room Integrator and Room Controller stations will reside, will provide a single BACnet IP port to be used to connect to the BMS or BAS system, will provide a means to access all the Controls valve and Fume Hood Display configuration data, input/output module

programming, diagnostic views, Lab Verification tools, as well as a central location to backup all the configuration data, valve characterization data, and balancing reports as generated from the Controls Lab Verification Tool.

The Room Manager software shall operate on a physical Personal Computer or on a Virtual machine:

The Controls Room Manager shall be field upgradable to a Controls Supervisor product where long term data storage, graphical display dashboards, SQL server storage, energy management data regarding the controls equipment and attached ancillary systems within a critical environment will be displayed for read and write access to device variables and available setpoints.

Supervisor:

For buildings that require a graphical dashboard display of their Controls Celeris valves and attached ancillary systems, and where long term data storage, trending, energy management actionable data, ACH ranking, Hood waste ranking, SQL data storage, single IP address to interface to the Building Management system (BMS) or Building Automation system (BAS) or where a local access point for all the Controls Room Integrators, Room Controllers, Valves and Ancillary components is necessary, a Controls Supervisor shall be used. The Supervisor shall house the database wherein all the Room Integrator and Room Controller stations will reside, will provide a single BACnet IP port to be used to connect to the BMS or BAS system (where applicable), will provide a means to access all the Controls valve and Fume Hood Display configuration data, Input/Output module programming, diagnostic views, Lab Verification tools, as well as a central location to backup all the configuration data, valve characterization data, and balancing reports as generated from the Controls Lab Verification Tool. Supervisor shall also provide data logging, historical data trending, standard reports, built in alarm monitoring console, security and password protection utilizing java authentication and encryption techniques, and shall support standard Niagara objects and feature set for additional programming. The Supervisor software shall operate on a physical Personal Computer.

E. .

Table 1. Typical Integration Points List (not all-inclusive)

Point Description	**Read/Write**		**Point Description**	**Read/Write**
Valve-Level (per Valve)			*Temperature Control (per Zone)*	
Flow Set Point	Read Only		Space Temperature	Read Only
Flow Feedback	Read Only		Avg Space Temperature	Read Only
Jam Alarm	Read Only		Discharge Air Temperature	Read Only
Flow Alarm	Read Only		Duct Temperature	Read Only
User Definable Inputs/Outputs	Read/Write		Temperature Set Points (7)	Read/Write
User Definable Alarm Points	Read Only		Effective Temp Set Points (3)	Read Only
Zone Balance Control (per Zone)			Offset Lever Enable	Read/Write
Occupied Min Ventilation Rate	Read/Write		Offset Lever Percent of Range	Read/Write
Unoccupied Min Ventilation Rate	Read/Write		Cooling Demand	Read Only
Offset	Read Only		Heating Demand	Read Only
Offset Set Point	Read/Write		Heat Delivered (BTU)	Read Only
MAV Command & Feedback	Read Only		Auxiliary Temp Control Demand	Read Only
GEX Command & Feedback	Read Only		*Humidity Control (per Zone)*	
Return Command & Feedback	Read Only		Space Humidity	Read Only
Total Zone Supply Flow	Read Only		Humidity Set Point	Read/Write
Total Zone Exhaust Flow	Read Only		Humidity Demand	Read Only
Total Hood Flow Feedback	Read Only		Active Pressure Control (per Zone)*	

Diversity Alarm	Read Only		Zone Pressure	Read Only
Fume Hood Control (per Hood Valve)			*Progressive Offset Control (POC)*	
Face Velocity	Read Only		Effective Pressure Set Point	Read/Write
Face Velocity Set Point	Read Only		Pressure Warning Set Point	Read/Write
Sash Opening Percentage	Read Only		Pressure Alarm Set Point	Read/Write
User Status	Read Only		Zone Pressure Alarm	Read Only
Hood Override Alarm	Read Only		Sensor Failure Alarm	Read Only
Hibernation Mode (nviRemoteDI[0])	Read/Write		Freeze Mode Time Set Point	Read/Write
Sash Height Alarm	Read Only		Freeze Mode Time Remaining	Read Only
Broken Sash Cable Alarm	Read Only		Freeze Mode Offset Set Point	Read/Write
Sash Switch Status	Read Only		Effective Pressure Control State	Read Only
Emergency Mode (per Zone)			**Points are only available on systems using Active Pressure Control (see Article 2.7)*	
Emergency Mode Override	Read/Write			
Emergency Mode State	Read Only			
Occupancy Control (per Zone)				
Occupancy Override	Read/Write			
Occupancy State	Read Only			

NOTE: The following Articles 2.7 to 2.11 are OPTIONAL and only apply to projects that include spaces requiring active pressure control (not volumetric offset control) such as pharmaceutical manufacturing clean rooms and bio-safety rooms. These Articles do NOT apply to laboratories containing fume hoods.

F. LACS critical environment integration shall support distributed network architecture from room level BACnet MS/TP segment or LON FTT-10 bus to a dedicated BACnet MS/TP segment, building BACnet/Ethernet, or BACnet/IP building backbone using single or multiple IP addresses. Backbone communication protocol must be field selectable/upgradable.

G. Communication between devices in a room or zone will operate independent of building level communications maintaining integrity of the airflow. LACS Building level communication, or loss of, will not disrupt the communication between devices in a room or zone.

H. LACS critical environment integration shall provide an easy means to access room level device health status at a room-by-room or building wide level via web page. The system health pages shall provide information to assist in diagnostics for:
   1. Online/Offline status for the room level integration appliance.
   2. Runtime information such as heap memory usage and CPU usage.
   3. Communication channel online/offline and configuration data.
   4. Device level online/offline information.
   5. Device level alarm information.
   6. Device level Configuration errors.

I. LACS critical environment integration shall provide an easy means to access a Test and Balance function tool at a room-by-room or building wide level via web page. Test and balance functions should include:
   1. Setting the devices in the room to various conditions in order to read airflow.
   2. Manually override the outputs for testing purposes.
   3. Adjust airflow to meet field acceptance tests.
   4. Output a report for airflow performance test.

J. LACS critical environment integration must be able to support SQL database for long term data storage.

K. LACS critical environment integration shall provide optional software to manage local backup and restore, entire site device management, building wide test and balance functions, building wide diagnostic tools, and building wide configuration tools. Software shall be field upgradable to support graphical dashboard displays.

2.07 USER INTERFACE

A. General

1. LACS supplier shall provide browser-accessed dashboards that can support unlimited simultaneous users as part of standard installation for viewing of LACS data on a web connected display, kiosk, or personal computer. Dashboard server within the LACS system shall be Controls Supervisor or Portal products.
15. Dashboards can share information with the BAS server and other BACnet IP field devices for the control system.
16. For small systems with 500 or fewer points, the dashboard software shall run on a Controls Portal or Supervisor.
17. For large systems with greater than 500 points, the dashboard software shall run on a Controls Supervisor. This software can reside on an owner-provided PC. Minimum PC platform requirements are:
    a. Processor: Intel Pentium® IV, 2 GHz or higher, Core 2 Duo also acceptable
    b. Operating System: Microsoft® Windows® XP Professional SP3 32-bit, Windows 2008 Server (if Microsoft IIS is disabled) 64-bit, Microsoft Windows 7 Professional 32-bit or 64-bit, Microsoft Windows 7 Enterprise 32-bit or 64-bit
    c. Memory: 1 GB minimum, 2GB or more recommended for large systems, 8 GB or more recommended for the Windows 64-bit version
    d. Hard Drive: 1 GB minimum, 5 GB for applications that need more archiving capacity
    e. Display: Video card and monitor capable of displaying 1024 x 768 pixel resolution or greater
    f. Network Support: Ethernet adapter (10/100 Mb with RJ-45 connector) and Ethernet driver support for BACnet I/P
    g. Network Connectivity: Full-time high-speed ISP connection recommended for remote site access (i.e., T1, ADSL, cable modem)
18. Web Browsers supported: Microsoft Internet Explorer® 9 or later, Google Chrome 24 or later, Mozilla Firefox® 18 or later, Apple Safari 5.1.7 for Windows or later.
19. Dashboard shall auto-discover LACS device points and other BACnet MS/TP field devices on the same network. Only those points used in displays and/or for calculations count against the point license limit. A point may be displayed on multiple dashboard pages and/or used in multiple calculations and it only counts as one point toward the point license limit.

B. Information Display

8. The web-based dashboard information screens shall:
    a. Support displaying up to at least 12,000 device points from the control system.
    b. Allow navigation by clicking on pre-configured tabs (e.g. Energy, Safety, and Building Health) and/or navigate via a 'tree' structure (e.g. building/floor/room) without the need for any additional user configuration.
    c. Support kiosk or lobby displays with little user interface (for example, touchscreen with no mouse or keyboard). The pages to be displayed per unique log-in credentials can be selected as a subset of all possible pages in the dashboard.
    d. Support site-specific customization which can include:
        i. Home page – Displaying building name(s)
        ii. Building page – For each building containing LACS equipment
        iii. Floor page – For each floor of each building that contains LACS equipment
        iv. Room page – For each room of each floor of each building that contains LACS equipment
        v. Energy Tab – Displaying Total Hood Flow, Total Supply, Air Changes per Hour, and Cause for Air Change Rates
        vi. Safety Tab – Displaying Room Offset, Air Quality Data (when present), Hood Face Velocity, Hood Exhaust Flow, Sash Opening, and Hood User Status
        vii. Room Status – Displaying Room Humidity, Room Temperature, Heating Setpoint, Cooling Setpoint, Device Alarm Status, Occupancy Status, Zone Balance Setpoint, Zone Offset, Total Zone Supply, Total Zone Exhaust, Emergency Mode, and Emergency Mode Command
    e. The end user shall be able to create additional pages and tag them as Favorites.
    f. The end user shall be able to view current and cumulative historical data on one of the following time scales:

Cumulative data for today, displayed in hour increments.
Cumulative data for the current week, displayed in daily increments.
Cumulative data for the current month, displayed in daily increments.
Cumulative data for the current year, displayed in monthly increments.
User can easily select a custom time frame by defining a range on the graph.

C. Dashboard Data
   8. Large systems with greater than 500 displayed points:
      a. The database for the dashboard can be stored on the host computer or located on the enterprise network running a Controls Supervisor. The database should be located on-site to maintain security and privacy.
      b. Data storage limitations shall be determined by the size of the drive on the host computer or enterprise network and the amount of data being stored.
   9. Small systems with less than 500 displayed points:
      a. The database for the dashboard shall be on the Controls Portal hardware device itself.
      b. Data storage limitations shall be determined by the size of the hardware device's storage capability.
   10. Dashboard data shall reside on site.
   11. The dashboard shall support Microsoft SQL database.

D. Dashboard Licensing
   8. The Dashboard shall utilize software licensing that will run in perpetuity.

E. Configuration
   8. End users shall be able to connect remotely (including dashboard location) to the system to make changes to the configuration using a browser
   9. Dashboard shall be maintainable by end-user staff with limited training.
   10. User generated/supplied content to include foreground images, background images, text, icons and support common image files including JPEG, PDF, and PNG.
   11. The system designer shall be able to configure:
      a. One or more home pages.
      b. One or more summary consumption pages. This page shows the total consumption for each configured entity within the system and a total for the entire enterprise.
      c. One or more current demand pages. This page shows the current demand for a given entity.
   12. Support ability to add additional capacity (more buildings, more devices) up to at least 12,000 points.

F. Security
   8. Dashboard access shall require at a minimum a user name and password to gain either Read or Read/Write access.
   9. The dashboard shall have the ability to restrict data behind a firewall or within a DMZ.
   10. The dashboard application shall not allow the user to update the system data. For example, the user shall not be allowed to update the present-value of an analog-value.
   11. The dashboard shall require a user authorization via user name and password to access the configuration screens.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The building management system (BMS) or building automation system (BAS) contractor shall install the sash sensors, interface boxes, presence and motion sensor, and fume hood monitor on the fume hood under initial supervision of the LACS supplier. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels or use of fixed sash sensors with take up reels is also permitted. Sash interface boxes with interface cards shall be mounted in an accessible location.

B. The BMS contractor shall install all Room Controllers and Room Integrators in an accessible location in or around the designated laboratory room.

C. The BMS shall install an appropriately sized and fused 24 VAC transformer suitable for NEC Class II wiring.

D. All cable shall be furnished and installed by the BMS contractor. The BMS contractor shall terminate and connect all cables as required. The BMS shall utilize cables specifically recommended by the laboratory airflow controls supplier.
E. The mechanical contractor shall install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.
F. The mechanical contractor shall provide and install all reheat coils, Neutralizers, Silencers, and transitions.
G. The mechanical contractor shall provide and install insulation as required.
H. Each pressurization zone shall have either a dedicated, single-phase primary circuit or a secondary circuit disconnect.

3.02 SYSTEM START UP

A. System start-up shall be provided by a factory-authorized representative of the LACS manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash sensing equipment, as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, make-up, general exhaust or return), system programming and integration to BMS (when applicable).
B. The balancing contractor shall be responsible for final verification and reporting of all airflows. For all field flow measurement devices the balancer shall produce a flow report that documents field flows vs device flow and associated error. This to be tabulated for each device location at several flows including min and max. Cost and responsibility to meet the specified performance to be carried by the LACS.

3.03 CLOSEOUT ACTIVITIES

A. Training
   1. The LACS supplier shall furnish a minimum of eight hours of owner training by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves and general troubleshooting procedures.
   2. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each training attendee.

END OF SECTION 23 09 95.00

SECTION 232111 - PIPING MATERIALS

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 a summary of all Piping Materials related work:

B. Related Sections:

1. 23 21 13 – HYDRONIC PIPING

1.3 HOT WATER PIPING

A. 2 ½" and Larger.

1. Pipe: Standard, A-53 black steel.

2. Fittings: Standard, butt-weld.

B. 2" and Smaller.

1. Pipe: Type "L" copper tubing, hard temper.

2. Fittings: Solder end, cast red brass or wrought copper.

1.4 CHILLED WATER PIPING

A. 2-1/2" and Larger.

1. Pipe: Standard, A-53 black steel.

2. Fittings: Standard, butt-weld.

B. 2" and Smaller.

1. Pipe: Type "L" copper tubing, hard temper.

2. Fittings: Solder end, cast red brass or wrought copper.

1.5 CONDENSING WATER PIPING

A. Above Grade.

1. Pipe: Standard, A-53 black steel.

2. Fittings: Standard, butt-weld.

B. Below Grade.

1. Pipe: Ductile iron, class 350.

2. Flanged Fittings: ANSI A21.10 or A21.15, class 150.

3. Joints: Tyton type.

1.6 MECHANICAL CITY WATER

A. 3" and Smaller

1. Pipe: Hard Temper, Type “L” copper, with solder joints.

2. Fittings: Wrought copper with solder joints.

1.7 GAS PIPING

A. 2-1/2” and Larger in Building.

1. Pipe: Standard, A-53 black steel.

2. Fittings: Standard, butt-weld.

1.8 GAS VENTS

A. 1-1/4” and Larger.

1. Pipe: Standard, A-53 black steel.

2. Fittings: Threaded 150# black malleable iron.

B. 1” and Smaller.

1. Pipe: Type “L” copper tubing, hard temper.

2. Fittings: Solder end, cast red brass or wrought copper.

1.9 DRAIN PIPING

A. Copper Piping.

1. Pipe: Type "L" copper tubing, hard temper.

2. Fittings: Solder end, cast red brass or wrought copper.

B. Steel Piping.

1. Pipe: Standard, A-53 black steel.

2. Fittings: Threaded 150# black malleable iron or 125# black cast iron.

PART 2 – PRODUCTS – (NOT USED)

PART 3 – EXECUTION – (NOT USED)

END OF SECTION 232111

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes piping, special-duty valves, and hydronic specialties for air vent piping, blowdown drain lines and condensate drain piping.

1.2 SUBMITTALS

A. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Grooved joint couplings and fittings shall be shown on drawings and product submittals and shall be specifically identified with the applicable manufacturer's style or series designation.

B. Welding Certificates: Copies of certificates for welding procedures and personnel.

C. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Failed test results and corrective action taken to achieve requirements.

D. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.3 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

C. To assure uniformity and compatibility of piping products in grooved end piping systems, all groove products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer.

D. The grooved coupling manufacturer's factory trained representative shall provide on-site training for contractor's field personnel in use of grooving tools, application of groove and installation of grooved joint products. The manufacturer's representative shall periodically visit the jobsite and review the installation. The Contractor shall remove and replace all joints deemed to be improperly installed.

1.4 COORDINATION

A. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate pipe sleeve installations for foundation wall penetrations.

C. Coordinate pipe fitting pressure classes with products specified in related Sections.

D. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3 Sections.

E. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping for fire wall and floor assemblies.

1.5 EXTRA MATERIALS

A. Water Treatment Chemicals: Furnish sufficient chemicals for initial system startup and for preventive maintenance for one (1) year 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. Pressure-Reducing Valves:

a. Amtrol, Inc.

b. Conbraco Industries, Inc.

c. ITT Bell & Gossett; ITT Fluid Technology Corp.

d. Spence Engineering Company, Inc.

e. Watts Industries, Inc.; Watts Regulators.

2.2 PIPING MATERIALS

A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. DWV Copper Tubing: ASTM B 306, Type DWV.

C. Wrought-Copper Fittings: ASME B16.22. For hot and chilled water piping, Pro-Press fittings rated for 200 PSI operating pressure, 600 PSI test pressure and with 50 year warranty shall be permitted as an acceptable alternative for pipe sizes up to 4 inch system to be per ASTM B16. 18 or ASTM B16.22 with EPDM O-Rings.

D. Wrought-Copper Unions: ASME B16.22.

E. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

F. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.6 VALVES

A. Gate, check, ball, and butterfly and calibrated balancing valves are specified in Division 23 Section 230523.

PART 3 – EXECUTION

3.1 PIPING APPLICATIONS

A. Condensate Drain Lines: Type L drawn-temper copper tubing with soldered joints.

3.2 VALVE APPLICATIONS

A. General Duty Valve Applications: Unless otherwise indicated, use the following valve types:

1. Shutoff Duty: Ball and butterfly valves, (as indicated on the drawings).

B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.

3.3 PIPING INSTALLATIONS

A. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

B. Install drains, consisting of a tee fitting, NPS 3/4 ball drain valve, at low points in piping system mains and elsewhere as required for system drainage.

C. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

D. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

E. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.

F. Anchor piping for proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports." Comply with requirements below for maximum spacing of supports.

B. Install the following pipe attachments:

1 Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.

2. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.

3. Spring hangers to support vertical runs.

4. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

C. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1.	NPS 3/4":	Maximum span, 5 feet; minimum rod size, 1/4 inch.
2.	NPS 1":	Maximum span, 6 feet; minimum rod size, 1/4 inch.
3.	NPS 1-1/2" to 2":	Maximum span, 8 feet; minimum rod size, 3/8 inch.
4.	NPS 2-1/2":	Maximum span, 9 feet; minimum rod size, 3/8 inch.

D. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors

3.5 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, un-insulated and exposed for examination during test.

2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

3. Flush system with clean water. Clean strainers.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.

2. While filling system, use vents installed at high points of system to release trapped air. Use drains installed at low points for complete draining of liquid.

3. Check expansion tanks to determine that they are not air bound and that system is full of water.

4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks. Final test shall hold pressure for eight (8) hours.

6. Prepare written report of testing.

3.6 CLEANING

A. Flush hydronic piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing hydronic piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers.

END OF SECTION 232113

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SECTION 232114 - HOT WATER HEATING SYSTEM

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 DESCRIPTION OF SYSTEM

A. Add loop hot water piping to accommodate improvements associated with this project.

1.3 HOT WATER PIPING SYSTEM EQUIPMENT

A. New Hot Water Boilers: Refer to Section 23 52 16.

B. New Hot Water Pumps: Refer to Section 23 21 23.

C. New Expansion Tanks: Refer to Section 23 05 17.

D. New Heating Coils on Air Handling Unit: Refer to Section 23 73 00.

1.4 VALVES AND SPECIALTIES

A. Furnish and install the valves and specialties as indicated on the drawings.

B. All control valves, etc. to be furnished by the Building Automation Contractor.

C. In branch piping at high points of the system: 1/8" manual air vent cocks.

D. In the mains at high point of system: Anderson, Crane, Fischer, 1/2" automatic air vent traps with cast iron body and bronze float and valve mechanism, and with discharge piped to floor drain.

E. At all low points of piping: A drain valve with hose fitting capped.

1.5 CONNECTIONS

A. Furnish and install the following valves and specialties:

1. At new hot water heating coils:

a. In supply connection to hot water heating coil: A butterfly valve or ball valve, strainer, and ¾" drain valve with hose fitting capped.

b. In return connection to hot water heating coil: A butterfly valve and ¾" drain valve with hose fitting capped.

c. In return connection from the hot water heating coil: An automatic two-way water valve, furnished by Building Automation Contractor, as hereinafter specified.

1.6 INSTRUMENTS

A. Furnish and install the following instruments:

1. In hot water supply and return piping: Wells furnished by the Building Automation Contractor.

2. In the piping, 1/2" pressure-temperature test plugs at the following locations for use with gauges and thermometers specified in Section 23 05 19:

   a. At inlet and outlet of each air handling unit.

PART 2 – PRODUCTS – (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION 232114

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SECTION 232115 - CHILLED WATER SYSTEM

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 DESCRIPTION OF SYSTEM

A. New chilled water piping to accommodate this project.

B. The expanded chilled water system consists of a two-pipe forced circulating system with two primary and two secondary variable speed chilled water pumps, and a supply and return piping system to circulate chilled water from the chiller to the cooling coils in air conditioning units and to return chilled water to the chiller.

C. Chilled water system to be 30% propylene glycol.

1.3 CHILLED WATER SYSTEM EQUIPMENT

A. New Cooling Coils in Air Handling Unit: Refer to Section 23 73 00.

B. New Chilled Water Pumps: Refer to Section 23 21 23.

C. New Chiller: Refer to Section 23 64 16.

1.4 CONNECTIONS

A. Furnish and install the following valves and specialties:

1. At chilled water cooling coils at each new Air Handling Unit:

   a. In supply connection to the bank of chilled water cooling coils: A butterfly or ball valve, strainer, and 3/4" drain valve with hose fitting capped.

   b. In return connection from chilled water cooling coil: A butterfly or ball valve and 3/4" drain valve with hose fitting capped.

   c. In return connection from chilled water cooling coil: An automatic two-way chilled water valve, furnished by Building Automation Contractor, as hereinafter specified.

   d. In inlet to each coil: A ball valve, 3/4" drain valve, and a flange.

   e. In outlet of each coil: A calibrated balancing valve, air vent, a ball valve, and a flange.

2. In new supply and return mains to each new air handling unit: A butterfly valve.

3. In chilled water supply and return mains to each new air handling unit: A differential pressure transmitter.

4. In branch piping, where shown, and at high points of the system: One 1/8" manual air vent cock.

5. In the mains at high points of the system: One Anderson, Crane, Fischer, Hoffman, or equal, 1/2" automatic air vent trap with cast iron body and bronze float and valve mechanism, and with discharge piped to floor drain except at fan coil units air vent discharge shall be piped to fan coil unit drain.

6. Where shown, and at all low points of piping: A 3/4" drain valve with hose fitting capped.

1.5 INSTRUMENTS

A. Furnish and install the following instruments:

1. In the suction and discharge piping at each pump: One (1) pressure gauge.

2. In the piping at the inlet and outlet of evaporator: One (1) 9" industrial stem thermometer.

3. In chilled water supply and return piping: Wells furnished by Building Automation Contractor.

4. In chilled water supply and return piping: One (1) valve outlet for Building Automation Contractor's pressure sensors.

5. In the piping, 1/2" pressure-temperature test plugs at the following locations as specified in Paragraph 23 05 19:

a. At inlet of coil.

b. At outlet of coil.

c. At inlet and outlet of strainer at coil.

d. At inlet and outlet of new temperature control valve at new coil.

1.6 VALVES AND SPECIALTIES

A. Furnish and install valves and specialties as indicated on the drawings.

B. All chilled water control valves, etc. to be furnished by the Building Automation Contractor.

C. In branch piping, where shown, and at high points of the system: One (1) 1/8" manual air vent cock.

D. In the mains at high points of the system: One (1) 2" automatic air vent with discharge piped to floor drain. Refer to Section 23 05 19.

E. Where shown, and at all low points of piping: A 3/4" drain valve with hose fitting capped.

PART 2 – PRODUCTS – (NOT USED)

PART 3 – EXECUTION – (NOT USED)

END OF SECTION 232115

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2 to plus 4 inch w.g. Metal ducts are to include the following:

1. Rectangular ducts and fittings.

2. Single-wall, round spiral-seam ducts and formed fittings.

3. Duct liner.

1.2 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air moving and distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by the Engineer. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.3 SUBMITTALS

A. See Section 230000 General HVAC for requirements for coordination drawings.

B. Shop Drawings: The Sheet Metal Contractor shall prepare ductwork drawings, at a minimum scale of 1/4" = 1'-0", in ACAD Release 2000 or newer edition. Submit an electronic copy of ductwork drawings for review and approval by the Architect/Engineer before coordination drawings are submitted for coordination. Drawings may be submitted to the Architect/Engineer in stages if required to expedite work. Do not proceed with fabrication of ductwork until submitted drawings are approved by the Architect/Engineer

1.4 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with the most current version of 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: Lock-forming quality; complying with ASTM A 653 and having G60 (Z180) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Carbon-Steel Sheets: ASTM A 366 cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

D. Stainless Steel: ASTM A 480, Type 304, and having a No. 2D finish for concealed ducts and mill for exposed ducts.

E. Aluminum Sheets: ASTM B 209, alloy 3003, tempered H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

F. Exposed ductwork shall be suitable for painting (paint grip) in field by General Contractor.

G. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

H. Tie Rods: Galvanized steel, 1/4 inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics.

B. Joint and Seam Tape: 2 inches wide; glass-fiber-reinforced fabric.

C. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.

D. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

E. Solvent-Based Joint and Seam Sealant: One-part, non-sag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.

F. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

G. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.4 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.

2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Strap and Rod Sizes: Comply with the most current version of SMACNA's "HVAC Duct Construction Standards-Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.

2. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36.

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.

3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

2.5 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.

2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

1. Manufacturers:

a. Ductmate Industries, Inc.

b. Nexus Inc.

c. Ward Industries, Inc.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.

1. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.

2. Longitudinal Seams: Pittsburgh lock sealed with non-curing polymer sealant.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of non-braced panel area unless ducts are lined.

2.6 ROUND DUCT AND FITTING FABRICATION

A. Round, Spiral Lock Seam Ducts: Fabricate supply ducts of galvanized steel according to the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

1. Manufacturers:

a. Lindab

b. McGill AirFlow Corporation.

c. SEMCO Incorporated.

B. Duct Joints:

1. Minus 2 inches wg to plus 2 inches wg pressure class

a. Ducts up to 20 inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.

b. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two (2) internal flanges with sealant and one (1) external closure band with gasket.

c. Joints shall be made with pop rivets or sheet metal screws and sealed.

2. Less than minus 2 inches wg or more than plus 2 inches wg pressure class

a. All fitting ends shall come factory equipped with a double lipped, U-profile, EPDM rubber gasket. Gasket shall be manufactured to gauge and flexibility so as to insure that system will meet all of the performance criteria set forth in the manufacturer's literature. Gasket shall be classified by Underwriter=s Laboratories to conform to ASTM E84-91a and NFPA 90A flame spread and smoke developed ratings of 25/50.

b. All fitting ends shall be calibrated to manufacturer=s published dimensional tolerance standard and associated spiral duct.

c. All fitting ends from 3" to 24" Dia. shall have rolled over edges for added strength and rigidity.

d. All elbows from 3" to 12" Dia. shall be 2-piece die stamped and continuously stitch welded. All elbows 14" Dia. and larger shall be standing seam gorelock construction and internally sealed.

e. The radius of all 90° and 45° elbows shall be 1.5 times the elbow diameter.

f. All fittings that are of either spot welded or button punched construction shall be internally sealed.

g. Fittings shall be connected with self tapping sheet metal screws or pressure proof pop rivets in quantity and procedure per manufacturer=s recommendations.

C. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "1985 HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

D. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

E. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:

1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

2. Die-Formed Elbows for Sizes through 12 Inches in Diameter with 2-piece welded construction, 24 ga.

3. Round Elbows Larger Than 14 Inches in Diameter: Fabricate gored elbows 22 ga. for 16 inches through 26 inches, 20 ga. for 28 inches and above.

F. All tees and crosses shall be conical fittings.

G. Round connections to rectangular ducts shall be made with bellmouth fittings.

H. All connections to round ductwork shall be made with full body fittings. Side taps and saddles are not acceptable.

2.7 INSULATED CASING

A. Construct casing for the air handling units exhaust and outdoor air plenums. Casing shall be built per field conditions and air handling unit connections. Casing shall be self-supporting, prefabricated steel panels, 2" thick, with 4-1/4 lb. density insulation, encased in inner face of minimum 20 gauge, and outer face of minimum 22 gauge galvanized steel sheets; connection between inner and outer skins shall be thermally broken. Stiffening elements shall be a minimum of 16 gauge and gasketed or cabled assembly to be airtight at 10" H_2O pressure difference. Provide minimum 20 gauge, hinged access door, with pressure type door handles and hinges with provision to operate from either side of door.

B. Interior skin to be stainless steel where indicated on drawings.

2.8 DUCT LINER

A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.

1. Manufacturers:

a. CertainTeed Corp.; Insulation Group.

b. Johns Manville International, Inc.

c. Knauf Fiber Glass GmbH.

d. Owens Corning.

2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.

    a. Thickness: 1 inch.

    b. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.

    c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.

    d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

    e. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.

        1) Tensile Strength: Indefinitely sustain a 50-lb tensile, dead-load test perpendicular to duct wall.

        2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.

        3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

2.9 APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

C. Butt transverse joints without gaps and coat joint with adhesive.

D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.

F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.

G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.

H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    1. Fan discharges.

    2. Intervals of lined duct preceding unlined duct.

    3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.

I. Terminate inner ducts with build-outs attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated build-outs (metal hat sections) or other build-out means are optional; when used, secure build-outs to duct walls with bolts, screws, rivets, or welds.

2.10 STAINLESS STEEL DUCTS

A. Where indicated on the drawings, within 18" of outdoor air louvers, ducts shall be constructed of 304-2B stainless steel with mill finish and shall conform to the following schedule:

Width in Inches	U. S. Gauge
Up to 30"	No. 26

B. Joints: All joints and seams shall be continuously soldered with stainless steel solder and made watertight. Longitudinal seams shall be on top side of horizontal ducts.

2.11 FUME HOOD EXHAUST DUCTS

A. Exhaust ducts from all fume hoods shall be constructed of No. 18 U.S. gauge 304-2B stainless steel with mill finish. Fittings shall be No. 18 U.S. gauge 304-2B stainless steel with mill finish.

B. Joints: All joints and seams shall be continuously welded. Elbows for round shall be of five-piece pattern except elbows 8" and smaller shall be uniform die stamped. Tees and crosses shall be of the flared conical entrance type. Outside dimension of fittings shall be slightly smaller than inside dimensions of companion duct size.

PART 3 – EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:

1. Supply Ducts (from air handling units to VAV terminal units), (Positive Pressure): 4 inch w.g. pressure class.

2. Supply Ducts: (from terminal units to air devices), (Positive Pressure): 2-inch w.g. pressure class.

3. Return Ducts: (from air devices to air handling units) (Negative Pressure): 2-inch w.g. pressure class.

4. Exhaust Ducts, (Negative Pressure): 2-inch w.g. pressure class.

6. Outside Air Ducts, (Positive and Negative Pressure): 2-inch pressure class.

7. Combustion Air & Transfer Air (Positive Pressure): 2 inch pressure class.

B. All ducts shall be of galvanized steel construction except for Type 2 exhaust hoods and clothes dryer exhaust ducts which shall be of aluminum construction and Type 1 exhaust hood ductwork which shall be welded 304 stainless steel. Type 1 and Type 2 exhaust hood exhaust ductwork shall comply with the requirements of the Ohio Mechanical Code.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install round ducts in lengths not less than 10 feet unless interrupted by fittings.

C. Install ducts with fewest possible joints.

D. Install fabricated fittings for changes in directions, size, and shape and for connections. Fittings indicated on drawings are diagrammatic and are for information purposes only.

E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of three (3) screws in each coupling.

F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

J. Coordinate layout with suspended ceiling, fire-dampers, lighting layouts, and similar finished work.

K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws. Longitudinal joints shall be on the top side of horizontal ducts.

L. Electrical Equipment Spaces: Route ducts to avoid passing through electrical equipment spaces and enclosures.

M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant.

O. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction." All ductwork is to be maintained at the SMACNA Intermediate Cleanliness level.

P. This Contractor shall paint interiors of metal ducts, that do not have duct liner, for 24 inches upstream and downstream of duct mounted registers and grilles. Apply one (1) coat of flat, black, latex finish coat over a compatible galvanized-steel primer.

Q. Duct dimensions on drawings are inside clear dimensions.

3.3 SEAM AND JOINT SEALING

A. Seal all duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.

B. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Support vertical ducts at maximum intervals of 6 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

D. Install concrete inserts before placing concrete.

E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

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 DUCT CLEANING

A. Clean existing duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.

2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.

3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.

5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.

6. Supply-air ducts, dampers, actuators, and turning vanes.

7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.

4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide drainage and cleanup for wash-down procedures.

7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.7 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test the entire system at the maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven (7) days' advance notice for testing.

3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2 inch w.g. (both positive and negative pressures) and leakage class 6 for pressure classes above 2 inch w.g.

4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

END OF SECTION 233113

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SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Backdraft dampers.
2. Volume dampers.
3. Fire dampers.
4. Smoke dampers.
5. Combination fire and smoke dampers.
6. Motorized Control Dampers.
7. Outside air intake and exhaust air hoods.
8. Turning vanes.
9. Remote damper operators.
10. Duct-mounting access doors.
11. Flexible connectors.
12. Flexible ducts.
13. Duct accessory hardware.

B. The motorized automatic control dampers are supplied by the HVAC Contractor. The HVAC contractor shall install the motorized automatic control dampers. TCC shall provide operators and linkage.

1.2 SUBMITTALS

A. Product Data: For the following:

1. Backdraft dampers.
2. Volume dampers.
3. Fire dampers.
4. Smoke dampers.
5. Combination fire and smoke dampers.
6. Motorized Control Dampers.
7. Outside air intake and exhaust air hoods.

8. Turning vanes.

9. Remote damper operators.

10. Duct-mounting access doors.

11. Flexible connectors.

12. Flexible ducts.

13. Duct accessory hardware.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. In other part 2 articles where subparagraphs titles below introduce lists, the following requirements apply for product selection.

1. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

2.2 SHEET METAL MATERIALS

A. Comply with the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653 and having G60 (Z180) coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480.

D. Aluminum Sheets: ASTM B 209, alloy 3003, tempered H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT DAMPERS

A. Manufacturers:

1. Air Balance, Inc.

2. American Warming and Ventilating.

3. Lindab (medium velocity basis of design)

4 Greenheck.

5 Prefco Products, Inc.

6. Ruskin Company. (low velocity basis of design)

B. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.

C. Frame: 0.090 extruded aluminum, with mitered corners and mounting flange.

D. Blades: 0.025-inch-thick, roll-formed aluminum.

E. Blade Seals: Vinyl.

F. Blade Axles: Galvanized steel.

G. Tie Bars and Brackets: Galvanized steel.

H. Return Spring: Adjustable tension.

2.4 VOLUME DAMPERS

A. Manufacturers:

1. Air Balance, Inc.

2. American Warming and Ventilating

3. Lindab (Medium velocity Basis of Design)

3. McGill AirFlow Corporation

4. Metalaire, Inc.

5. Ruskin Company (Low velocity Basis of Design)

B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include dial type quadrant handle locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class. Provide stand-off assembly for all balancing dampers that are installed in insulated ducts.

C. Standard Volume Dampers: Single-blade up to 6" blade width and opposed multi-blade on 8" and larger blade width, standard leakage rating, and suitable for horizontal or vertical applications.

1. Steel Frames: 22 gauge, hat-shaped, galvanized sheet steel channels, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.

2. Roll-Formed Steel Blades: 22 gauge galvanized sheet steel.

3. Blade Axles: Galvanized steel.

4. Bearings: Molded synthetic.

5. Tie Bars and Brackets: Aluminum.

6. Tie Bars and Brackets: Galvanized steel.

D. Low velocity rectangular: Ruskin Model MD25

E. Low velocity round: Ruskin Model MDRS25

F. Medium velocity round: Lindab Model DRU

2.5 FIRE DAMPERS

A. Manufacturers:

1. Air Balance, Inc.

2. Greenheck.

3. Prefco Products, Inc.

4. Ruskin Company.

B. Fire dampers shall be labeled according to UL 555.

C. Fire Rating: 1-1/2 hours.

D. Frame: Curtain type with blades and frame outside airstream; fabricated with roll-formed, 0.034-inch thick galvanized steel; with mitered and interlocking corners. Rectangular: Style "C". Round: Style "CR".

E. Mounting Sleeve: Factory or field-installed, galvanized sheet steel, mounted outside airstream.

1. Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.

2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.034-inch thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch thick, galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Fusible Links: Replaceable, 212 deg F.

2.6 SMOKE DAMPERS

A. General Requirements: Label according to UL 555S by an NRTL.

B. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with interlocking, gusseted corners and mounting flange.

C. Blades: Roll-formed, horizontal, interlocking, 0.034-inch-thick, galvanized sheet steel.

D. Leakage: Class I.

E. Rated pressure and velocity to exceed design airflow conditions.

F. Mounting Sleeve: Factory-installed, 0.039-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

G. Damper Motors: two-position action.

H. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.

7. Electrical Connection: 115 V, single phase, 60 Hz.

I. Accessories:

1. Auxiliary switches for signaling.

2. Test and reset switches, damper or remote mounted as required depending upon field conditions.

2.7 COMBINATION FIRE AND SMOKE DAMPERS

A. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

C. Fire Rating: 1-1/2 and 3 hours as required at each location.

D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with interlocking, gusseted corners and mounting flange.

E. Heat-Responsive Device: Resettable, 165 deg F rated, fusible links.

F. Heat-Responsive Device: Electric resettable device and switch package, factory installed, rated.

G. Blades: Roll-formed, horizontal, interlocking, 0.063-inch- thick, galvanized sheet steel.

H. Leakage: Class I.

I. Rated pressure and velocity to exceed design airflow conditions.

J. Mounting Sleeve: Factory-installed, 0.039-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

K. Master control panel for use in dynamic smoke-management systems.

L. Damper Motors: two-position action.

M. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.

7. Electrical Connection: 115 V, single phase, 60 Hz.

N. Accessories:

1. Auxiliary switches for signaling.

2. Test and reset switches, damper or remote mounted as required, depending on field conditions.

2.8 MOTORIZED CONTROL DAMPERS

A. Manufacturers:

1. Air Balance, Inc.

2. American Warming and Ventilating.

3. Greenheck.

4. Ruskin Company.

B. General Description: AMCA-rated, parallel or opposed blade design; minimum of 11 gauge thick, galvanized-steel frames with holes for duct mounting with maximum blade width of 8 inches.

1. Secure blades to 1/2 inch diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings,

and thrust bearings at each end of every blade.

2. Operating Temperature Range: From minus 40 to plus 200 deg F .

3. Provide parallel or opposed-blade design with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4 inch wg when damper is being held by torque of 50 in. x lbf; when tested according to AMCA 500D.

4. Coordinate damper configuration with the Temperature Control Contractor including blade and rod as well as the operator mounting.

5. Refer to section 230900 for damper actuator specifications.

2.9 OUTDOOR AIR INTAKE AND EXHAUST AIR HOODS

A. General Description:

1. Ventilator shall be low silhouette for exhaust or intake applications

2. Units for ducted application.

B. Hood and Base:

1. Material Type: Aluminum.

2. Hood Constructed of formed, arched panels with interlocking seams

3. Vertical end panels shall be fully locked into hood end panels

4. Base height minimum 5 inches

5. Curb cap shall be six inches larger than throat size

6. Curb cap shall have pre-punched mounting holes for installation

C. Birdscreen:

1. Constructed of ½ inch aluminum mesh.

2. Mounted horizontally across the intake area of the hood

D. Hood Support:

1. Constructed of galvanized steel and fastened so the hood can either be removed completely from the base or hinged open

E. Accessories:

1. Roof Curbs: Provide 12 inch high insulated roof curb per requirements of Section 230500 and as detailed on the project drawings.

2. Hinged Access: Provide hinged connection from hood to base suitable for roof access to the connecting ductwork. Provide hinge assembly complete with locking device that secures the hood in the open position.

2.10 TURNING VANES

A. Fabricate to comply with the most current version of SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2 inch wide, airfoil-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

1. Manufacturers:

a. Ductmate Industries, Inc.

b. Duro Dyne Corp.

c. METALAIRE, Inc.

2.11 REMOTE DAMPER OPERATORS

A. Description: Cable system designed for remote manual damper adjustment.

B. Tubing: Copper.

C. Cable: Stainless steel.

D. Wall-Box Mounting: Recessed.

E. Wall-Box Cover-Plate Material: Stainless steel.

2.12 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include piano hinge and cam latches.

1. Manufacturers:

a. American Warming and Ventilating.

b. CESCO Products.

c. Ductmate Industries, Inc.

d Greenheck.

e. McGill AirFlow Corporation.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Provide number of hinges and locks as follows:

a. Less Than 12 Inches square: Secure with two (2) sash locks.

b. Up to 18 Inches Square: Two (2) sash locks.

c. Up to 24 by 48 Inches: Secure with two (2) compression locks.

C. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

D. Insulation: 1-inch thick, fibrous-glass or polystyrene-foam board.

2.13 FLEXIBLE CONNECTORS

A. Manufacturers:

1. Ductmate Industries, Inc.

2. Duro Dyne Corp.

3. Ventfabrics, Inc.

B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3" to 6" wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch thick aluminum sheets. Select metal compatible with ducts.

D. 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: Minus 40 to plus 200 deg F.

E. 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: Minus 50 to plus 250 deg F.

2.14 FLEXIBLE DUCTS

A. Manufacturers:

1. Flexmaster U.S.A., Inc.

2. Hart & Cooley, Inc.

3. McGill AirFlow Corporation.

B. Non-insulated-Duct Connectors: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire.

1. Pressure Rating:4-inch wg positive and 0.5-inch wg negative.

2. Maximum Air Velocity: 4000 fpm.

3. Temperature Range: Minus 20 to plus 175 deg F.

C. Insulated-Duct Connectors: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor barrier film.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.

2. Maximum Air Velocity: 4000 fpm.

3. Temperature Range: Minus 20 to plus 175 deg F.

D. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 through 18 inches to suit duct size.

PART 3 – EXECUTION

3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in the most current version of 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. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft dampers on exhaust fans or exhaust ducts where indicated.

D. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two (2) duct widths from branch takeoff. Locking quadrants shall be easily accessible and shall be installed on the outside of the duct insulation.

E. Install fire dampers, smoke dampers, and combination fire/smoke dampers with fusible links, according to manufacturer's UL-approved written instructions.

F. Install all intake or exhaust air hoods on insulated roof curbs per all requirements of the hood manufacturer. The HVAC contractor is to provide flashing for all roof hoods.

G. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. On both sides of duct coils.

2. Downstream from volume dampers and equipment.

3. Adjacent to fire dampers, providing access to reset or reinstall fusible links.

4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing. Duct mounted grilles will replace access doors for duct cleaning.

5. On sides of ducts where adequate clearance is available.

H. Install the following sizes for duct-mounting, rectangular access doors: Based on the following maximum duct dimensions:

1. 9" and smaller: 6" x 8" door size.

2. 10" to 12": 9" x 12" door size.

3. 13" to 16": 12" x 16" door size.

4. 18" and larger: 14" x 14" door size.

I. Label access doors according to Division 23 Section "Mechanical Identification."

J. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

K. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

L. Connect diffusers to low pressure ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place. See detail on drawings.

M. Connect flexible ducts to metal ducts with draw bands.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing."

END OF SECTION 233300

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SECTION 233423 – HVAC FANS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Provide exhaust fans, as specified in this Section.

1.2 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base air ratings on 800 feet above sea level.

B. Operating Limits: Classify according to AMCA 99.

C. Fan noise levels shall not exceed 55 DBA in the daytime and 50 DBA in the nighttime at any occupied locations within the building.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.

2. Certified fan sound-power ratings.

3. Motor ratings and electrical characteristics, plus motor and electrical accessories.

4. Material gages and finishes, including color charts.

5. Dampers, including housings, linkages, and operators.

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. Differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data: For exhaust fans and combustion air fans, provide maintenance manuals as specified in Division 1.

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. Performance ratings: Conform to ANSI/AMCA Standards 210 and 300. Fans must be tested in accordance with AMCA Publications 211 and 311 in an AMCA accredited laboratory and certified for sound and air performance. Fan shall be licensed to bear the AMCA ratings seal for air performance (AMCA 210) and sound performance (AMCA 300). Manufacturers that are not licensed to bear the AMCA 210 ratings seal must provide performance witness testing (at the manufacturer's expense), per paragraph 1.4.D.

C. Classification for Spark Resistant Construction shall conform to ANSI/AMCA Standard 99.

D. Each fan shall be vibration tested before shipping, as an assembly, in accordance with ANSI/AMCA Standard 204. Each assembled fan shall be test run at the factory at the specified fan RPM and vibration signatures shall be taken on each bearing in three planes - horizontal, vertical, and axial. The maximum allowable fan vibration shall be less than 0.10 in. /sec peak velocity; filter-in reading as measured at the fan RPM. This report shall be provided at no charge to the customer upon request.

E. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

F. UL Standard: Power ventilators shall comply with UL 705.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.6 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.7 EXTRA MATERIALS

A. Furnish under provisions of Division 1.

B. Provide two sets of belts for each fan.

1.8 WARRANTY

A. Equipment shall carry an all-inclusive manufacturer’s parts warranty for a period of two (2) years from date of final acceptance or date of beneficial use, as agreed to between Contractor and Architect or Construction Manager. Any materials, equipment, or controls found to be defective during this warranty period shall be made good without expense to the Owner, including any required replacement of fluids, glycol, or refrigerant. The warranty shall include a delayed start-up provision such that the warranty does not begin at time of delivery. The labor for the warranty shall be performed by the manufacturer’s authorized service agent.

PART 2 – PRODUCTS

2.1 MANUFACTURERS – EXHAUST FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

1. Greenheck (Basis of Design – VEKTOR MH series)

2. Cook

3. Strobic

4. Twin City

2.2 ROOF MOUNTED LABORATORY FANS,

A. General:

1. Variable speed, High-Plume dilution laboratory exhaust system.

B. Exhaust Fan Design Criteria per system: Two identical exhaust fan systems required.

1. Exhaust Air: 38,000 cfm at 4.5" external static pressure
2. Insulated plenum/curb assemble and integrated dampers, no actuators.
3. Variable air volume system with CV plume 15' minimum above roof.
4. Direct drive fans, bifurcated.
5. Lifting lugs.
6. Fan assemblies designed for 125 mph wind loading without use of guywires.
7. Power: 480/3/60
8. Motors: Premium efficiency
9. Heat Recovery Coil - AHU manufacturer to provide both recovery coils for installation by OTHERS in exhaust system fan plenum for heat recovery. Exact size to be determined upon selection of vendor. Coil size to be based on 19,000 CFM exhaust at 650 fpm, maximum 0.15 air PD and maximum 5' water PD.
10. Spark Resistant Class C.

C. Corrosion Resistant Coating

1. All fan and system components (fan, nozzle and plenum) shall be corrosion resistant coated with a two part electrostatically applied and baked, sustainable, corrosion resistant coating system.
2. All parts shall be cleaned and chemically prepared for coating using a multi-stage wash system which includes acid pickling that removes oxide, increases surface area, and improves coating bond to the substrate.
3. The first powder coat applied over the prepared surface shall be a zinc rich epoxy primer (no less than 70% zinc) and heated to a gelatinous consistency (partial cure) at which the second powder coat of polyester resin shall be electrostatically applied and simultaneously be cured at a uniform temperature of 400°F.

D. Wheel:

1. Constructed of aluminum.
2. Non-overloading, backward inclined centrifugal.
3. Statically and dynamically balanced in accordance to AMCA Standard 204-05.

4. The wheel cone and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency.

E. Motors:

1. Motor enclosures: Open drip-proof.

2. Motors shall permanently lubricated, heavy duty ball bearing type to match with the fan load and furnished at the specific voltage and phase.

3. Mounted on vibration isolators, out of the airstream.

4. For motor cooling there shall be fresh air drawn into the motor compartment through an area free of discharge contaminants.

5. Accessible for maintenance.

F. Electronically Commutated Motor:

1. Motor enclosures: Open type.

2. Motor to be a DC electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.

3. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor.

4. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VCD signal.

5. Motor shall be a minimum of 85% efficient at all speeds.

G. Shafts and bearings:

1. Fan shaft shall be ground and polished solid steel with an anti corrosive coating.

2. Permanently sealed bearings or pillow block ball bearings.

3. Bearing shall be selected for a minimum L10 life in excess of 100,000 hours at maximum cataloged operating speed.

4. Bearings are 100 percent factory tested.

5. Fan Shaft first critical speed is at least 25 percent over maximum operating speed.

H. Housing:

1. Motor cover, shroud, curb cap, and lower windband shall be constructed of heavy gauge aluminum.

2. Shroud shall have an integral rolled bead for extra strength.

3. Shroud shall be drawn from a disc and direct air downward.

4. Lower windband shall have a formed edge for added strength.

5. Motor cover shall be drawn from a disc.

6. All housing components shall have final thicknesses equal to or greater then preformed thickness.

7. Curb cap shall have pre-punched mounting holes to ensure correct attachment.

8. Rigid internal support structure.

9. Leak proof.

I. Housing Supports And Drive Frame:

1. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators.

J. Drive Assembly:

1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.

2. Belts: Static free and oil resistant.

3. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.

4. The motor pulley shall be adjustable for final system balancing.

5. Readily accessible for maintenance.

K. Vibration Isolation:

1. Double studded or pedestal mount true isolators.

2. No metal to metal contact.

3. Sized to match the weight of each fan.

L. Disconnect Switches:

1. NEMA rated: 3R

2. Positive electrical shut-off.

3. Wired from fan motor to junction box installed within motor compartment.

M. Accessories:

1. Auto Belt Tensioner:

2. Automatic tensioning device that adjusts for the correct belt tension, only for single drives.

3. Birdscreen:

a. Material Type: Aluminum.

b. Protects fan discharge

4. Roof Curbs:

a. Types: Suitable for pitched roof, welded straight side curb with 2 inch flashing flanges and wood nailer

b. Mounted onto roof with fan

c. Material: Aluminum.

d. Insulation thickness: 1.5 inches

5. Curb Seal:

a. Rubber seal between the fan and the roof curb.

N. Refer to the exhaust fan schedule on the drawings for performance requirements.

2.3 MOTORS

A. Refer to Division 23 Section "Motors" for general requirements for factory-installed motors.

B. Motor Construction: NEMA MG 1, general purpose, continuous duty, Design B.

2.4 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with 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. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install exhaust fans level and plumb.

B. For units with integral inlet grilles mounted in ceiling tiles, install with grilles centered in ceiling tiles.

C. Install units with clearances for service and maintenance.

D. Label units according to requirements specified in Division 23 Section "For HVAC Piping and Equipment."

E. Installed flexible connections between fan inlet and discharge ductwork. Ensure metal bands between connectors are parallel with minimum one-inch flex between ductwork and fan while running.

F. Provide safety screen where inlet or outlet is exposed.

G. Pipe scroll drains to nearest roof drain.

H. Provide backdraft dampers on inlet or discharge of exhaust fans and as indicated.

3.2 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 Section "Duct Accessories."

B. Install ducts adjacent to exhaust fans to allow service and maintenance.

C. Ground equipment.

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

3.3 FIELD QUALITY CONTROL

A. Equipment Startup Checks:

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. Verify lubrication for bearings and other moving parts.

6. Verify that manual and automatic volume control and fire dampers in connected ductwork systems are in fully open position.

B. Starting Procedures:

1. Energize motor and adjust fan to indicated rpm.

2. Measure and record motor voltage and amperage.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Shut unit down and reconnect automatic temperature-control operators.

F. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

G. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Lubricate bearings.

C. Adjust belt tension.

3.5 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

END OF SECTION 233423

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SECTION 233600 – AIR TERMINAL UNITS

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. Pressure independent, variable volume air terminal units.

1.3 SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.

1. Air terminal units.

2. Liners and adhesives.

3. Sealants and gaskets.

4. Seismic-restraint devices.

B. Shop Drawings: For air terminal units. 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.

3. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.

2. Size and location of initial access modules for acoustic tile.

3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Field quality-control reports.

E. Operation and Maintenance Data: For air terminal 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. Instructions for resetting minimum and maximum air volumes.

2. Instructions for adjusting software set points.

1.4 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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

PART 2 - PRODUCTS

2.1 DAMPER MOTOR OPERATED VARIABLE VOLUME TERMINAL UNITS WITH HOT WATER REHEAT COILS

A. Furnish and install, where shown, DDC operated, pressure independent, variable volume air control terminal units.

B. Variable air volume supply air control terminals for connection to medium pressure duct, central air systems, with direct digital control, and unit mounted hot water coils.

C. Identify each terminal unit with clearly marked identification label and airflow indicator. Label shall include unit nominal air flow, maximum factory set air flow, minimum factory set air flow, and coil type. Also provide, mounted on bottom of box to be clearly visible from below, laminated label indicating box number and AHU number which feeds box.

D. Controls: Terminal unit manufacture shall include factory mounting, continuity check, calibrating, and testing of direct digital controls provided by Temperature Control Contractor under a separate bid package.

E. Casings: Units shall be completely factory assembled, manufactured of corrosion protected welded steel, and fabricated with a minimum of 18-gauge metal on the inlet side of the VAV damper and 22-gauge metal on the outlet side and unit casing.

F. Insulation: Foil Face - Interior surface of unit casing is acoustically and thermally lined with a minimum of 1 inch, R-Value 4.3, 1.9 lb./cu. ft. foil face insulation. All exposed edges are sealed to prevent fibers in the airstream. Meets NFPA-90A, UL 181 and bacteriological standard ASTM C 665.

G. Assembly: Air volume damper, fans, and controls in single cabinet.

H. Volume Damper: Locate air volume damper assembly inside unit casing. Construct from extruded aluminum or a minimum of 20 gauge galvanized steel components. Key damper blades into shaft with nylon fitted pivot points. Flow sensor must be provided regardless of control chosen. Flow sensor must be a ring or cross. Bar or single point sensing device is not acceptable. Air volume control damper shall be factory calibrated assembly consisting of air valve with integral actuator. Electric actuator shall position damper.

I. Hot water heating coil: Heating coil capacities shall be as scheduled on the drawings. A quick opening access panel shall be provided to allow cleaning and inspection of the coil. The coils shall be constructed of 0.500" x 0.017" copper tube. Fins shall be 0.0045" thick aluminum sine wave configuration. The coil shall be contained in a 0.030" galvanized steel casing. The coils shall be pressure tested to 349 PSIG at 300 degree Fahrenheit tube

surface temperature. Coil shall be tested and certified according to ARI Standard 410. Coil connections can be right hand or left hand as noted on the drawings. Control valves, air vents and drain vents shall be field installed by the HVAC contractor.

J. Tests:

1. Factory set and check all DDC controllers to within 5% of scheduled maximum and minimum settings. Base performance on tests conducted in accordance with ARI 880.

2. Maximum Casing Leakage: 1 percent of nominal air flow at 0.5 in wg inlet static pressure.

3. Maximum Damper Leakage: 1 percent of design air flow at 4 in wg inlet static pressure.

K. Each terminal unit shall operate as follows:

1. At all times (ddc control): Unit shall be capable of regulating supply air from minimum to maximum supply air quantities. Refer to schedule on drawings for minimum and maximum air quantities.

2. Each terminal unit shall include a laminated label showing terminal unit number and which ACU it is fed from.

3. Bids shall be based on, Price, Carrier, York, Trane, Tuttle & Bailey or pre-approved equal terminal units equipped with hot water reheat coil of various types and sizes as scheduled on the drawings.

4. Unit shall include inlet air temperature sensor to automatically change from the heat/cool mode to satisfy zone requirements.

2.2 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type**,** and ARI certification seal.

2.3 FAN POWERED TERMINAL UNITS

A. Configuration: Fan blower, electronic speed controller, single point electrical and control connection, primary air valve damper assembly inside unit casing with control components located inside a protective metal shroud.

B. Casing: 20 gauge galvanized steel.

1. Casing Lining: 2 inch-thick, smooth, non-porous lining with metal end caps and mold resistant caulking, secured with adhesive. Insulation 1.5 lb. density fiberglass with a minimum k-value of .23. Insulation to be coated to prevent mold growth and air erosion per UL181.

2. Air inlet: Round stub connection or S-slip and drive connections for duct attachment.

3. Air Outlet: S-slip and drive connections.

4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

C. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch w.g. inlet static pressure.

2. Damper Position: Field adjustable for normally open or normally closed.

D. Hot water heating coil: Heating coil capacities shall be as scheduled on the drawings. A quick opening access panel shall be provided to allow cleaning and inspection of the coil. The coils shall be constructed of 0.500" x 0.017" copper tube. Fins shall be 0.0045" thick aluminum sine wave configuration. The coil shall be contained in a 0.030" galvanized steel casing. The coils shall be pressure tested to 349 PSIG at 300 degree Fahrenheit tube surface temperature. Coil shall be tested and certified according to ARI Standard 410. Coil connections can be right hand or left hand as noted on the drawings. Control valves, air vents and drain vents shall be field installed by the HVAC contractor.

E. Air Flow Sensor: Sensor shall be of a cross configuration. The sensor shall have minimum twelve total pressure sensing ports and a center averaging chamber designed to accurate average the flow across the inlet of the assembly. Sensor shall provide accuracy within 5% with a 90 degree sheet metal elbow directly at the inlet of the assembly. The air flow sensor shall amplify the sensed air flow signal. Two flexible tubes, one connected to the high pressure poet and the other connected to the low pressure port of the air flow sensor, shall extend through the assembly housing to allow for easy monitoring of the airflow.

F. Fan blower shall be constructed of steel with forward curved blades, dynamically balanced wheels and direct drive motor. Motors shall be ECM type, with lubricated bearing s and thermal overload protection. Motor shall be designed for use with adjustable electronic fan speed control. Provide isolation between motor and blower assembly.

G. Provide an electronic speed controller which allows continuously adjustable fan speed from maximum to minimum. Speed control shall be electronic and shall be matched to operate with the motor. Speed control shall be equipped with a minimum voltage stop to ensure motor will not operate in the stall mode. Voltage stop shall be factory adjusted.

H. Units shall incorporate a single point electrical and control connection for the entire unit. All electrical components shall be enclosed in a single control box with an access panel mounted on the side of the assembly. All controls shall be sealed from primary air flow. Units shall be ETL listed and ARI certified.

I. Units shall have a filter rack with disposable filter on inlet of opening.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

3.2 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "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 and for slabs more than 4 inches thick.

4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.

5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. 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.

3.3 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts."

D. Make connections to air terminal units with flexible connectors complying with requirements in Division 23 Section "Air Duct Accessories."

3.4 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

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

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.

2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Air terminal unit will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.

3. Verify that controls and control enclosure are accessible.

4. Verify that control connections are complete.

5. Verify that nameplate and identification tag are visible.

6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

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SECTION 233713 - DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 REFERENCE

A. SCOPE OF WORK

1. Provide grilles, diffusers, air devices and appurtenances with size and capacities as shown on drawings.

1.2 SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish and mounting details; and performance date including throw and drop, static-pressure drop and noise ratings.

2. Diffuser, Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size and accessories furnished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified:

1. Price (Basis of Design)

2. Krueger

3. Titus

4. Anemostat

2.2 SQUARE PLAQUE FACED CEILING DIFFUSERS

A. Ceiling diffusers of sizes and mounting types designated by the plans and air device schedule. Diffusers shall consist of a precision formed back cone of one piece seamless construction which incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct. An inner plaque assembly shall be incorporated that drops no more than 1/4" below the ceiling plane to assure proper air distribution performance. The inner plaque assembly shall be completely removable from the diffuser face to allow full access to any dampers or other ductwork components located near the diffuser neck. The diffuser is to include an integral opposed blade damper that is adjustable from the face of the air device. Finish shall be white powder coat.

2.3 SUPPLY REGISTERS

A. Supply registers of the sizes and mounting types indicated on the plans and outlet schedule. Registers shall be double deflection type with two sets of fully adjustable deflection blades spaced 3/4" on center. The front set of blades shall run parallel to the short or long dimension of the register as indicated in the air device schedule. The integral volume control damper shall be of the opposed blade type and shall be constructed of cold rolled steel. The damper shall be operable from the register face. The damper shall be coated steel. Registers are to be suitable for surface mounting or duct mounting as indicated on the drawings. Registers mounted in walls shall have steel plaster frames. Provide 1-1/4 " margin with countersunk screw mounting for drywall and masonry surfaces complete with mounting frame. Units in equipment rooms shall be a mill finish. All other registers shall have a white powder coat finish.

2.4 HEAVY DUTY BAR TYPE RETURN REGISTER AND GRILLES

A. Exhaust registers of the sizes and mounting types indicated on the plans and outlet schedule. Registers shall be 45 degree deflection fixed louver type with blades spaced 3/4" on center. The outlet shall have 14 gauge steel blades and heavy duty steel support bars and frame. Blades shall run parallel to the long dimension of the register. The integral volume control damper shall be of the opposed blade type and shall be constructed of cold rolled steel. The damper shall be operable from the register face. The damper shall be coated steel. Registers mounted in walls shall have steel plaster frames. Provide 1-1/4 " margin with countersunk screw mounting for drywall and masonry surfaces complete with mounting frame. All registers shall have a white powder coat finish.

2.5 EGGCRATE GRILLES AND REGISTERS

A. Exhaust registers and grilles of the sizes and mounting types indicated on the plans and air device schedule. Units shall be of aluminum construction, consisting of aluminum 1/2" x 1/2" x 1/2" eggcrate core and an extruded aluminum border. Units designated as registers shall be equipped with integral volume control damper of the opposed blade type and shall be constructed of heavy gauge cold rolled steel. The damper shall be operable from the register face. The damper shall be coated steel. Units in equipment rooms shall be a mill finish. All other units shall have white powder coat finish.

2.6 PLENUM SLOT DIFFUSERS

A. Modular linear diffusers of the sizes and mounting types indicated on the plans and linear diffuser schedule. Units shall be of aluminum construction with frame and support bars of extruded aluminum. The pattern controller shall be a curved “ice tong” shaped steel deflector capable of 180 degree pattern adjustment from the face of the diffuser. Units shall have two ¾” slots. Units shall be complete with integral insulated plenums, extruded aluminum end borders, end caps and mitered corners. Diffusers shall have a white powder coat finish.

2.7 ROUND DIFFUSERS

B. Round duct diffusers shall be Price, or equal, model RCDA, adjustable round cone diffuser. The three center cones move in unison for adjusting horizontal to vertical patterns. Diffuser shall be of heavy gauge spun steel. Diffusers shall come with wire guard to protect the face in the gymnasium applications. Diffuser shall be finished in white powder coat.

2.8 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install grilles, registers, diffusers and air devices level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw and pressure drop. Make final locations where indicated as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install grilles, registers, diffusers and air devices with airtight connections to ducts and to allow service and maintenance of dampers, air extractors and fire dampers.

3.3 ADJUSTING

A. After installation, adjust grilles, registers, diffusers and air devices to air patterns indicated, or as directed before starting air balancing.

END OF SECTION 233713

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SECTION 233714 - LOUVERS

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. Louvers.

B. Related Sections:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.

2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

2. Louver Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For louvers with factory-applied color finishes. Custom color to be selected by Architect.

C. Samples for Verification: For louvers, in manufacturer's standard sizes to verify custom color selected.

D. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Method of attaching hangers to building structure.

2. Duct access panels.

E. Source quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS OF LOUVERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Ruskin
2. Louvre + Dampers
3. American Warming
4. Greenheck

2.2 RECTANGULAR LOUVERS

A. This contractor shall furnish and install new outdoor air and exhaust louvers where shown. Each louver shall be of Greenheck, Louvre & Dampers, Inc. Type IEL6, American Warming (Model LE-33), or Ruskin manufacture with Type "C" frame and No. 4 sill extension, constructed of 6063-T5 alloy extruded aluminum sections, .08" minimum thickness with 3/8" stainless steel expansion bolts in jambs spaced 2'-0" on center and at top and bottom. Louvers shall be AMCA Certified for air and water penetration. Louvers shall be equipped with aluminum bird screen ½" mesh, 16 gauge aluminum wire in extruded aluminum frame. Screen frame to be securely fastened to inside face of louver. Furnish gaskets for installation between aluminum and dis-similar metals. Furnish and install extruded aluminum closure angles between louvers and other materials if required by drawings, and as required to complete a finished closure between louvers and other materials. All exposed parts of louver sill, bird screen and screen frame shall be finished in a Kynar 500 coating in a custom color selected by Architect. Aluminum surfaces to be in contact with masonry shall be given heavy coat of bituminous paint. Secure louver in openings with adequate anchorage and all surfaces plumb, square and true. Grout under sill. Upon completion, remove all dirt and foreign matter from surfaces and leave louver clean. Caulk around perimeter of louvers.

B. Where indicated, behind certain louvers, provide blank off panels hereinbefore specified consisting of prefabricated insulated panels forming a complete enclosure on top, bottom, sides and ends. Furnish and install continuous aluminum angles around masonry opening behind louvers and secure blank off panels thereto. Junction posts between panels, if any, shall be aluminum. Thoroughly caulk between aluminum angles and masonry opening and between aluminum angles and blank off panels.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where louvers are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install louvers in strict accordance with the manufacturer’s instructions.

B. Install louvers level and plumb.

END OF SECTION 233713

SECTION 237300 – CUSTOM AIR HANDLING UNIT

PART 1 - GENERAL

1.1 GENERAL

A. The Owner will purchase air handling unit, herein specified.

B. Under a separate contract, a contractor shall receive air handling unit from rigger's yard in Greater Cincinnati, shall handle and transport, shall rig, shall install and shall assume the same responsibilities as though the contractor had initially invited proposals and made award on the equipment.

C. The air handling unit shall be complete in all details, shall be factory assembled and tested and delivered F.O.B. rigger's yard in Greater Cincinnati, Ohio. The air handling unit manufacturer included all freight charges in his bid. This contractor shall accept air handling unit in Cincinnati, shall include hauling and rigging, shall furnish all necessary labor and supervision to erect the equipment on proper foundations and/or supports, and shall perform all grouting required. Prior to start-up, the air handling unit manufacturer shall confirm that the air handling unit have been accurately leveled by this contractor. After water, drain, and vent piping, and electric connections have been made, the air handling unit shall be placed in operation by the manufacturer. The manufacturer shall test and place unit in operation.

D. The start-up of the air handling unit shall be performed by the manufacturer and the cost of same shall be included in proposal. The contractor shall coordinate and assist the manufacturer on start-up. The mechanic in charge of the crew performing the start-up of the air handling unit shall be factory trained on the type of work to be performed and shall always be present while this work is being performed. All details of construction and installation shall meet the approval of the Engineer. Manufacturer shall provide, in addition, the operation instructions and the equipment operation and performance information as hereinafter specified.

1.2 BIDDING INFORMATION

A. Provide air handling unit and variable-frequency motor controllers (Section 237314) specified including factory start-up.

B. The entire installation shall comply with all local laws, laws of the State of Ohio, and the Safety Code of ASHRAE, and the National Electrical Code.

C. The equipment shall comply with the specification herein, shall be the product of a reputable manufacturer, and shall operate at the manufacturer's standard ratings, in all respects. All parts shall be suited to the service and not subject to injury under any condition that may occur in the normal operation of the system.

D. Each air handling unit shall be fabricated so that it can be delivered in proper shipping sections to permit entry through openings in the buildings. The HVAC Contractor will be responsible to coordinate shipping sections with the manufacturer.

E. In addition to setting the air handling unit in place, and making requisite piping connections thereto, the HVAC Contractor shall be responsible for field installation of the various accessories and miscellaneous components related to the air handling unit, including but not limited to, the following:

1. Energy Recovery Wheels.

1.3 RELATED DOCUMENTS

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

B. Related Sections

1. 23 73 14 - Variable-Frequency Motor Controllers

1.4 SUMMARY

A. Section Includes:

1. Variable-air-volume, single-zone air-handling unit.

1.5 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design vibration isolation details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Casing panels shall be self-supporting and capable of 1% at a total internal static pressure of +/- 12" w.c., without panel joints exceeding a deflection of L/240 where "L" is the unsupported span length within completed casings.

1.6 SUBMITTALS

A. Product Data: For each air-handling unit indicated.

1. Unit dimensions and weight.

2. Cabinet material, metal thickness, finishes, insulation, and accessories.

3. Fans:

a. Certified fan-performance curves with system operating conditions indicated.

b. Certified fan-sound power ratings.

c. Fan construction and accessories.

d. Motor ratings, electrical characteristics, and motor accessories.

4. Certified coil-performance ratings with system operating conditions indicated.

5. Dampers, including housings, linkages, and operators.

6. Filters with performance characteristics.

7. Roof curbs and flashing (on applicable unit).

B. Delegated-Design Submittal: For vibration isolation and restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Vibration Isolation Base Details: Each fan shall be internally isolated using 2" isolation springs. For fan systems not using internally isolated springs, external fan isolation is required. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

2. Design Calculations: For fan systems not using internal spring isolation, calculate requirements for selecting vibration isolators for designing vibration isolation bases.

C. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.

2. Support location, type, and weight.

3. Field measurements.

D. Source quality-control reports.

E. Field quality-control reports.

F. Operation and Maintenance Data: For air-handling unit to include in emergency, operation, and maintenance manuals.

1.7 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. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling unit and components.

C. ARI Certification: Air-handling unit and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Unit," and shall be listed and labeled by ARI.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2010, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

E. ASHRAE/IESNA 90.1-2007 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2007, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Comply with NFPA 70.

G. ETL Compliance: Unit shall be listed and labeled by ETL.

1.8 COORDINATION

A. Coordinate with General Contractor sizes and locations of steel housekeeping curb members, based upon actual equipment provided.

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. Filters: One set(s) for each air-handling unit.

2. Gaskets: One set(s) for each type of access door.

3. Fan Belts: One set(s) for each belt driven air-handling unit fan (if any).

1.10 WARRANTY

A. Equipment shall carry an all-inclusive manufacturer's parts and labor warranty for a period of two (2) years from date of final acceptance or date of beneficial use, as agreed to between Contractor and Architect or Construction Manager. Any materials, equipment, or controls found to be defective during this warranty period shall be made good without expense to the Owner, including any required replacement of fluids, glycol, or refrigerant. The warranty shall include a delayed start-up provision such that the warranty does not begin at time of delivery. The labor for the warranty shall be performed by the manufacturer's authorized service agent. All rotating parts shall carry a five year parts warranty from date of unit start-up.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Energy Labs

2. Climate Craft.

3. Air Enterprises.

4. Governair.

5. Mammoth

6. Temtrol

7. TMI

8. Haakon

9. Trane Custom

B. GENERAL

1. Furnish and install new air handling unit as indicated on the drawings. Provide associated auxiliary equipment for the new systems all as hereinafter specified.

C. NEW AIR HANDLING UNIT

1. Furnish and install air handling unit as shown on the drawings and hereinafter specified, consisting of casing, pre-filter, after-filter, heating coils, cooling coils, drip pans, filter gauge, fans, fan drives, motors, bases, dampers, louvers, power connections, etc., all as hereinafter specified. Unit arrangement and dimension shall be as detailed on the drawings.

2. AHU Performance Criteria: Based on 93.4/70.6 Outside Air – summer, 0F winter. 74/60F return air summer, 70/58 winter.

   a. Supply Air: 50,000 cfm, variable volume, 3" external static pressure

   b. Outside Air: 43,000 cfm, variable volume

   c. Return Air: 7,000 cfm, variable volume, 1" external static pressure

   d. Power: 480/3/60

   e. Filters: MERV 13

   f. Motors: Premium efficiency

   g. Pre-Heat Coil: Face and Bypass, 30% propylene glycol, leaving air temperature under winter design to be 70F. Entering water temperature 180F, leaving 160F. Max water PD 10'

   h. Heat Recovery Coil: 30% propylene glycol, two coils (one per 24,000 cfm exhaust system). Max water PD 5'.

   i. Cooling coil: Leaving air temperature at design condition cooling 52F saturated. Entering water temperature 42F, leaving 56F max water PD 10'.

   j. Casing pressure design 10" water column – tested in accordance with AHRI/SMACNA guidelines (Factory pressure and leakage test required. L/240 and <1% leakage at 10" shall be met.)

   k. Casing thermal resistance and insulation: Thermal resistance of R-26 shall be provided for entire unit casing and doors. Insulation shall be spray injected foam.

   l. Service corridor – gasketed access doors, lights switched and pre-wired. Service corridor to be conditioned by return air.

   m. All controls and sensors to be provided by others with EXCEPTION of damper actuators and fan array monitoring system – AHU manufacturer to provide, install, test all damper actuators prior to shipping unit for BAS/DDC contractor control.

   n. AHU manufacturer to provide both recovery coils for installation by OTHERS in exhaust system fan plenum for heat recovery. Exact size to be determined upon selection of vendor. Coil size to be based on 24,000 CFM exhaust at 650 fpm, maximum 0.15 air PD and maximum 5' water PD.

   o. Fans arrays shall be able to achieve 100% design airflow during N-1 operation.

   p. Factory performance test

3. Cabinet and Frame

   a. The unit framework shall be structural, welded heavy gauge steel. All frames shall be fabricated from structural 5" high (min.) steel electrically welded or bolted and painted for maximum protection from rust. Lifting lugs shall be provided on the base of the unit for rigging the unit in single piece and shall accept cable or chain hooks. The cabinet shall be designed to resist a maximum static of 12" w.g. The maximum panel deflection shall be l/240 along the panel's length center line at 12". Leakage of cabinet shall be <1% at 12".

   b. Decks shall be fabricated from a minimum 16 gauge galvanized steel. Unit shall be 4" double wall construction with a minimum 20 gauge galvanized steel liner. With the exception of the cooling coil discharge section, all unit shall have a perforated liner and mylar coated insulation.

   c. All exterior panels shall be fabricated from a minimum 16 gauge galvanized steel finished with one mil coat of baked acrylic enamel over an epoxy primer. The entire unit will receive a final coat of paint in custom color, approved by architect, after final assembly to insure complete coverage of exterior panels. Painted finish shall withstand a 500 hour salt spray test. Cabinet panel to be thermal break construction.

   d. Unit casings that utilize self tapping sheetmetal binding screws for field assembly shall not be acceptable.

   e. Ceiling, walls, and doors shall be 4" double wall construction to accept 4-inch fiberglass or foam injected insulation. Insulation in all exterior panels (i.e. roof panels, side and end panels, and doors) will have a minimum R-Value of 26. Underside of deck to be insulated with 4" thick foam insulation (minimum R-valve of 26) with steel under liner.

   f. Hinged access doors shall be complete with tooled latches to provide quick access to service personnel and provide a positive air seal but prevent unauthorized access. Door frames to be thermal break type. Each door shall be equipped with a 12" diameter or a 10" square tempered glass view ports and Durodyne or approved equal IP-4 test port on each door.

   g. Dual durometer gasketing to be provided with all access doors. Adhesive-backed gasketing applied to the frame perimeter shall not be acceptable.

   h. Hinges shall be of stainless steel with stainless steel pins.

   i. Doors shall be complete with locking door retainer to protect doors against damage when open. Hinged access doors shall be provided to the following components: fans, filters, dampers, main control panel, coils and heat wheel.

4. Heat Recovery

   a. AHU to have two heat recovery coils based on 30% propylene glycol. Each coil to be connected to recovery coil located remotely in exhaust system.

   b. AHU manufacturer to include/provide these two remote coils for installation by others. Final size/configuration to be determined upon award of contract..

5. Coils

   a. General: All coils shall meet or exceed all capacities specified on the mechanical schedule for the project. All water coil performances shall be certified by the manufacturer to be in accordance with ARI Standard 410. Cooling coils shall be mounted in the unit for horizontal air flow. Coil air face velocities shall not exceed the specified velocities of the mechanical schedule. All coils shall be mounted on steel glide channels and fastened to the air seal wall. All coil piping connections to be schedule 40 red brass.

   b. Drain Pans: Entire coil section shall have a pitched drain pan constructed form 16 gauge stainless steel. All corners shall be welded water tight. Drain pan is to be a minimum of 2" deep with a minimum pitch of 1" from high point to drain outlet connection. Coil condensate drain pan shall be completely insulated. If coils are stacked, an intermediate drain pan is required. This intermediate pan shall drain to the bottom main pan. Drain pan will be sloped for positive drainage to eliminate standing water. The coil main pan shall have a drain extended to the exterior of the air handler.

6. Hot and Chilled Water Coils: All hydronic coils shall be tested to 350 psig compressed air under clear water. Coils shall be designed to operate at 250 psig internal pressure and up to 300 F. Internal tubes shall be round seamless 5/8, .035" wall copper tubes which have been deoxidized by the addition of phosphorous. Coil casing shall be constructed of a minimum of 16 gauge continuous stainless steel. Coil casing reinforcements shall be required for fin lengths over 42". Coil fins shall be plate type, die-formed ripple edge corrugated 0.008 aluminum for hot water coils and 0.008 aluminum for chilled water coils with guide channels to create turbulent wiping behind the tubes with collars drawn and belled. Internal copper tubes shall be staggered in direction of air flow. The copper circuiting tubes shall be mechanically expanded to the aluminum copper fins. All hydronic coils shall be drainable with a 0.25" F.P.T. plugged drain or vent tap on the supply and return headers. Seamless copper tubes shall be brazed to the copper supply and return headers. Coils shall be manufactured by air handling unit manufacturer or Aerofin, Marlo, or Heatcraft.

7. Supply Fans and Return Fans – Fan Array Technology

   a. Fans shall be of the Class and Type as scheduled, selected to provide the airflow and pressure specified. Fans used in the smoke control system shall be provided with 1.5 times the required number of belts, ie. if 1 belt is required, 2 belts shall be provided and the pulley and sheaves shall be sized to match.

   b. Fans shall be multiple direct drive single width single inlet plenum type with inlet bell and free discharge installed in parallel. Fan segments shall be equipped with 9 or 12 blade single width single inlet (SWSI) plenum fans as scheduled. Single width single inlet fan (SWSI) shall have airfoil (AF) blades. Wheels shall have a spun non-tapered style blade retaining ring on the inlet side to allow higher efficiencies over the performance range of the fan. The wheels shall be non-overloading type. The blades shall be securely welded, die-formed backward curved (16” and smaller) or airfoil (18” and larger) type. All wheels shall be statically and dynamically balanced throughout the operating range on precision electronic balancers to a level of G6.3 (per ANSI 2-19) or better and shall be factory tested for vibration and isolation.

   c. All airfoil fans shall bear the AMCA Seal. Airfoil fan performance shall be based on tests made in accordance with AMCA standards 210 and comply with the requirements of the AMCA certified ratings program for air and sound. In addition, all airfoil wheels shall comply with AMCA standard 99-2408-69 and 99-2401-82.

   d. Fans shall have polished steel shafts sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class. Close tolerances shall be maintained where the shaft makes contact with the bearing. Shaft shall be factory coated after assembly with an anti-corrosion coating. Bearings shall be heavy duty, grease lubricated, antifriction ball or roller, self-aligning, pillow block type and selected for a minimum average bearing life (AFBMA L-50) in

excess of 400,000 hours at the maximum fan RPM. All bearings shall be equipped with re-greasable zerk fittings and, where necessary, extended lube lines for easy access for re-lubrication.

e. Each fan and motor assembly shall be independently isolated within the structural assembly using 2 inch deflection spring isolators. Isolators shall be mounted in a three point arrangement that provides both vertical and horizontal (thrust) isolation and shall not require field adjustment. If hard mounted or rubber in shear is used in place of internal spring isolations, external isolation of the entire unit is required.

f. Each fan shall be provided with backdaft isolation to close when the fan is off. Control isolation dampers are not acceptable.

g. Fans shall be provided with unloading technology to allow fan modulation without surge from 100% to 10%; while maintaining the part load static pressure requirements of the system. There shall be no static pressure or intake plenum losses or any horsepower penalty associated with the system.

1) Fan cycling to allow stable part load operation shall be allowed only if a maximum of 50% of the fans will be cycled off at any time. Each fan is to be cycled in such a manner that all fans operate an equal number of hours in any given 168 hour (1-week) operating period. Control system shall indicate the individual fans operating and not operating. A separate control signal shall be required to indicate fan failure, separate from an indication that a fan is intentionally controlled to be off.

2) Manufacturer shall not use fan width modulation systems which require the use of an actuator. Fan unloading shall be done by shutting off individual fans or using a mechanical fan width modulation system, in conjuction with, the variable frequency drives.

h. After the pre-balanced fan is installed on the fan skid and isolator rails, the entire fan skid shall be run-balanced at the specified speed to insure smooth and trouble-free operation. The run balance shall include filter-in and filter-out balancing in all three (3) planes, on both sides of the fan assembly at the bearings.

1) Filter-in measurements shall be taken in the horizontal and vertical planes on the drive and opposite-drive sides of the fan shaft.

2) Filter-out measurements shall be taken in the horizontal, vertical and axial planes on the drive and opposite-drive side of the fan shaft.

3) An IRD or PMC analyzer shall have been used to measure velocity, with a final balanced reading not exceed 0.1 inches/second

i. Fan and motor assemblies shall be mounted on welded and painted inertia bases with factory or field installed concrete or provided with a fan support structure equal to 2x times that mass of the structure. The entire assembly shall be supported by 2" deflection seismic isolators with earthquake restraints. The isolators shall be selected to provide an isolation efficiency equal to 95% or better.

1) The fan motor shall be on an adjustable base.

2) Fan segment shall be equipped with a 36” access door.

3) A fan inlet screen shall be provided on all fans.

4) SWSI Plenum fans shall be provided with a fan cage.

5) Fan assemblies shall be balanced for inverter duty operation.

6) The fan will be balanced over the entire range of fan operation (30% to 100% of RPM). Concrete shall be installed in inertia bases before balancing and the fan/motor/inertia base shall be balanced as an assembly.

j. Motors shall be TEFC type in accordance with the project specifications. Their efficiency must be in accordance with NEMA Premium, design B. The motors shall be inverter duty rated for inverter service in accordance with NEMA Standard Publication MG-1, Part 31. Motors connected to VFD's shall be furnished with AEGIS SGR shaft grounding ring kit, installed by the equipment manufacturer. Motors shall be by Baldor, Marathon, U.S. Electric.

k. Each fan shall be provided with an airflow measurement piezometer ring. An inlet tap shall mounted on the face of the inlet cone, and the piezometer ring mounted on the throat of the inlet cone. The flow measuring station shall not obstruct the inlet of the fan and shall have no effect on fan performance (flow or static) or sound power levels. Unit manufacturer shall also provide pressure transducer.

l. A motor removal rail shall be supplied over the Motor and in line with the access door. A motor removal trolley shall be supplied for and installed. The trolley shall be designed to move on the motor rail to deliver the motor 24" outside of the motor access door. The trolley shall be designed so it can be moved to any of the motor rails on any of the Custom Air Handlers supplied for the project. Alternatively, a motor removal davit can be provided for each air handling unit.

All fan systems shall be selected to operate at 100% at N-1. Submittal shall show fan ratings at N and N-1 design.

m. Fan arrays shall be controlled using a common control signal, such as the duct static control signal, to modulate the fan speed.

n. Each fan array in the air handling unit shall be provided with a factory installed airflow measuring instrument. Every fan in the array will have an airflow measuring device that is guaranteed by the unit manufacturer to have no impact on the fan airflow performance and will not increase the fan sound power. The output of the airflow measurement device on each fan shall be wired by the unit manufacturer back to a central processor mounted on the cabinet exterior that will add the flow from each fan to provide a total airflow for the fan array. Using one air flow measuring device and multiplying by the number of fans provided is not acceptable due to lack of accuracy.
The central processor shall be able to detect and report a fan failure. Auxiliary contacts on the motors starters are not acceptable as fans can fail without tripping overloads. Current sensors wired into the central processors can be utilized. Acceptable manufactures are: AccAMP series ACSX, CR Magnetics model CR439, Greenheck FMS, NK Technologies series AS1.Piezometric volume taps with pressure transducers are acceptable. Transducer accuracy shall be 1% of pressure reading from full scale down to 10% of full scale reading to improve accuracy to less than 0.5% of calculated flow from 100%-30% of flow. The square root linearization and conversion of the pressure signal to flow shall be done at the central processor. Acceptable pressure transducers are: MatrixMonitor™ Fan Sensor, Omega PX656, Greenheck FMS, Setra Model 239.

o. Measure the airflow back flowing through all failed fans in the array. The backflow shall be subtracted from the sum of the operating fans to provide an accurate delivered airflow for the entire fan array. The system measurement accuracy shall be $\pm$5% of measurement throughout the entire operating range of the fan array down to 15% of design flow. Systems with accuracy rated as a percentage of full scale are not acceptable. The system shall adjust for changes in barometric pressure and temperature to maintain accuracy in changing atmospheric conditions and at any altitude. The system shall be able to measure airflow and report it in unit of ACFM or SCFM as selected by the user.
The system shall have the capability to communicate to the BMS with discretely wired analog signals or through an RS485 two wire multi drop network using the MODBUS protocol. All information available through the local keypad display unit shall be made available through the

MODBUS interface. At a minimum there shall be two locally scalable 0 to 10 VDC signals to report airflow and array pressure rise to the BMS. In addition there shall be three SPDT relay outputs to report on the condition of the fan array. One relay will switch when the control is energized, one will switch in the event of fan failure detection and one will switch if fan surge is detected.

p. In addition to fan failure detection the system shall also be able to detect and report when any fan is in surge. The system shall have self-diagnostic capabilities and be able to report measurement and system errors. Individual and total flow measurements, entering air temperature and fan array pressure rise shall be available at a unit mounted key pad display.

q. Unit manufacturer shall supply and mount for each fan in the air handler a tri-axial accelerometer used to measure fan vibration. The output of each accelerometer shall be processed in real time through a FFT processor to provide frequency domain vibration for each fan. The vibration readings shall be reported in velocity and available for a frequency range that is a minimum of 3 times the operational speed of the fans. The system shall be capable of checking the fan vibration against user selectable vibration limits and reporting when those limits are exceeded. Each fan vibration sensor will be tied back to the airflow monitor where the individual fan vibration levels can be displayed on the local keypad display and the alarms and data can be transmitted to the BMS through the MODBUS communication link. Acceptable manufacturers are: MatrixMonitor™ Fan Sensor, IMI Sensors model 685B, Greenheck FMS, Metrix Instrument Co. model 440.

Each fan array in the air handler shall be equipped with a grease monitoring system to track the intervals between motor bearing greasing. The system shall monitor the motor shaft speed for every fan motor in the array and integrate this data over time to determine the optimum elapsed time between bearing greasing. The system shall maximize the time interval between motor bearing greases while maintain proper lubrication of the bearings to maximize the motor life. The system shall notify the operator when it is time to grease the motor bearings through a locally mounted key pad display. The system will also estimate the number of days remaining until the motor bearings need to be greased. The system shall be capable of reporting the grease life information to the BMS through an RS485 two wire multi drop network using the MODBUS communication protocol.}

r. Acceptable Manufacturers:

1) Fans shall be as manufactured by air handling unit manufacturer.

2) Alternatively, fans shall be manufactured by Twin City, Chicago Blower, or New York Blower.

8. Variable Frequency Motor Controllers

a. Refer to Section 23 73 14 “Variable Frequency Motor Controllers”.

9. Filter Section

a. The unit shall be provided with a filter rack and 4-inch 30% efficient pleated media filters. Filter efficiency is rated per ASHRAE Standard 52-76. Access to the filters shall be through hinged access door. Unit to include additional filter rack, 12 inch MERV 13 pleated media after filter.

b. Unit equipped with energy recovery wheels which include an additional 2" thick pleated media outdoor air filter.

c. Contractor shall provide and install a complete set of new filters (all three types) at building turnover, as well as, provide additional set of attic stock for each AHU.

10. Outside Air/return air/exhaust air (OA/RA/EA) Dampers

    a. Dampers shall be constructed of heavy gauge aluminum airfoil shaped blades. Damper edges have blade seals of extruded vinyl with an inflatable pocket and shall be locked into extruded aluminum blade slots. Dampers shall have flexible side seals of flexible metal compression type. Leakage rate of aluminum dampers shall not exceed 3 cfm/sq. ft. at 3" static pressure differential across the damper. Dampers shall be Tamco 1000 or equal.

    b. The integral air monitoring station shall incorporate measuring ports built into the monitoring blades and shall control the minimum amount of outside air as recommended by ASHRAE Standard 62. Standard construction shall be 4" x 1" .081 (102 x 25 x 2) control damper frame which incorporates mounting flanges both sides. Control damper blades shall be heavy gage extruded aluminum airfoil type. Airflow monitoring blades shall be heavy gage anodized extruded aluminum airfoil shaped fixed in 10" (254) 16 GA (1.6) galvanized frame. Jamb seals along control damper sides shall be flexible metal compression type. Damper linkage shall be concealed out of the airstream and located within the damper frame to reduce pressure drop and noise. The integral air monitoring station shall incorporate an air straightener section contained in a 5" (127) long 16 gage galvanized sleeve attached to the monitoring blade frame. The air straightener section shall be flanged as required by the application. Airflow monitoring station shall have tested for pressure drop in accordance with AMCA Standard 610-93 in an AMCA registered laboratory. The airflow monitoring station must bear the AMCA Certified Ratings Seal for Airflow Measurement Station Air Performance. Airflow monitoring station shall beTamco/Ebtron combination AFMS damper. .

    c. Where exhaust connections are not ducted, provide heavy-duty gratings over the exhaust openings. Gratings shall be capable of supporting at least 300 pounds.

11. Electrical Devices

    a. Install and wire fans to VFD's and to single connection point (one for supply fans and one for return fans).

    b. Provide 100 watt equivalent LED Crouse-Hinds, Appleton or equal vapor proof lighting fixture with lens guard in each section for service. Provide two GFI outlets in each unit. Terminate wiring in junction box mounted on exterior of unit.

    c. Electric Contractor shall extend and make connections to (3) power connection points.

12. Piping Locations

    a. The heating coil and cooling coil stubs shall be terminated per the Mechanical Drawings. All piping shall be insulated by installing contractor in the field.

13. Schedule of Air Conditioning Unit: Refer to Schedule of Air Handling Unit on the drawings.

2.2 SOURCE QUALITY CONTROL

A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

C. Water Coils: Factory tested to 300 psig according to ARI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Coordinate the following examination procedures with the HVAC Contractor.

B. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

C. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

D. Examine roughing-in for hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate the following installation procedures with the HVAC Contractor.

B. Arrange installation of unit to provide access space around air-handling unit for service and maintenance.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

D. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 STEEL SUPPORTS, ROOF CURBS, CONCRETE PADS

A. Steel supports or concrete pads shall be installed by the Contractor (where required).

B. Roof curbs will be provided by unit manufacturer (where required).

C. Coordinate supports under each air handling unit as detailed on the drawings and based upon actual equipment provided.

3.4 CONNECTIONS

A. Coordinate the following connection procedures with the HVAC Contractor.

B. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Install piping adjacent to air-handling unit to allow service and maintenance.

D. Connect piping to air-handling unit mounted on vibration isolators with flexible connectors.

E. Connect condensate drain pans using, ASTM B 88, Type L (ASTM B 88L, Type B) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

F. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

G. Connect duct to air-handling unit with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories."

3.5 FIELD QUALITY CONTROL

A. Coordinate the following field quality control procedures with the HVAC Contractor.

B. Manufacturer's Field Service: Provide 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: Provide a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks.

2. Fan Operational Test: After electrical circuitry has been energized, start unit to confirm proper motor rotation and unit operation.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Provide a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Verify that shipping, blocking, and bracing are removed.

3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.

4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.

5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.

6. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.

7. Comb coil fins for parallel orientation.

8. Verify that proper thermal-overload protection is installed for electric coils.

9. Install new, clean filters.

10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling unit include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.

2. Measure and record motor electrical values for voltage and amperage.

3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7 ADJUSTING

A. Assist the successful HVAC Contractor with the following adjusting procedures.

B. Adjust damper linkages for proper damper operation.

C. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.8 CLEANING (BY HVAC CONTRACTOR)

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling unit internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 DEMONSTRATION

A. Provide a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling unit. Video training sessions. Provide at least 8 hours of training for Owner’s personnel.

END OF SECTION 237300

SECTION 237314 – VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Related Sections:

1. 237300 – Custom Air Handling Units (Provided with AHU's)

2. 233423 – HVAC Fans

1.2 DESCRIPTION OF WORK

A. Furnish the new variable frequency drives of NEMA type 1 and type 3R (outdoor locations) construction as required and as hereinafter specified and consisting of the following principal essentials.

B. The start-up of the variable frequency drives shall be performed by the manufacturer, the cost of which shall be included in his proposal. All details of construction and installation shall meet the approval of the Engineer. In addition, manufacturer shall provide the operating instruction manuals and a total of four (4) hours of instruction and training on the operation of the variable frequency drives.

C. The equipment shall comply with the specification, shall be the product of a reputable manufacturer, and shall operate at the manufacturers standard ratings in all respects. All parts shall be suited to the service and not subject to injury under any condition that may occur in the normal operation of the system.

D. The variable frequency drives shall be compatible with any standard NEMA design B, premium efficiency, 1.15 SF, Class H insulation, three phase induction motor.

E. The entire installation shall comply with all state and local laws, and the National Electrical Code.

1.3 SUMMARY

A. Includes separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.4 DEFINITIONS

A. AHU: Air Handling Unit

B. BAS: Building automation system.

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. IGBT: Insulated-gate bipolar transistor.

F. LAN: Local area network.

G. LED: Light-emitting diode.

H. MCP: Motor-circuit protector.

I. NC: Normally closed.

J. NO: Normally open.

K. OCPD: Overcurrent protective device.

L. PCC: Point of common coupling.

M. PID: Control action, proportional plus integral plus derivative.

N. PWM: Pulse-width modulated.

O. RFI: Radio-frequency interference.

P. TDD: Total demand (harmonic current) distortion.

Q. THD(V): Total harmonic voltage demand.

R. VFC: Variable-frequency motor controller (drive).

1.5 SUBMITTALS

A. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated. 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 enclosed unit.

f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

C. Product Certificates: For each VFC, from manufacturer.

D. Source quality-control reports.

E. Field quality-control reports.

F. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals. Include the following:

1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.

2. Manufacturer's written instructions for setting field-adjustable overload relays.

3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.

4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

G. 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.

H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

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

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test VFC according to IEEE 344 to withstand seismic forces.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store VFC’s indoors to clean, dry space with uniform temperature to prevent condensation. Protect VFC’s from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than 14 deg F and not exceeding 104 deg F.

2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.

3. Humidity: Less than 95 percent (noncondensing).

4. Altitude: Not exceeding 3300 feet.

1.9 COORDINATION

A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:

1. Torque, speed, and horsepower requirements of the load.

2. Ratings and characteristics of supply circuit and required control sequence.

3. Ambient and environmental conditions of installation location.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs 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 described below 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 two of each size and type.

2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

3. Indicating Lights: 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.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. ABB – Series ACH 550.

2. Yaskawa Electric America, Inc.; Drives Division.

3. Pre-approved "equal" – submitted to engineer/owner prior to bid submission

B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

2.2 VARIABLE FREQUENCY MOTOR CONTROLLERS (DRIVES)

A. Provide drives as scheduled.

B. Each variable speed drive package shall consist of a non-fusible disconnect switch, a non-fusible disconnect service switch, control power supply, fuses, relays and terminals, all installed in a single standardized NEMA type 1 enclosure.

C. A disconnect shall be provided in the incoming line of each VFC package and shall consist of a 600 volt A.C. 3 pole non-fusible disconnect switch with quick-make, quick-break mechanism. The operating handle of each disconnect shall clearly indicate whether the switch is ON or "OFF". External operating handle shall be equipped with provision for locking disconnect in "OFF" position.

D. Variable Frequency Drive

1. The variable frequency drive controller shall be microprocessor based, fully transistorized pulse width modulated (PWM) design producing a sine-coded output waveform. The output transistors shall be of insulated gate bipolar transistors (IGBT) with soft switching technology to facilitate noiseless motor operation and improved reliability.

2. The variable frequency drive controller shall be equipped with a graphic back-lit liquid crystal display (LCD) and keypad which can be configured to display, output frequency, current, set points, VFC status and fault codes, BACNET card, etc.

3. Operating features:

a. Linear speed control from 0% to 100% of maximum speed.

b. The variable frequency drive shall be able to withstand input voltage variations of 15% below and 10% above 460 volt 3 phase nominal, and imbalance no greater than 3% without tripping or adversely affecting drive performance.

c. The displacement power factor of the variable frequency drive shall be 95% lagging or higher for all speeds.

d. Drive efficiency at rated load shall be 95% or higher.

e. "Speed search" transfer: Drive shall have the ability to automatically start into a spinning motor without stopping the motor or creating a fault condition.

f. Auto restart: programmable "intelligent" auto restart precludes any attempt at restart in the event of trips typically indicative of component failure. Programmable for up to ten (10) restarts.

g. Minimum of two second power loss ride-through capability. In the event of a loss of power lasting two seconds or less the drive shall maintain operation and prevent nuisance trips upon return of power. In the event of a loss of power lasting more than two seconds, the auto restart function shall restart drive.

h. Output three phase current sensing class 20 overload relay to provide motor protection.

i. Carrier frequency: 1 to 12KHZ

j. Acceleration and deceleration settings: 0.1 to 1800 seconds, using three modes (linear, S-curve, non-linear).

k. System Control interfaces: The variable frequency drive shall be set up to accept control signals from the campus DDC system through the drives standard embedded fieldbus (EFB) using standard BAC net protocol.

l. 24 volt DC level commands for remote digital inputs to drive to indicate:

   1) Start/Stop

   2) Control (Preset) Speed 1

   3) Safety Interlock

m. 230 volt AC rated contacts for remote indication of VFD status.

   1) VFD ready

   2) VFD run

   3) VFD fault

n. Remote serial control: Each VFD shall be equipped with standard BAC net communication interface protocol for connection to the DDC system to integrate VFD specific parameters into the system such as operating characteristics (current, voltage, frequency) and inverter faults. A separate RS-

232 port shall be provided for connection to an external PC for troubleshooting purposes without interrupting the operation of the RS-485 link.

E. All variable frequency drives shall be equipped with a keypad/annunciator panel to show all HVAC specific data for intuitive, convenient operation by building personnel. Annunicator shall include the following:

1. A single-line diagram of power circuit with LED indicators for status of each of the following components:

a. Ready

b. Enable

c. Output contactor

d. VFD run

2. LED indicators for status of the following alarm conditions:

a. Automatic transfer

b. VFD fault

3. Individual keypad pushbuttons and LED indicators for the following:

a. VFD drive select

b. VFD reset

c. VFD auto

d. VFD off

e. VFD hand

F. Nameplates

1. On the front of each variable frequency drive, provide suitable black plastic nameplate with white cut letters. Abbreviations will not be permitted unless authorized by the Engineer.

G. Schedule Of Variable Frequency Drives

1. Refer to Drawings.

2.3 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.

2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs 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. Coordinate the following examination procedures with the HVAC Contractor.

B. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance.

C. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

D. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Coordinate the following installation procedures with the HVAC Contractor.

B. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

C. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in each fusible-switch VFC.

F. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."

G. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

I. Comply with NECA 1.

3.3 IDENTIFICATION

A. Assist the HVAC Contractor with the following identification procedures.

B. Identify VFCs, components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each VFC with engraved nameplate.

3. Label each enclosure-mounted control and pilot device.

C. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.4 CONTROL WIRING INSTALLATION

A. Assist the HVAC Contractor with the following control wiring installation procedures.

B. Install wiring between VFCs and remote devices and facility's central-control system.

C. Bundle, train, and support wiring in enclosures.

D. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.

2. Connect selector switches with control 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 FIELD QUALITY CONTROL

A. Assist the HVAC Contractor with the following field quality control procedures.

B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Provide a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.

1. Manufacturer's Field Service: Provide factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

E. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

F. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.

2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.

3. Test continuity of each circuit.

4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer and Commissioning Agent before starting the motor(s).

5. Test each motor for proper phase rotation.

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

7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

G. VFCs will be considered defective if they do not pass tests and inspections.

H. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Provide a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

A. Assist the HVAC Contractor with the following adjustment procedures.

B. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

C. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

D. 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 Engineer and Commissioning Agent before increasing settings.

E. Set the taps on reduced-voltage autotransformer controllers.

F. Set field-adjustable pressure switches.

3.8 PROTECTION

A. Assist the HVAC Contractor with the following protection procedures.

B. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

C. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Provide a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs. Video training sessions. Provide a minimum of 4 hours of training for Owner’s personnel.

END OF SECTION 237314

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SECTION 238239 - UNIT HEATERS

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. Cabinet unit heaters with centrifugal fans and hot-water coils.

2. Propeller unit heaters with hot-water coils.

3. Wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CWP: Cold working pressure.

C. PTFE: Polytetrafluoroethylene plastic.

D. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product 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. Plans, elevations, sections, and details.

2. Location and size of each field connection.

3. Details of anchorages and attachments to structure and to supported equipment.

4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.

5. Location and arrangement of piping valves and specialties.

6. Location and arrangement of integral controls.

7. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, 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. Suspended ceiling components.

2. Structural members to which unit heaters will be attached.

3. Method of attaching hangers to building structure.

4. Size and location of initial access modules for acoustical tile.

5. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.

b. Air outlets and inlets.

c. Speakers.

d. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

D. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.5 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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Cabinet Unit Heater Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 CABINET UNIT HEATERS

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

1. Carrier Corporation.
2. Dunham-Bush, Inc.
3. McQuay International.
4. Sterling Vulcan
5. Trane.

B. Description: A factory-assembled and -tested unit complying with ARI 440.

1. Comply with UL 2021.

C. Coil Section Insulation: ASTM C 1071; surfaces exposed to airstream shall be facing to prevent erosion of glass fibers.

1. Thickness: 1 inch.
2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Coil Section Insulation: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.

1. Thickness: 1 inch.
2. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

E. Cabinet: Steel with baked-enamel finish with manufacturer's custom paint, in color selected by Architect.

1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch galvanized, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.

2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0677-inch-thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.

3. Recessing Flanges: Steel, finished to match cabinet.

4. Control Access Door: Key operated.

5. Base: Minimum 0.0528-inch- thick steel, finished to match cabinet, 4 inches high with leveling bolts.

6. Extended Piping Compartment: 8-inch wide piping end pocket.

7. False Back: Minimum 0.0428-inch- thick steel, finished to match cabinet.

F. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Washable Foam: 70 percent arrestance and 3 MERV.

2. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.

3. Pleated: 90 percent arrestance and 7 MERV.

G. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

H. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.

2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

I. Factory, Hot-Water Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet and outlet.

1. Two-way, two-position control valve.

2. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.

3. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.

4. Automatic Flow-Control Valve: Brass or ferrous-metal body, 300-psig working pressure at 250 deg F, with removable, corrosion-resistant, tamperproof, self-cleaning, piston-spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig.

5. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 threaded pipe and full-port ball valve in strainer drain connection.

6. Wrought-Copper Unions: ASME B16.22.

J. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

K. Basic Unit Controls:

1. Control voltage transformer.

2. Unit-mounted thermostat with the following features.

a. Heat-off switch.

b. Fan on-auto switch.

c. Manual fan speed switch.

d. Adjustable deadband.

e. Exposed set point.

f. Exposed indication.

g. Deg F indication.

3. Wall-mounting temperature sensor.

4. Unoccupied period override push button.

5. Data entry and access port.

a. Input data includes room temperature, and occupied and unoccupied periods.

b. Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.

L. BAS Interface Requirements:

1. Interface relay for scheduled operation.

2. Interface relay to provide indication of fault at central workstation.

3. Interface shall be BAC-net compatible for central BAS workstation and include the following functions:

a. Adjust set points.

b. Cabinet unit heater start, stop, and operating status.

c. Data inquiry, including supply-air and room-air temperature.

d. Occupied and unoccupied schedules.

M. Electrical Connection: Factory wire motors and controls for a single field connection.

N. Capacities and Characteristics:

1. Cabinet:

a. Vertical, Surface Mounted: Upflow.

1) Top: Flat.

2) Air Inlet: Front, punched louver grille.

3) Air Outlet: Front, extruded-aluminum bar grille.

b. Vertical, Semirecessed: Upflow.

1) Air Inlet: Front, punched louver grille.

2) Air Outlet: Front, extruded-aluminum bar grille.

c. Vertical, Fully Recessed: Upflow.

1) Air Inlet and Outlet: Front, punched louver inlet and punched louver outlet.

d. Horizontal, Fully Recessed:

1) Air Inlet and Outlet: Front, punched louver inlet and punched louver outlet.

2. Refer to drawings for capacities and type.

2.2 PROPELLER UNIT HEATERS

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

1. Carrier Corporation.

2. Dunham-Bush, Inc.

3. McQuay International

4. Sterling Vulcan

5. Trane

B. Description: An assembly including casing, coil, fan, and motor in vertical and horizontal discharge configuration with adjustable discharge louvers.

C. Comply with UL 2021.

D. Comply with UL 823.

E. Cabinet: Removable panels for maintenance access to controls.

F. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.

G. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

H. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

I. General Coil Requirements: Test and rate hot-water propeller unit heater coils according to ASHRAE 33.

J. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F with manual air vent. Test for leaks to 350 psig underwater.

K. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

L. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Type: Permanently lubricated, multispeed.

M. Control Devices:

1. Wall-mounting thermostat.

N. Capacities and Characteristics

1. Refer to the Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants."

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Install propeller unit heaters level and plumb.

D. Suspend cabinet unit heaters from structure with elastomeric hangers . Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

E. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers. Hanger rods and attachments to structure are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

F. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

G. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."

E. Comply with safety requirements in UL 1995.

F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 23 Section "Hydronic Piping."

G. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of unit heater. Steam specialties are specified in Division 23 Section "Steam and Condensate Heating Piping."

H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Operate electric heating elements through each stage to verify proper operation and electrical connections.

3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

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

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238239

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SECTION 250000 – INTEGRATED AUTOMATION

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. This Section includes a summary of all Integrated Automation which is principally Direct Digital Control (DDC System) related work.

B. Related Sections:

1. 250501 – COMMON WORK RESULTS FOR INTEGRATED AUTOMATION
2. 250800 – COMMISSIONING OF INTEGRATED AUTOMATION
3. 250990 – SEQUENCE OF OPERATION

C. Work by Others:

1. The following work will be done by other contractors, as specified under, which this contractor shall read to ascertain what is called for therein:

    a. General Construction

    b. Fire Protection

    c. Plumbing

    d. HVAC

    e. Electric

    f. Technology

    g. Laboratory Airflow Controls

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks and BACNET: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.4 GENERAL

A. This contract shall include the furnishing of all labor and materials required for the installation of new temperature regulating systems in the Buildings to monitor, control, and regulate automatically and completely the new air conditioning, ventilating, and heating systems, exterior lighting, some interior lighting, as shown on the accompanying drawings and hereinafter specified. The temperature control equipment shall be installed by trained mechanics and technicians employed by the manufacturer and working in conjunction with the other contractors.

B. Bids for the temperature control work, hereinafter specified, shall be based upon a Talon by ASA Controls or Siemens Building Technologies (APOGEE) direct digital control system with electronic sensors for indication and control functions, electrically actuated devices including new dampers, valves, etc., and all connections to sensors and actuated devices. All bidders of controls shall comply with this specification and shall provide any additional labor, hardware, software, programming, network integrators, etc., to communicate with, control and display graphically the new systems.

C. The Building Management System (BMS) shall be a complete system (hardware and software) designed for use within the Xavier University system. Devices residing on the automation network located in equipment rooms and similar locations shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.

D. All points of user interface shall be on standard PCs, IPads, that do not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser such as Microsoft Internet Explorer, or Netscape.

E. A Robust Data Server shall be used for the purpose of providing a location for extensive archiving of system configuration data, and historical data such as trend data and operator transactions. All data stored will be through the use of a standard data base platform: Microsoft Data Engine (MSDE) or Microsoft SQL Server as dictated elsewhere in this specification. A single server will be provided to serve the entire District.

F. The BMS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMS.

G. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this project.

H. The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:

1. Operator information, alarm management and control functions.

2. Enterprise-level information and control access.

3. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.

4. Diagnostic monitoring and reporting of BMS functions.

5. Offsite monitoring and management access.

6. Energy management.

7. Standard applications for terminal HVAC systems.

I. Acceptable Manufacturers and Installers:

1. Siemens Talaon installed by ASA Controls.

2. Siemens Building Systems, installed by the Siemens Factory Branch Office.

3. Alternate controls only considered upon prior approval by Owner.

J. The BMS Contractor shall be a recognized national manufacturer, installer and service provider of BMS. The BMS Contractor shall have a branch facility within a 50-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.

K. The Building Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Management Systems, and shall be the manufacturer's latest standard of design at the time of bid.

L. The new systems shall be complete with all piping connections, switches, relays, wiring, or other devices required to accomplish the required results. All control devices shall be of the manufacturer's best construction. Complete shop drawings of the control system shall be submitted for approval. Contractor shall become thoroughly familiar with interconnections, with equipment specified under other sections of this specification including electric work, and all work furnished by the Direct Digital Control Contractor shall be coordinated therewith.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project. The control contractor shall have a minimum of three years documented experience for the installation of the specified control system.

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 ASHRAE 135 for DDC system components.

1.6 COORDINATION

A. Coordinate location of thermostats, humidistats and other exposed control sensors with places and room details before installation.

B. Coordinate equipment with "Network Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

E. Coordinate equipment with Division 26 Section “Panelboards” to achieve compatibility with starter coils and annunciation devices.

F. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

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

1.7 SYSTEM ARCHITECTURE

A. The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall not be limited to a single open communication protocol standard, but to also integrate a wide variety of third-party devices and applications via additional protocols and through the latest software standards. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.

B. The Building Management System shall consist of the following:

1. Standalone Building Level Server(s).

2. DDC Controllers (HVAC etc.).

3. Local Display Devices.

4. Portable Operator's Terminals.

5. Distributed User Interfaces.

6. Network processing, data storage and communications equipment.

7. Other components required for a complete and working BMS.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

E. Automation Network

1. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard Aoff the shelf@ products available through normal PC vendor channels.

2. The BMS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.

3. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.

4. Automation engines shall reside on the Owner’s IT network.

5. The automation network shall be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

F. Control Network

1. Control networks shall provide either "Peer-to-Peer", Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.

2. DDC Controllers shall reside on the control network.

3. Control network communications shall be provided for a peer-to-peer distributed system utilizing LonWorks or Bacnet technology, Free Topology Transceivers (FTT-10a).

4. The LonWorks or Bacnet network shall employ industry standard, open protocol devices manufactured to LonMark-compliant standards for LonMark or Bacnet compliant standards for Bacnet. Where devices are not covered by current guidelines for interoperability by LonMark International (www.lonmark.org) the BMS contractor shall submit detailed product literature and/or sample devices as required to prove interoperability.

1.8 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.

2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.

3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.

4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.

5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

a. Water Temperature: Plus or minus 1 deg F.

b. Water Flow: Plus or minus 5 percent of full scale.

c. Water Pressure: Plus or minus 2 percent of full scale.

d. Space Temperature: Plus or minus 1 deg F.

e. Ducted Air Temperature: Plus or minus 1 deg F.

f. Outside Air Temperature: Plus or minus 2 deg F.

g. Dew Point Temperature: Plus or minus 3 deg F.

h. Temperature Differential: Plus or minus 0.25 deg F.

i. Relative Humidity: Plus or minus 5 percent.

j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.

k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.

l. Airflow (Terminal): Plus or minus 10 percent of full scale.

m. Air Pressure (Space): Plus or minus 0.01-inch wg.

n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.

o. Carbon Dioxide: Plus or minus 50 ppm.

p. Electrical: Plus or minus 5 percent of reading.

1.9 BUILDING LEVEL SERVER (BLS)

A. The Building Level Server shall be a fully user-programmable, supervisory controller. The Automation Engine shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Automation Engines.

B. Automation network – The Building Level Server (BLS) shall reside on the automation network. Each BLS shall support one or more sub-networks of a minimum of 100 controllers each.

C. User Interface – Each BLS shall have the ability to deliver a web based user interface as previously described. All computers connected physically or virtually to the automation network shall have access to the web based user interface. Systems without such capability at this level shall provide a user interface via the combination of operator workstations and Web servers as determined by the owner for comparable operation. With the appropriate IP address, access codes, and passwords, this system shall be viewable by any web browser anyplace in the world.

D. Processor – Controllers shall be microprocessor-based with a minimum word size of 32 bits. They shall be multi-tasking, multi-user, and real-time digital control processors. Standard operating systems shall be employed. Controller size and capability shall be sufficient to fully meet the requirements of this Specification.

E. Memory – Each controller shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

F. Hardware Real Time Clock – The controller shall have an integrated, hardware-based, real-time clock.

G. Communications Ports – The BLS shall provide at least (1) USB ports and (1) RS-232 serial data communication port for operation of operator I/O devices, such as industry-standard computers, modems, and portable operator's terminals. Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.

H. Diagnostics – Controller shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.

I. Power Failure – In the event of the loss of normal power, The BLS shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software. Flash memory shall be incorporated for all critical controller configuration data.

1. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions.

2. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

J. Certification – All controllers shall be listed by Underwriters Laboratories (UL).

1.10 DEDICATED WEB BASED SYSTEM WORKSTATION

A. The BMS Contractor shall provide and install, at Nagel Middle School, where indicated and directed by the Owner, a personal computer for command entry, information management, network alarm management, and database management functions. All real-time control functions, including scheduling, history collection and alarming, shall be resident in the BMS Building Level Servers to facilitate greater fault tolerance and reliability. Prior to ordering and installing the system, all hardware and software shall be coordinated with and approved by Owner's IT Department. All equipment shall have power management features which allow equipment to be shut down automatically when not in use.

B. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Contractor and by other third party applications suppliers, including but not limited to Microsoft Office Applications. Specifically it must be implemented to conform to the following interface standards:

1. Microsoft Internet Explorer for user interface functions.

2. Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions.

3. Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports.

4. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries.

C. Laptop Computer: (Quantity: 1)

1. Minimum Specifications: similar to Dell Precision M4400.

a. RAM memory – 8GB SDRAM or greater.

b. CPU – Intel Core 2 Duo Processor.

c. Hard drive – 1000 GB (5400 RPM).

d. Hard drive backup system – 8 x DVD +/- RW Drive.

e. Ports - (2) serial, (1) parallel, (2) USB ports.

f. Display – 15.4" LCD, 1280 x 1024 minimum resolution.

g. Graphics – NVIDIA Quadro FX 2700M.

h. Warranty – Three year, On-site next business day.

D. Desktop Workstation Computer, Monitor, Keyboard, Mouse: (Quantity: 1)

1. Minimum Specifications: similar to Dell Precision T5400.

a. RAM memory – 12 GB SDRAM or greater.

b. CPU – Quad – Core Intel Xenon Processor.

c. Hard drive - 1000 GB SATA 3.0 Gbls, 7200 RPM or greater.

d. Hard drive backup system

e. Ports - (2) serial, (1) parallel, (2) USB ports.

f. Display – 24” Widescreen flat panel monitor, 1920 x 1200 minimum resolution.

g. Keyboard - 101 keyboard with 2 button/wheel mouse.

h. Graphics – 256 MB Pcle x 16, NVIDIA NVS 290.

i. Warranty – Three year, on-site next business day.

2. If system can only be programmed at the operator workstation, then two of these workstations shall be provided and included in the base bid

E. Operating System Software:

1. Windows 7 or later.

2. Where user interface is not provided via browser, provide complete operator workstation software package, including any hardware or software keys. Include the original installation disks and licenses for all included software, device drivers, and peripherals.

3. Provide software registration cards to the Owner for all included software.

F. Peripheral Hardware:

1. Reports printer:

a. Printer Make/Model – Dell 2135CN multi-function color laser printer.

b. Print Speed – 16 PPM Black, 12 PPM Color.

c. Resolution – 600 x 600 DPI

d. Color Printing – Include Color Kit.

G. Distributed Web Based User Interface:

1. All features and functions of the dedicated user interface previously defined in this document shall be available on any computer connected directly or via a wide area or virtual private network (WAN/VPN) to the automation network and conforming to the following specifications.

2. The software shall run on the Microsoft Internet Explorer browser.

1.11 SYSTEM SOFTWARE

A. Operator Interface:

1. An integrated browser based client application shall be used as the user operator interface program.

2. All inputs, outputs, setpoints, and all other parameters as defined herein, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software. The system shall permit not less than 25 simultaneous users.

3. The user interface software shall provide help menus and instructions for each operation and/or application.

4. All controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include: setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.

5. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:

   a. User access for selective information retrieval and control command execution.

   b. Monitoring and reporting.

   c. Alarm, non-normal, and return to normal condition annunciation.

   d. Selective operator override and other control actions.

   e. Information archiving, manipulation, formatting, display and reporting.

   f. BMS internal performance supervision and diagnostics.

   g. On-line access to user HELP menus.

   h. On-line access to current BMS as-built records and documentation.

   i. Means for the controlled re-programming, re-configuration of BMS operation and for the manipulation of BMS database information in compliance with the prevailing codes, approvals and regulations for individual BMS applications.

6. The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.

B. Navigation Trees

1. The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.

2. Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.

3. The navigation trees shall be Adockable@ to other displays in the user interface such as graphics. This means that the trees will appear as part of the display, but can be detached and then minimized to the Windows task bar or closed altogether. A simple keystroke will reattach the navigation to the primary display of the user interface.

C. Alarms

1. Alarms shall be routed directly from Building Level Servers to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs, servers, pagers, cell phones, etc. Alarms with higher priority shall be able to be easily programmed to send text messages via pagers, cell phones, e-mail, etc. Such alarms will be identified by the Owner during the commissioning process. The programming of such alarm features shall be performed at that time and the cost for such programming included in the base bid. The alarm management portion of the user interface shall, at the minimum, provide the following functions:

   a. Log date and time of alarm occurrence.

   b. Generate a “Pop-Up” window, with audible alarm, informing a user that an alarm has been received.

   c. Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.

   d. Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.

   e. Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop-up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.

   f. Any attribute of any object in the system may be designated to report an alarm.

   g. The BMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions.

D. Reports and Summaries

1. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:

   a. All points in the BMS system.

   b. All points in each BMS application.

   c. All points in a specific controller.

d. All points in a user-defined group of points.

e. All points currently in alarm.

f. All points locked out.

g. All BMS schedules.

h. All user defined and adjustable variables, schedules, interlocks and the like.

2. Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.

3. Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.

4. The system shall allow for the creation of custom reports and queries via a standard web services XML interface and commercial off-the-shelf software such as Microsoft Access, Microsoft Excel, or Crystal Reports.

E. Schedules

1. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:

a. Weekly schedules.

b. Exception Schedules.

c. Monthly calendars.

2. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.

a. It shall be possible to define one or more exception schedules for each schedule including references to calendars.

b. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.

c. Changes to schedules made from the User Interface shall directly modify the Building Level Server schedule database.

d. Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.

F. Password

1. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.

2. Each user shall have the following: a user name (24 characters minimum), a password (12 characters minimum), and access levels.

3. The system shall allow each user to change his or her password at will.

4. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.

5. A minimum of five levels of access shall be supported individually or in any combination as follows:

   a. Level 1 = View Data.

   b. Level 2 = Command.

   c. Level 3 = Operator Overrides.

   d. Level 4 = Database Modification.

   e. Level 5 = Database Configuration.

   f. Level 6 = All privileges, including Password Add/Modify.

6. A minimum of 100 unique passwords shall be supported.

7. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.

8. The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.

G. Screen Manager - The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.

H. Dynamic Color Graphics

1. The graphics application program shall be supplied as an integral part of the User Interface.

2. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed. The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.

3. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:

   a. All graphics shall be fully scalable.

   b. The graphics shall support a maintained aspect ratio.

   c. Multiple fonts shall be supported.

   d. Unique background shall be assignable on a per graphic basis.

e. The color of all animations and values on displays shall indicate if the status of the object attribute.

4. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows accessible via the pointing device.

5. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.

   a. The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.

   b. In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.

6. Aliasing – Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.

I. Historical trending and data collection

1. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:

   a. Any point, physical or calculated, may be designated for trending. Two methods of collection shall be allowed:

      1) Defined time interval.

      2) Upon a change of value.

   b. Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.

J. Trend data viewing and analysis

1. Provide a trend viewing utility that shall have access to all database points.

2. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.

3. The trend viewing utility shall have the capability to define trend study displays to include multiple trends

4. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.

5. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.

6. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.

7. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

1.12 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database and programming requirements and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and not less than 72 hour battery backup.

2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.

3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP data link/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

1.13 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant for wall, immersion or duct mounting, as required.

B. RTDs and Transmitters:

1. Accuracy: Plus or minus 0.2 percent at calibration point.

2. Wire: Twisted, shielded-pair cable.

3. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.

4. Averaging Elements in Ducts: 24 feet long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.

5. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.

6. Room Sensor Cover Construction: Manufacturer's standard locking covers except in public spaces sensors shall have auxiliary keyed metal covers of color to match sensors.

a. Set-Point Adjustment: Concealed.

b. Set-Point Indication: Concealed.

c. Without Thermometer:

d. Color: Architect shall select color from manufacturer's full range.

e. Orientation: Horizontal.

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

C. Humidity Sensors: Bulk polymer sensor element.

1. Accuracy**:** 2 percent full range with linear output.

2. Room Sensor Range: 20 to 80 percent relative humidity.

3. Room Sensor Cover Construction: Manufacturer's standard locking covers.

a. Set-Point Adjustment: Concealed.

b. Set-Point Indication: Concealed.

c. Color: Architect selected color from manufacturer's full range.

d. Orientation: Horizontal.

5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.

6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 40 to plus 170 deg F.

7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

D. Pressure Transmitters/Transducers:

1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input and temperature compensated.

a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.

b. Output: 4 to 20 mA.

c. Building Static-Pressure Range: 0- to 0.25-inch wg.

d. Duct Static-Pressure Range: 0- to 5-inch wg.

e. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

2. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.

3. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

4. Pressure Transmitters: Direct acting for gas, liquid or steam service; range suitable for system; linear output 4 to 20 mA.

E. Room Sensor Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: Exposed.

2. Set-Point Indication: Exposed.

F. Room sensor accessories, include the following:

1. Insulating Bases: For sensors located on exterior walls.

2. Guards: Locking, solid metal, ventilated for public spaces.

3. Adjusting Key: As required for calibration and cover screws.

1.14 STATUS SENSORS

A. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current with no load discrimination adjustment.

B. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

C. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

D. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

E. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

F. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

1.15 GAS DETECTION EQUIPMENT

A. Manufacturers:

1. B. W. Technologies.

2. Ebtron, Inc.

3. INTEC Controls, Inc.

4. I.T.M. Instruments Inc.

5. MSA Canada Inc.

6. TSI Incorporated.

7. Vaisala.

8. Vulcain Inc.

B. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output;, for wall mounting.

1.16 AIR FLOW MEASURING STATIONS

A. Duct Airflow/Temperature Measuring Station: Bead in glass thermistor array in aluminum tubes connected to transmitter.

B. Manufacturers:

1. Ebtron, Inc.

2. Air Monitor Corporation.

3. Wetmaster Co., Ltd.

C. Provide airflow/temperature measurement devices (AFMS) where indicated on the plans.

1. Each AFMS shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

a) Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.

b) Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.

c) The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.

d) The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.

e) Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.

2. All Sensor Probes

a) Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.

b) Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).

c) Airflow accuracy shall be +/-3% of reading over the entire operating airflow range.

1) Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.

d) Temperature accuracy shall be +/-0.15° F over the entire operating temperature range of -20° F to 160° F.

e) The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).

f) Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.

g) Each sensor assembly shall not require matching to the transmitter in the field.

h) A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.

3. Duct and Plenum Probes

a) Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.

b) Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:

1) Insertion mounted through the side or top of the duct.

2) Internally mounted inside the duct or plenum.

3) Standoff mounted inside the plenum.

c) The number of sensor housings provided for each location shall be as follows:

Duct or Plenum Area (sq. ft.)	Total # Sensors/ Location
<2	4
2 to <4	6
4 to <8	8
8 to <16	12
>= 16	16

d) The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

4. Transmitters

a) The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.

b) The transmitter shall be capable of field configuration and diagnostics using an on-board pushbutton interface and LCD display.

c) The transmitter shall have a power switch and operate on 24 VAC (isolation not required).

1) The transmitter shall use a switching power supply fused and protected from transients and power surges.

2) The transmitter shall use “watch-dog” circuitry to assure reset after power disruption, transients and brown-outs.

d) All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.

e) The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be installed at a location that is protected from weather and water.

f) The transmitter shall be capable of communicating with the Automated Logic system.

1.17 THERMOSTATS

A. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet.

2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

B. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

1. Electric Heating Thermostats: Equip with off position on dial, wired to break ungrounded conductors.

2. Selector Switch: Integral, manual on-off-auto.

1.18 ACTUATORS

A. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Manufacturers:

a. Belimo Aircontrols (USA), Inc. or equal.

2. Valves: Size for torque required for valve close off at maximum pump differential pressure.

3. Dampers: Size for running torque calculated as follows:

a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.

b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.

c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft. damper.

d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.

b. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.

c. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.

5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.

6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.

7. Power Requirements (Two-Position Spring Return): 24 or 120-V ac.

8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.

9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.

10. Temperature Rating: Minus 22 to plus 122 deg F.

11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.

12. Run Time: 12 seconds open, 5 seconds closed.

1.19 CONTROL VALVES

A. Manufacturers:

1. Siemens Building Technologies, Inc.

2. Invensys Building Systems, Inc.

3. Erie Controls.

4. Honeywell.

5. Johnson Controls.

B. Hot Water and Chilled Water Control Valves

1. Control valve shall be globe or ball style with equal percentage flow characteristics.

2. Sizing:

a. The valve shall be sized o have control authority over the coil branch circuit. Valve authority shall be between 0.25 and 0.5 as defined by pressure drop at valve full open divided by pressure drop of full circuit with valve full open.

b. Select the control valve using the Cv of the control valve to be as close to or one size higher that the Cv of the rest of the circuit. The Cv of the rest of the circuit defined by the design flow of the coil (gpm) divided by the square root of the cumulative pressure drops in the circuit, such as coil, piping, fittings, isolation valves, balancing vales, triple duty valves, strainers, etc.

c. Four pipe fan coil valves shall be pressure independent control valves as described below in this section.

d. Air handler chilled water control valve shall be a three way modulating valve sized for the revised flow requirements as indicated on the plans.

C. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc and screwed ends with backseating capacity repackable under pressure.

2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends and renewable seat and disc.

3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

4. Sizing: 3-psig maximum pressure drop at design flow rate or the following:

    a. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.

    b. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

D. Ball Valves

1. Ball valves shall meet "general" specifications above.

2. Full port ball valves shall only be used for isolation or 2-position on-off control.

E. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: Lug.

2. Disc Type: Aluminum bronze.

3. Sizing: 1-psig maximum pressure drop at design flow rate.

F. Terminal Unit Control Valves: Bronze body, stainless steel trim, two ports as indicated, ball valves replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.

2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.

3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

1.20 DAMPERS

A. Automatic Control Dampers: Furnished and installed by HVAC contractor. TCC shall coordinate with the HVAC contractor to establish details of damper linkage and operator that shall be provided by the TCC. Control dampers with operators and linkage attached to the air handling units shall be provided by the air handling unit manufacturer.

1.21 VAV TERMINALS

A. The HVAC contractor shall furnish and install VAV Terminal and reheat coil. The TCC shall furnish the reheat hot water control valve for installation by HVAC Contractor. The TCC shall furnish the DDC controller for factory mounting by the VAV Terminal manufacturer. TCC shall provide wiring for control valve and all control components.

1.22 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling."

1.23 PROJECT CONDITIONS

A. Addition of New DDC Systems

1. The contract shall include new work as shown, specified, or required, and shall include, but not limited to, the following principle components:

   a. Provide complete system for control of all equipment and systems as specified herein.

   b. Provide interface with certain components such as fire alarm, pumps, air handling systems, lab controls, and exhaust fans.

   c. Furnish and install UPS equipment for entire control system including all “server type” equipment. All components of control system shall be on UPS power. Contractor shall provide the requisite equipment to back-up all control functions for 30 minutes.

   d. Provide and install and coordinate with Electric Contractor at each building, all required circuits, including breaker, conduit, and wiring for system operation.

B. Shop Drawings

1. As soon as possible after award of the contract, and prior to fabrication, the contractor shall prepare complete shop drawings of the DDC systems, which shall in general conform to the bidding documents; any deviations deemed necessary by the contractor shall be noted and agreed upon prior to starting the work.

2. In preparing his working drawings, the contractor shall coordinate the location of all equipment and devices with the other contractors. Drawings shall show ceiling grids, lights, registers, grilles, heat detection devices, access panel, skylights, etc. Any changes in fabricated DDC layout occasioned by lack of coordination shall be made by the contractor at no change in the contract price.

3. Drawing shall be on 11” x 17” or 18” x 24” sheets at the contractor’s option.

4. All submittals shall be in PDF format and routed through the Construction Manager.

5. The submittals shall include control diagrams of all equipment that is to be controlled, monitored, etc. The submittal shall include all of the control information for chiller, boilers, air handling systems, variable frequency drives, etc.

6. The contractor shall implement all control sequences specified and indicated on the input/output schedules.

7. Each input/output device shall have a unique identifier which shall be permanently labeled on or adjacent to the device. The unique identifier shall be labeled on the various submittals as well.

C. Restoration Of Surfaces

1. Refer to Division 01.

D. Guarantee

1. This contractor shall guarantee all workmanship, materials, and equipment entering into this contract for a period of two years; all from date of substantial completion or from the "recognized" start-up date, whichever is later. Should the Owner or Construction Manager elect to accept a portion of work prior to the date of substantial completion, the guarantee period for the accepted portion of the work shall commence on the date of acceptance or on the "recognized" start-up date for that portion of the work, whichever is later. If the specifications dictate a different period of guarantee for a given component or piece of equipment, the more stringent requirements shall govern.

2. The "recognized" start-up date shall be defined as that date on which the contractor has successfully completed all phases of his work, including the following:

   a. Submitted and received approval of three (3) copies of the Instruction Booklets.

   b. Submitted complete "As-Built" drawings.

   c. Completed all testing, cleaning, adjusting, and trial run. This testing shall include the successful completion of all commissioning tasks.

3. In the case where the Engineer is accepting a portion of the work, the contractor shall have completed all phases of that portion of the work to be accepted, including Items above, for that accepted portion of the work.

4. Any workmanship, materials, or equipment proving to be defective during this guarantee period shall be made good by this contractor without additional cost to the Owner or Construction Manager.

E. Equipment

1. Any and all costs associated with piping, electric, wiring, conduit, supports, pads, or other modifications to accommodate installation for manufacturer’s equipment that differs from equipment layout on drawings shall be included on contractor’s bid. The contractor is responsible to insure that the equipment will fit within space allocated with appropriate clearances for maintenance, operation, servicing, and code.

F. Project Schedule

1. The following summarizes the anticipated project schedule subject to change to meet the summer schedule. The Integrated Automation Contractor shall integrate their work and scheduling with the owner and all associated subcontractors.

Project	Construction Start	Substantial Completion	Intended Occupancy
Logan Hall	5/1/2016	8/1/2017	8/8/2017

2. The contractor shall be responsible to meet the project schedule as stated above. The contractor shall include in his bid the cost associated with all requisite coordination.

3. In addition, the contractor must prepare a schedule for his work that integrates with the Owner's various project schedules. The contractor shall update progress and revise schedule at least twice monthly.

4. This contractor shall be responsible to expedite any materials and work any overtime in order to meet the schedules. The cost for any expediting of overtime work shall be included in his bid.

1.24 FUNCTIONAL PERFORMANCE TEST

A. The Functional Performance test (FPT) shall be executed by the Contractor and approved by the Owner. If the project is phased, then a separate test plan shall be executed for each phase. Use FPT sample procedures, designated by the Commissioning Agent, as a guide to creating the test plan spreadsheets.

B. Obtain written approval of the Functional Performance Test plan for each phase of testing before beginning that phase of testing. Give the Commissioning Agent written notification of planned testing at least 30 days prior to the test but not before completion of any test and balance (TAB) requirements have been completed. Notification shall be accompanied by the proposed test procedure, a verified Pre-performance Testing Checklist, and a written estimated time table required to perform the test. After the written notification is received, the Commissioning Agent shall convene a meeting with the Contractor and the Owner at least 14 days prior to testing. In no case will the Contractor be allowed to start testing without written owner approval of the Functional Performance Test plan.

C. Demonstrate compliance of the heating, ventilating, and air conditioning control system with the contract documents including proper labeling of controls and wiring. Furnish personnel, equipment, instrumentation, and supplies necessary to perform calibration and site testing. Ensure that test personnel are regularly employed in the testing and calibration of DDC systems.

D. Functional Performance testing will include, but not be limited to, workstation operations, calibration results for input and output devices required by manufacturer, proper tuning of control loops, and ensuring proper execution of the sequence of operation. Use the BACnet protocol analyzer during the performance testing to demonstrate communications reliability.

E. The Pre-performance Testing Checklist shall be used as the Contractor's guide to prepare for the FPT and to guide discussions at the pre-performance test meeting between the Contractor and the owner. Every item on the check list shall be validated by the Contractor's QC representative prior to the test meeting.

F. Verify all workstations, notebook computers, and maintenance personnel interface tools have been delivered, all system and database software installed, and graphic pages created for each workstation and notebook computers. Notify the owner when phone lines or network connections are needed at least 30 days prior to installation of the workstation.

1. Verify integrity/safety of all electrical connections.

2. Verify proper interface with fire alarm system.

3. Verify proper communications over network segments and between controllers.

4. Co-ordinate with TAB contractor to obtain control settings that are determined from balancing procedures.

5. Test, calibrate, and set all digital and analog sensing and actuating devices as required.

6. Check and set zero and span adjustments for all actuating devices as required.

7. Check each digital controller for stand-alone operation by temporarily removing from the network.

8. Check proper sequences have been installed and tested.

9. Check all control loops have been properly tuned.

10. Check all alarms are programmed and routed to their proper destination.

11. Check all trends are operating for each item marked for trending on the points list.

12. Check all schedules are operating for each item marked for schedules on the points list.

13. Complete all "as-built" record drawings and I/O points list.

G. The test procedure reporting documents shall be developed by the Contractor and based specifically on the control system installed in a spread sheet format allowing sufficient space for individual testing of each area of the control system. List the test procedure and the expected response for each piece of equipment and system in each test area specified. Develop a separate row or column for each item that is required to be "demonstrated" within a test area. Allow ample space for comments, pass, fail, and retest lines. Each area of testing shall have four signature lines, one for the Contractor's QC representative, the Contractor's FPT administrator, the Commissioning Agent representative, and the Owner to acknowledge successful completion for each test area. Include references to the paragraph number or drawing number in the contract documents for each item or group of items to be tested. BACnet protocol analyzer test results shall be included with the test reporting. During and after completion of the Functional Performance Test, identify, determine causes, replace, repair or calibrate equipment that fails to meet the specification, and submit a written report to the Owner.

H. Document all tests with detailed test results. Explain in detail the nature of each failure and corrective action taken. Provide a written report containing test documentation after the Functional Performance Test. Schedule a meeting with the Owner to present the results to the Owner after all failures have been corrected. Based on the report and test review meeting, the Owner will determine the successful completion of the testing. If retesting of any portion of the FPT is required, do not retest until after receipt of written notification by the Owner. At the conclusion of retest, assessment will be repeated. The Owner reserves the right to require retesting of 100 percent on every component in the system when results from sampled areas are found deficient. Final test results will be submitted in electronic format on CD media.

I. Using the completed shop drawings and the FPT spreadsheet, conduct the performance verification test to demonstrate workstations and network communications are operating correctly, control system maintains set points, control loops are tuned, and controllers are programmed for the correct sequence of operation. The test report shall include the required four authorization signatures for successful completion of each test area. Test areas may have several sub-areas and each shall be fully satisfied to receive approval. Partial completion cannot be signed off. Random sampling may be used for certain test areas that have identical hardware and control sequences at the discretion of the Owner. These test areas, when allowed, are preceded with the statement "*Ten percent sample testing allowed in this area for terminal zones that use identical controllers and sequences.*" If this statement is not found in the following test areas, the contractor shall assume that testing is at the 100 percent level for every terminal zone. When random sampling is allowed, the Owner will choose which items to test from the contract drawings. Allow for this when creating spreadsheets to insert the name and location on-site for random selection. Specifically the FPT consists of the individual test areas below and shall demonstrate the following:

J. Controller Capability, Accessibility, and Labeling

1. Memory: Demonstrate that programmed data, parameters, and trend/alarm history collected during normal operation is not lost due to power failures.

2. Direct Connect Interface: Demonstrate the ability to connect directly to each type of digital controller with a notebook computer. Demonstrate that maintenance personnel interface tools perform as specified in the Manufacturer's technical literature.

3. Wiring and AC Power: Demonstrate the ability to disconnect any controller safely from its power source using the AC Power Table.

4. Demonstrate the ability to match wiring labels easily with the control drawings. Demonstrate the ability to locate a controller's location using the riser communications diagram in the control drawings.

5. Nameplates and Tags: Demonstrate the nameplates and tags bearing device unique identifiers are accurate and permanently attached to HVAC the control panel doors and back plates. Demonstrate that plastic or metal tags have the correct equipment name and point identifier.

K. Workstation and Software Operation

1. For operators workstation (OWS) and notebook computer provided:

   a. Verify that the correct software has been installed and licensed with the latest revisions available, delivery of all associated peripheral components are installed correctly, CD installation media including system restore disks are delivered, and the on-site warranty has been properly registered with the manufacturer. For each existing user workstation or notebook computer specified for upgrade, verify that all hardware and software upgrades have been installed and licensed correctly.

   b. Demonstrate that point’s lists are generated as specified and conform to the proper naming conventions.

   c. Demonstrate that graphics are complete, resolution size fills the workstation or notebook computer screen areas without scrolling and the operator can navigate successfully to every mechanical system and zone.

   d. Demonstrate the UPS backup maintains power for the specified time on the workstation during a power failure and can recover automatically after an extended power loss when the UPS battery has drained.

2. BACnet Communications and Interoperability Areas

   a. Demonstrate proper functioning of the five interoperability areas of data sharing, alarm and event management, trending, scheduling, and device and network management. Use the BACnet protocol analyzer to demonstrate that communications are free from errors and that devices from different manufacturers are interoperable. These requirements shall be met even if there is only one manufacturer's equipment installed.

3. If system can only be programmed at the operator workstation, then two of these workstations shall be provided and included in the base bid.

L. Data Sharing

1. Data Presentation - On each web server workstation, demonstrate graphic display capabilities as follows: Each graphic page shall initially display with current data within 5 seconds over a web-based browser connection. Updated information shall occur when a change of value (COV) notification is received or, if COV is not implemented, within 15 seconds. Demonstrate that any data value from any networked device shall be available for plotting at a workstation in real time. Select binary and analog data concurrently and plot multiple instances of each data type on the same screen. Demonstrate the ability to select sampling intervals from 10 seconds to 60 minutes. For devices that implement COV reporting, select this as the means to update the plot.

2. Monitoring of Any Property - Demonstrate the ability to display any value of any property of any object from any networked device including all properties required by BACnet, all supported optional properties, and any proprietary extensions. Compare the difference between properties shown on the operator workstation over the network and the properties shown when directly connected to the controller in the field.

3. Set point and Parameter Modifications - Demonstrate the ability to modify all control loop set points and tuning parameters via BACnet messages initiated through operator interaction with graphics displays. Compare the difference between parameters modified on the operator workstation over the network and the parameters modified when directly connected to the controller in the field.

4. Peer-to-Peer Data Dependencies - Demonstrate all BACnet devices are installed and configured to exchange data values directly, without the need for operator or workstation intervention, to implement the sequence of operations specified in the mechanical system drawings and to share global data values.

M. Alarm and Event Management

1. Alarm Lists - Demonstrate that alarms are installed and configured to detect alarms and events for the points indicated in the system drawings and are prioritized according to the standardized list designated by the Owner. Demonstrate system alarms, such as offline controllers are generated. Demonstrate software logic has been set up to avoid nuisance alarms, e.g., no temperature or status alarms shall be generated when fan systems are not running, or during start-up and shut-down transitions. Demonstrate that delays between the occurrence of an alarm condition and its annunciation are adjustable. Demonstrate alarms appear at any local workstation within 5 seconds over a web-based browser connection and 15 seconds on a dial-up modem connection. Demonstrate workstations display an alarm message window that appears on top of any other open windows and alarm message window has a distinctive color and appearance to attract the operator's attention. Demonstrate alarms that require operator acknowledgment and cause the alarm window to remain active until such an acknowledgment is received and when multiple alarms are received, unacknowledged alarms shall be displayed on a first-come first-served basis grouped by priority, with the highest priority alarms displayed first.

2. Alarm Parameter Adjustment - Demonstrate the ability for operators (with sufficient privilege) to change alarm parameters for all standard BACnet event types.

3. Alarm Routing Adjustment - Demonstrate the ability for operators (with sufficient privilege) to change alarm routing (BACnet notification classes) for each alarm including the destination for each type of alarm and alarm priority, the day of week and time of day, and the type of transition involved (TO-OFFNORMAL, TO-NORMAL, etc.).

4. Alarm conditions shall be capable of being email notifications.

N. Scheduling

1. Schedule Lists - Demonstrate that schedules are installed and configured start/stop, mode change, and night setback schedules as defined in the sequence of operations including holidays. Demonstrate the ability to program alterations to programmed operating schedules based on the priority of events, including the ability to temporarily override the programmed schedule of equipment. Demonstrate operational override of a programmed schedule shall be for a specific duration following which the schedule shall revert back to the preprogrammed schedule.

2. Display of Start/Stop Times and Actions -Demonstrate the ability to inspect the content of any schedule and determine the specific control actions that will occur at any time, on any date.

3. Modification of Schedules - Demonstrate that all calendar entries and schedules shall be modifiable from any local workstation by an operator with sufficient privilege.

O. Trending

1. Archival Storage of Data - Demonstrate that archival storage of data will be handled by the operator workstation/server. Demonstrate that local trend archiving and display can be accomplished through the use of BACnet Trend Log objects.

2. Modification of Trend Log Parameters - Demonstrate that an operator with sufficient privilege shall be able to change the data points to be logged, the sampling rate, and the duration of a trend log.

P. Device and Network Management

1. Display of Device Status Information - Operators shall be able to display at any time the operational status of any device on the network.

2. Display of BACnet Object Information - Operators shall be able to display at any time any property of any BACnet object. Operators shall be able to display property values of objects grouped by object type, object location, and building system.

3. Silencing Devices that are Transmitting Erroneous Data -Operators shall be able to direct a field device to stop transmitting event, alarm, or COV notifications until a subsequent command to resume transmissions is received.

4. Time Synchronization - Operators shall be able to set the time and date in any device on the network that supports time-of-day functionality. The operator shall be able to select to set the time and date for an individual device or all devices on a single local network.

5. Remote Device Re-initialization - Operators shall have the ability to issue re-initialization commands to any device that supports remote reinitialization.

6. Backup and Restore - Operators shall have the ability to backup and restore all BACnet devices on the network that support this capability.

Q. Execution of Sequence of Operation - Demonstrate the HVAC system operates properly through the complete sequence of operation. Insert the complete sequence of operation into the PVT spreadsheet with spaces between each line to allow for observations and comments.

R. Control Loop Stability and Accuracy - Furnish the Owner graphed trends of control loops to demonstrate the control loop is stable and that setpoint is maintained. Control loop response shall respond to setpoint changes of 10 percent and stabilize in 3 minutes or less. Control loop trend data shall be in real time and the time between data points shall not be greater than one minute.

S. Stand-alone Capability - Demonstrate stand-alone controller capability for each central mechanical system, each air handler, and each zone. Zones with identical controllers and identical sequences may be randomly tested one controller per zone. Controllers shall provide stable and reliable stand-alone operation using default values or other method for values normally read over the network. Verify that a system alarm is generated indicating the communications failure for each controller in a stand-alone state.

END OF SECTION 250000

SECTION 250501 - COMMON WORK RESULTS FOR INTEGRATED AUTOMATION

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. Integrated Automation equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Sleeve seals.
4. Grout.
5. Common Integrated Automation installation requirements.

B. Related Sections:

1. 250000 – INTEGRATED AUTOMATION
2. 250800 – COMMISSIONING OF INTEGRATED AUTOMATION
3. 250990 – SEQUENCE OF OPERATION

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of Integrated Automation equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for Integrated Automation items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

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.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.

b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Basis-of-Design Product: Subject to compliance with requirements, provide one of the following:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Metraflex Co.

d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

3. Pressure Plates: Carbon steel. Include two for each sealing element.

4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR INTEGRATED AUTOMATION INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both Integrated Automation equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR INTEGRATED AUTOMATION PENETRATIONS

A. Integrated Automation penetrations occur when raceways, pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

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.

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 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.4 FIRESTOPPING

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

END OF SECTION 250501

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SECTION 250800 – COMMISSIONING OF HVAC

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.

B. Refer to Section 019113 “Commissioning” for all specific requirements required associated with the commissioning process that will be required as part of this work. As part of this project, participation in the commissioning process as described in Section 01 91 13 shall be required.

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC systems, assemblies, and equipment.

B. Related Sections:

1. 250000 – INTEGRATED AUTOMATION
2. 250501 – COMMON WORK RESULTS FOR INTEGRATED AUTOMATION
3. 250990 – SEQUENCE OF OPERATION

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. DDC: Direct Digital Controls.

E. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 ALLOWANCES

A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Division 01 Section "Allowances."

1.5 UNIT PRICES

A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Division 01 Section "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

1.6 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase HVAC and Integrated Automation coordination meetings.

C. Attend testing, adjusting, and balancing review and coordination meetings.

D. Participate in HVAC systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.7 CxA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.8 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.

2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.

3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC systems, assemblies, equipment, and components to be verified and tested.

4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.

5. Certificate of readiness certifying that HVAC systems, subsystems, equipment, and associated controls are ready for testing.

6. Test and inspection reports and certificates.

7. Corrective action documents.

8. Verification of testing, adjusting, and balancing reports.

1.9 SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

1.10 COMMISSIONING AUTHORITY

A. Motz Engineering acting in conjunction with the Owner’s Maintenance Personnel will take the role of the Commissioning Authority for this project. The Commissioning Authority will respond to all issues directly to the Owner and shall have the authority to grant final acceptance of each system commissioned.

1.11 COMMISSIONING PLAN

A. This section and sections in other Divisions shall outline the work required for the project, consistent with the Commissioning Plan. Any discrepancies between the Commissioning Plan and the Project Manual sections shall be brought to the attention of the Commissioning Agent for clarification.

1.12 COORDINATION

A. The General Contractor and appropriate Subcontractors shall be responsible for cooperating and coordinating their work during the installation and commissioning process. Refer to the specific requirements and other sections for required work associated with coordination of installation work and preparation of Coordination Construction Drawings by the contractors.

B. The Commissioning Authority will participate in the coordination of installation work as necessary to insure the installation of system components meet the Owner's project requirements and will provide a facility that has appropriate access and means for future maintenance and service by Owner.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify 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 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. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

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 TESTING VERIFICATION

A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

B. Notify the CxA at least 10 days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.

C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC systems at the direction of the CxA.

1. The CxA will notify testing and balancing Subcontractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.

2. The testing and balancing 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 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.

4. 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.

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. Tests will be performed using design conditions whenever possible.

E. 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.

F. The CxA may direct that set points be altered when simulating conditions is not practical.

G. 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.

H. 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.

I. 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. The following systems shall be commissioned:

1. HVAC systems including:

a. Direct digital automatic temperature control system.

b. Air distribution systems.

c. Exhaust systems.

d. Unitary equipment.

END OF SECTION 250800

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SECTION 250990 – SEQUENCE OF OPERATION

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. This Section includes a summary of all Integrated Automation which is principally Direct Digital Control (DDC System) related work.

B. Related Sections:

1. 250000 – INTEGRATED AUTOMATION
2. 250501 – COMMON WORK RESULTS FOR INTEGRATED AUTOMATION
3. 250800 – COMMISSIONING OF INTEGRATED AUTOMATION

1.3 SUMMARY OF WORK

A. This contract shall include the furnishing of all labor and materials required for the installation of new temperature regulating systems to monitor, control, and regulate automatically and completely the new air conditioning, ventilating, hydronic and heating systems, as shown on the accompanying drawings and hereinafter specified. The temperature control equipment shall be installed by trained mechanics and technicians employed by the manufacturer and working in conjunction with the other contractors.

B. The Integrated Automation Contractor shall extend all requisite power and control wiring in conduit to the devices, equipment, panels, workstation, servers, etc. that are provided under their contract.

C. The Integrated Automation Contractor shall provide all interface equipment required for interconnectivity of their system to the equipment, panels, servers, workstation, meters, etc. that are part of the Owner's system.

D. The Integrated Automation Contractor shall coordinate installation of all devices, meters, sensors, etc. with other contractors and their systems.

1.4 MASTER OUTDOOR AIR CHANGEOVER CONTROLS

A. The master outdoor air changeover controls shall control new systems installed as a part of this project. The DDC controller is programmed to perform the following seasonal changeover mode of operation for each air handling unit.

1. When the outside air enthalpy is less than return air enthalpy, each air handling unit shall operate in the "Economizer" or free-cooling mode of operation, wherein outside air is used to condition the space.

2. When the outside air enthalpy is greater than return air enthalpy, or when outside air temperature rises above 75°F (DDC adjustable), each air handling unit shall switch to "Non-Economizer" or mechanical cooling mode of operation, wherein chilled water is circulated to the cooling coil of the unit, and is used to condition the space.

3. The following changeover functions shall occur.

   a. Air Handling Unit supply fans and return fans shall operate continuously.

   b. For new Custom Air Handling Unit, when supply fan is operating:

   c. Cause outdoor air and exhaust air dampers associated with Energy Recovery coil to open. Cause bypass outdoor air, return air, and bypass exhaust air dampers to be fully operational, during Economizer mode.

   d. Cause heating coil valve to be operational.

   e. Cause cooling coil valve to be operational during Non-Economizer mode and cause valve to close during Economizer mode.

   f. Cause energy recovery pump No. 1 and No. 2 to operate when outdoor air temperature is above 74° F (DDC adjustable) and below 65° F (DDC adjustable).

1.5 EXISTING CONTROLS

A. Remove and replace all temperature controls throughout building and replace with new.

1.6 CONTROLS FOR CHILLED WATER SYSTEMS

A. Existing chilled water provided from central plant.

1.7 CONTROLS FOR NEW HOT WATER SYSTEM

A. Existing hot water provided from central plant.

1.8 CONTROLS FOR NEW BUILDING EXHAUST FANS

A. Controls for Exhaust Fans

1. Provide new controls, as indicated on the input/output schedule and the drawings at the end of this section.

1.9 CONTROLS FOR NEW AIR HANDLING UNIT

A. New variable air volume Air Handling Unit consisting of supply and return fan walls will supply conditioned air to the building. The unit shall operate when the spaces are occupied. Variable frequency drive associated with the fans will operate fans at varying speed settings to provide temperature control.

B. The unit shall operate continuously. An energy recovery coil associated with AHU shall operate only when the outside air temperature is below 68° F, or above 75° F (DDC Adjustable). Variable frequency drives associated with supply fan array and return fan array will operate fans at varying speed settings to provide supply air static pressure at setpoint in ductwork.

C. Provide new controls, consisting of DDC controller, electronic sensors, etc., to monitor and control the system as indicated on the input/output schedule and drawings in the appendices. For operation of controls, refer to the following paragraph.

D. Operation of Controls.

1. Fan operating cycle: DDC controller shall cause supply and return fans to operate continuously. When supply fan is operating, DDC controller shall perform the following functions.

    a. Permit energy recovery pumps to be operational, only as described herein.

    b. Permit cooling coil valve to be operational only as described herein.

    c. Permit heating coil valve to be operational only as described herein.

    d. Permit supply fan and return fan speed control devices to be operational.

    e. Permit zone terminal units to be operational.

2. Mixed Air Controls.

    a. A manually inputted command at DDC controller shall permit manual closing of bypass outdoor air and exhaust air dampers and manual opening of return air dampers when supply fan is operating. Another manually inputted command shall permit manual emergency opening of bypass outdoor air and exhaust air dampers and manual closing of return air damper during Non-Economizer mode when supply fan is operating. When supply fan is indexed to "off" or when fans stop because of a fire condition, low temperature cutout condition or high supply air static pressure condition; DDC controller shall close outdoor air and exhaust air dampers and shall open return air dampers.

    b. When air handling unit is operating in Economizer mode, DDC controller, receiving signals from mixed air and supply air temperature sensors, shall modulate bypass outdoor air, return air and bypass exhaust air dampers to maintain mixed air temperature at supply air temperature setpoint minus 2°F (DDC adjustable).

    c. Air flow tracking operation: When air handling unit is operating, DDC controller, receiving signals from air flow monitoring stations located in the outdoor air, return air, and supply air plenums and zone occupancy sensors in all spaces.

    d. Cooling coil valve controls: When supply fan is operating and outside air temperature is above 55° F, adjustable, DDC controller, receiving signal from outside air temperature sensor and supply air temperature sensor shall modulate cooling coil valve to maintain present supply air temperature reset schedule based on outside air temperature. Supply air temperature shall be based on automatic schedule (DDC adjustable) to supply warmest air to satisfy critical zone for cooling.

    e. Heating coil valve controls: When supply fan is operating, DDC controller, receiving signal from outside air temperature sensor and supply air temperature sensor shall modulate heating coil valve to maintain present supply air temperature reset schedule based on outside air temperature. Supply air temperature shall be based on the following reset schedule (DDC adjustable). When supply fan is not operating, or outside air temperature rises above 50°F DDC controller shall close hot water heating valve.

3. Fan speed controls:

    a. When supply fan is operating, DDC controller, receiving signal from supply air static pressure sensor, shall vary supply fan speed in order to maintain static air pressure at setpoint in supply ductwork. In addition, DDC controller shall vary return fan speed based on supply fan speed and a fixed pressurization constant in order to maintain a positive pressure within the building.

b. Air handling unit supply air static pressure setpoint shall be reset from the initial programmed value based on the position of all VAV terminal unit dampers served by that unit. Static pressure setpoint shall be raised in increments of 0.05" WC every 5 minutes if 5% (DDC adjustable) of all VAV terminal dampers is at the 90% open or greater position (DDC adjustable). Static pressure setpoint shall be lowered in increments of 0.05" WC every five minutes when less than 5% of all VAV terminal unit dampers are less than 90% open position. Reset of static pressure setpoint shall be limited to the range of 0.5" WC to 1.5" WC (DDC adjustable).

4. Zone Controls:

a. Each room will have its own individual control.

b. All room variable air volume (VAV) terminal units shall use electronic damper valve actuators. The damper/valve actuators shall move in a smooth, steady progression without overloading the actuator in any way. The Direct Digital Control Contractor shall be responsible for properly sizing actuators to the torque requirements of each terminal unit damper and reheat valve. The speed of the actuator shall be appropriate to the application so that the control loop may be easily tuned. This Contractor shall be responsible for properly securing the actuator to the terminal box damper shaft. Electronic actuated valves shall be capable of being manually opened or closed.

c. Provide terminal equipment controllers (TEC's) as required for all variable air volume terminal boxes. Each TEC shall be a microprocessor based direct digital control unit and shall be capable of operating either as a stand-alone controller or on a multi-drop communications network originating at a direct digital controller at associated air handling unit direct digital controller. Provide each TEC with sufficient memory to operate independently supporting its own inputs and outputs, operating system, database and programs necessary to perform specified control sequences.

d. An airflow sensor with multi-point, center averaging velocity sensors will be provided with each terminal unit. The multi-point sensor shall provide a representative average of the box total air flow at the box discharge, regardless of air flow profiles, assuring an accurate signal to the controller. The controller shall modulate the terminal damper actuator from the minimum to maximum CFM set points specified for each VAV terminal box. Provide test port openings in flow sensor tubing for local manometer readings of differential pressure across the pitot tube. After the new TEC controller is installed, the Test and Balance (TAB) Contractor will measure the actual air volume through the terminals as part of the commissioning and acceptance process. The Direct Digital Control Contractor shall then adjust the volume indication at the controller to the actual volume found at both the minimum and maximum setpoint of the terminal box.

e. Each terminal equipment controller controlling space temperature shall be provided with a matching room temperature sensor. The sensor shall be an RTD providing the following minimum performance requirements:

1) Accuracy: 0.5 Degrees F.

2) Operating range: 35 Degrees F. to 115 Degrees F.

3) Setpoint range: 55 Degrees F to 95 Degrees F.

4) Modes: Occupied, Unoccupied, Heating, and Cooling.

5) Calibration adjustments: None.

6) Installation: Up to 100 ft. from controller.

f. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable laptop or similar operator's terminal to control and monitor all hardware and software points associated with the controller.

g. The room temperature sensor shall include the following auxiliary devices:

1) Setpoint adjustment buttons dial.

2) LCD temperature indicator.

3) Occupied override pushbutton.

h. The setpoint adjustment dial or button shall allow for modification of the temperature setpoint by the occupant. Setpoint adjustment may be locked out, overridden or limited as to temperature or time of day through software by an authorized operator at an existing operator's workstation.

i. Each controller shall perform its primary control function independent of other digital controllers on the network, network communication, or if the network communication is interrupted.

j. 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 a portable computer. Controllers that incorporate proportional, and integral (PI) control algorithms only, shall not be acceptable.

k. All user defined database information required for each terminal controller must be stored in the controller in non-volatile EEPROM or FLASH ROM. Terminal controller point/controller database information must also be stored at the direct digital controller to which terminal controller local area network is connected. The terminal controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.

l. Terminal controller's occupied/unoccupied setpoint shall be controlled by a dry contact located in the room's occupancy sensor(s) also used for direct control of room lighting. For rooms without occupancy sensors, room terminal controller shall be provided with a time of day schedule to allow for 365 day advanced scheduling of rooms HVAC operation, (e.g. for common class and office schedules). All room schedules shall be located in the direct digital controller also serving the rooms associated air handler.

m. Each terminal controller shall have connection provisions for a portable laptop computer similar to the connection provided at the room temperature sensor as previously specified. The terminal may be used for readout of system variables, override control, adjustment of control parameters, air balancing, servicing and troubleshooting. The Direct Digital Control Contractor shall provide three copies of the terminal control interface software required to communicate with the terminal controller.

n. All communications and displays via the portable computer shall be in full English with accompanying English and SI units.

o. Terminal controller hardware inputs/outputs required:

1) Analog inputs:

a) Terminal box discharge air velocity sensor.

b) Terminal box discharge air temperature sensor.

c) Room temperature sensor.

d) Room temperature setpoint dial.

2) Analog (or three-point floating) outputs:

a) Damper actuators.

b) Reheat valve actuator.

3) Digital inputs:

a) Occupied/Unoccupied switch-over signal (By room occupancy sensors dry relay contact).

p. Occupancy sensor and power packs:

1) Under another contract, the Electric Contractor will furnish all items of material, labor, conduit, wire, junction boxes, etc., necessary to furnish a completely operational occupancy sensor system to control room lighting and provide an occupied input signal to certain room VAV terminal controllers.

2) The occupancy sensor system shall be as manufactured by Watt-Stopper, or approved equal. The Electric Contractor shall submit complete shop drawings for approval. Submittals shall include occupancy sensor(s) layout for each room, relay power pack quantity and location, all wiring diagrams clearly marked, showing device location, orientation, and coverage of each sensor.

3) Electrical Wiring:

a) Electric Contractor: The Electric Contractor shall furnish and install the occupancy sensors, relay packs and all line voltage branch circuit conduit and wiring to directly control room lights. In addition, the Electric Contractor shall furnish all Class 2 control wiring between each occupancy sensor and its associated relay power packs.

b) Direct Digital Control (DDC) Contractor: The DDC Contractor shall extend a Class 2 control wiring input signal from a spare contact in each occupancy sensor to room VAV terminal controller for room occupied/unoccupied status.

5. Safety controls:

a. Smoke Sensor: If products of combustion are sensed by new air duct smoke sensors located in the supply and return ducts of the AHU, a hard wired smoke shutdown control relay furnished and installed in the DDC panel shall perform the following:

1) Shut down the supply fan variable frequency controller.

2) Shut down the return fan variable frequency controller.

3) Disable the energy recovery wheel.

4) Close all outdoor air and exhaust air dampers and open the return air damper.

5) Shut down all associated exhaust fans.

6) Signal DDC of smoke condition.

b. High Static Pressure Cutout: If a high static air pressure condition is sensed by new static pressure device located in supply air duct of the AHU, a hardwired high pressure shutdown control relay furnished and installed in the DDC panel shall perform the following:

1) Shut down the supply fan variable frequency controller.

2) Shut down the return fan variable frequency controller.

3) Disable the energy recovery wheel.

4) Close all outdoor air and exhaust air dampers and open the return air damper.

5) Shut down all associated exhaust fans.

6) Signal DDC of high static pressure condition.

c. Low Temperature Cutout: If a low temperature of 40°F occurs at the outlet of the heating coil as sensed by low temperature protection thermostats by Direct Digital Contractor, a hardwired low temperature shutdown control relay furnished and installed in the DDC panel shall perform the following:

1) Enable the energy recovery wheel.

2) Close all outdoor air and exhaust air dampers and open the return air damper.

3) Reduce all associated exhaust fans to minimum flow.

4) Signal DDC of low temperature condition.

E. Sequence of Operation

1. General: DDC shall log usage totals based on day, month and year. Logs shall be automatically generated and stored in a comma separated value format.

2. Metering:

a. DDC controller shall receive instantaneous usage values from each metering device. This valve will be used to totalize usage.

b. DDC controller shall establish communication with each system after any interruption in communication before recording usage or peak demand history.

c. If the DDC controller loses input data from the metering device for 30 minutes (DDC adjustable) DDC controller will generate a loss of signal alarm.

3. Usage History

a. Upon establishing communication with each metering device, DDC controller shall record consumption history.

b. At 12:00 AM every night, DDC controller shall reset the daily usage recorder for the next day. The reset signal shall last no longer than 1 second. The recorder shall retain the previous day's data for comparison.

c. When the daily usage recorder is reset for the first day of each month, the month-to-date recorder shall also be reset. The recorder shall retain the previous month=s data for comparison.

d. When the month-to-date recorder is reset in January, the year-to-date recorder shall also be reset. The recorder shall retain the previous year=s date for comparison.

4. Alarm Notification

a. DDC Controller shall indicate an alarm condition on the graphic Event Page and on the system graphic if the DDC Controller detects a loss of input signal from any metering device. Workstation will notify the user with a printout, e-mail, sounds or other reporting actions based on user configuration.

1.10 SYSTEM INPUT/OUTPUT SCHEDULES

A. Refer to Input/Output Schedule.

CONTROL SYSTEM POINTS - INPUT/OUTPUT SUMMARY
FOR LOGAN HALL HVAC UPGRADES
XAVIER UNIVERSITY

Point	DEVICE MARK	CONTROL POINTS	INPUTS/OUTPUTS				CONTROL	MONITOR	ALARM	DATA	DETAIL	COMMENTS
#		POINT NAME DESCRIPTION	AI	DI	DO	AO						
		VAV AND SAV UNITS HOT WATER HEAT: XX NEW UNITS									**8/M700**	
	FM-1	FLOW MEASUING SENSOR	X					X				PROVIDED WITH VAV BOX
	AAD-1	DAMPER				X	X					PROVIDED WITH VAV BOX
	TT-1	SUPPLY AIR TEMPERATURE TRANSMITTER	X				X					
	T-1	ROOM TEMPERATURE SENSOR	X				X					
	OCC-1	OCCUPANCY SENSOR		X			X					PROVIDED BY OTHERS
	TCV	TEMPERATURE CONTROL VALVE				X	X					
		HOT WATER CABINET UNIT HEATER:									**6/M700**	
	SF-1	UNIT HEATER SUPPLY FAN ENABLE/DISABLE			X		X					
	T-1	ROOM TEMPERATURE SENSOR	X									
	TCV-1	HOT WATER TEMPERATURE CONTROL VALVE				X	X					
		CENTRAL HEATING SYSTEM CONTROLS DIAGRAM									**3/M700**	
	FS-B-1-1	FLOW TRANSMITTER	X									EXISTING - TIE IN/CONNECT TO NEW BMS
	TT-B1-1	TEMPERATURE TRANSMITTER	X									EXISTING - TIE IN/CONNECT TO NEW BMS
		CENTRAL CHILLED WATER SYSTEM CONTROL DIAGRAM									**2/M700**	
	DPT-CHW-1	DIFFERENTIAL PRESSURE TRANSMITTER	X									EXISTING - TIE IN/CONNECT TO NEW BMS
	TT-CHW-1	TEMPERATURE TRANSMITTER	X									EXISTING - TIE IN/CONNECT TO NEW BMS
	CHWP-1	CHILLED WATER PUMP ENABLE/DISABLE			X							
	CHWP-1	CHILLED WATER PUMP STATUS		X								
	CHWP-1	CHILLED WATER PUMP ALARM		X								
	CHWP-1	MODBUS INTERFACE										
		CHILLED WATER FLOW										
		AIR HANDLING UNIT - EXISTING AHU-1									**1/M701**	
	TT-GI-1	OUTSIDE AIR TEMPERATURE SENSOR	X									
	HT-GI-1	OUTSIDE AIR HUMIDITY SENSOR	X									
	SF-1	AHU SUPPLY FAN ENABLE/DISABLE			X		X					
	SF-1	AHU SUPPLY FAN SPEED SIGNAL				X	X					
	SF-1	AHU SUPPLY FAN STATUS		X				X	X			
	SF-1	AHU SUPPLY FAN ALARM		X				X	X			
	SF-1	SUPPLY AIR CFM										SUPPLY FAN RING SENSORS SUMMED
	FM-2	AIRFLOW MEASURING	X				X					AIRFLOW MEASURING DEVICE PROVIDED BY CONTROLS CONTRACTOR
	RF-1	AHU RETURN FAN ENABLE/DISABLE			X		X					
	RF-1	AHU RETURN FAN SPEED SIGNAL				X	X					
	RF-1	AHU RETURN FAN STATUS		X				X	X			
	RF-1	AHU RETURN FAN ALARM		X				X	X			
	RF-1	RETURN AIR CFM										RETURN FAN RING SENSORS SUMMED
	FM-1	AIRFLOW MEASURING	X				X					AIRFLOW MEASURING DEVICE PROVIDED WITH UNIT
		HEAT RECOVERY ENABLE/DISABLE			X		X					
		HEAT RECOVERY PUMP ENABLE/DISABLE				X	X					
		HEAT RECOVERY PUMP ENABLE/DISABLE				X	X					
		HEAT RECOVERY STATUS		X				X	X			
		HEAT RECOVERY STATUS		X				X	X			
		HEAT RECOVERY ALARM		X				X	X			
		HEAT RECOVERY ALARM		X				X	X			
	AAD-EA-1	ECONOMIZER RELIEF AIR DAMPER				X	X					
	AAD-OA-1	ECONOMIZER OUTSIDE AIR				X	X					
	AAD-OA-2	MINIMUM OUTSIDE AIR				X	X					
	AAD-RA-1	MIXED AIR				X	X					
	TT-1	SUPPLY AIR TEMPERATURE TRANSMITTER	X				X					
	TT-2	MIXED AIR TEMPERATURE SENSOR	X				X					AVERAGING SENSOR
	LTS-1	FREEZE THERMOSTAT		X			X		X			SHUTDOWN FANS AND CLOSE DAMPERS
	DPS-1	LOW LIMIT RETURN AIR PRESSURE SENSOR		X			X		X			HARD WIRED, SHUTDOWN FANS AND CLOSE DAMPERS
	DPS-2	HIGH LIMIT SUPPLY AIR PRESSURE SENSOR		X			X		X			HARD WIRED, SHUTDOWN FANS AND CLOSE DAMPERS
	SD	SMOKE DETECTOR- FIRE ALARM DEVICE		X			X		X			HARD WIRED, SHUTDOWN FANS AND CLOSE DAMPERS
	SD	SMOKE DETECTOR - BMS AUX CONTACT		X				X	X			
	TT-3	RETURN AIR TEMPERATURE TRANSMITTER	X				X					
	HT-1	RETURN AIR HUMIDITY TRANSMITTER	X					X				
	SPT-1	SUPPLY DUCT PRESSURE TRANSMITTER	X				X		X			
	TCV-1	HOT WATER TEMPERATURE CONTROL VALVE				X	X					
	TCV-2	CHILLED WATER TEMPERATURE CONTROL VALVE				X	X					
	FB	HOT WATER FACE AND BYPASS										

CONTROL SYSTEM POINTS - INPUT/OUTPUT SUMMARY
FOR LOGAN HALL HVAC UPGRADES
XAVIER UNIVERSITY

Point	DEVICE MARK	CONTROL POINTS	INPUTS/OUTPUTS				CONTROL	MONITOR	ALARM	DATA	DETAIL	COMMENTS
#		POINT NAME DESCRIPTION	AI	DI	DO	AO						
		AIR HANDLING UNIT - EXISTING AHU-2									**5/M700**	
	TT-GI-1	OUTSIDE AIR TEMPERATURE SENSOR	X									
	HT-GI-1	OUTSIDE AIR HUMIDITY SENSOR	X									
	SF-1	AHU SUPPLY FAN ENABLE/DISABLE			X		X					
	SF-1	AHU SUPPLY FAN STATUS		X				X	X			
	SF-1	AHU SUPPLY FAN ALARM		X				X	X			
	AAD-EA-1	ECONOMIZER RELIEF AIR DAMPER				X	X					
	AAD-OA-1	ECONOMIZER OUTSIDE AIR				X	X					
	AAD-RA-1	RETURN AIR DAMPER				X	X					
	TT-1	SUPPLY AIR TEMPERATURE TRANSMITTER	X				X					
	LTS-1	FREEZE THERMOSTAT		X			X		X			SHUTDOWN FANS AND CLOSE DAMPERS
	SD	SMOKE DETECTOR- FIRE ALARM DEVICE		X			X		X			HARD WIRED, SHUTDOWN FANS AND CLOSE DAMPERS
	SD	SMOKE DETECTOR - BMS AUX CONTACT		X				X	X			
	TCV-2	CHILLED WATER TEMPERATURE CONTROL VALVE				X	X					
		TOILET EXHAUST FAN									**7/M700**	
	EF-1	EXHAUST FAN ENABLE/DISABLE			X		X					
	EF-1	EXHAUST FAN STATUS		X				X	X			
		LABORATORY AIR CONTROLS										
		SPACE TEMPERATURE			X		X					
		SPACE STATUS		X				X	X			
	OCC-1	ROOM OCCUPANCY SENSOR		X								BY OTHERS (MONITOR STATUS)
		FIRE ALARM INTERLOCK									**1/M700**	
		BUILDING FIRE ALARM PANEL			X			X	X			
	SD	SMOKE DETECTOR- FIRE ALARM DEVICE		X			X		X			HARD WIRED, SHUTDOWN FANS AND CLOSE DAMPERS
	SD	SMOKE DETECTOR - BMS AUX CONTACT		X				X	X			
		WATER METERING:									**3/M700**	
		(CHILLED, HOT)										
	FM	FLOW METER	X					X	X	X		CONNECT TO EXISTING
	FM	FLOW METER	X					X	X	X		CONNECT TO EXISTING
		CENTRAL EXHAUST SYSTEM SERVING FUME HOODS									**4/M700**	
	EF-1A	EXHAUST FAN ENABLE/DISABLE			X		X					
	EF-1A	EXHAUST FAN SPEED SIGNAL				X	X					
	EF-1A	EXHAUST FAN ISOLATION DAMPER				X	X					
	EF-1A	EXHAUST FAN STATUS		X				X	X			
	EF-1B	EXHAUST FAN ENABLE/DISABLE			X		X					
	EF-1B	EXHAUST FAN SPEED SIGNAL				X	X					
	EF-1B	EXHAUST FAN ISOLATION DAMPER				X	X					
	EF-1B	EXHAUST FAN STATUS		X				X	X			
	EF-1C	EXHAUST FAN ENABLE/DISABLE			X		X					
	EF-1C	EXHAUST FAN SPEED SIGNAL				X	X					
	EF-1C	EXHAUST FAN ISOLATION DAMPER				X	X					
	EF-1C	EXHAUST FAN STATUS		X				X	X			
	EF-1D	EXHAUST FAN ENABLE/DISABLE			X		X					
	EF-1D	EXHAUST FAN SPEED SIGNAL				X	X					
	EF-1D	EXHAUST FAN ISOLATION DAMPER				X	X					
	EF-1D	EXHAUST FAN STATUS		X				X	X			
	EF-1A	BYPASS DAMPER SIGNAL		X				X	X			
	EF-1B	BYPASS DAMPER STATUS		X				X	X			
	EF-1C	BYPASS DAMPER SIGNAL		X				X	X			
	EF-1D	BYPASS DAMPER STATUS		X				X	X			
	EPT-1	EXHAUST DUCT PRESSURE TRANSMITTER NORTH RISER	X				X		X			
	EPT-1	EXHAUST DUCT PRESSURE TRANSMITTER	X				X		X			
	T	EXHAUST TEMPERATURE INLET TO HEAT RECOVERY	X				X		X			
	T	HEAT RECOVERY SUPPLY TEMPERATURE	X				X		X			
	SD	SMOKE DETECTOR- FIRE ALARM DEVICE SOUTH		X			X		X			HARD WIRED, SHUTDOWN FANS AND CLOSE DAMPERS
	SD	SMOKE DETECTOR - BMS AUX CONTACT		X				X	X			
	DP	FILTER DIFFERENTIAL PRESSURE	X				X		X			HARD WIRED, SHUTDOWN FANS AND CLOSE DAMPERS

SECTION 260000 – ELECTRICAL WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes a summary of all Electrical related work.

B. Related Sections:

1. 260000 – Electrical Work
2. 260400 – General Electrical Requirements
3. 260500 – General Electrical Provisions
4. 260512 – Electrical Powered Equipment
5. 260519 – Wires and Cables
6. 260526 – Grounding and Bonding
7. 260529 – Supporting Devices
8. 260533 – Raceway and Boxes
9. 260534 – Junction and Pull Boxes
10. 260535 – Raceway Fittings
11. 260553 – Electric Identification
12. 260800 – Commissioning of Electrical Systems
13. 260923 – Lighting Control Devices
14. 262416 – Switchboards and Panelboards
15. 262726 – Wiring Devices
16. 262730 – Taps, Splices, and Terminations
17. 262813 – Fuses
18. 262816 – Enclosed Switches
19. 262913 – Motor Starters
20. 269999 – Digital, Addressable Fire-Alarm System

1.3 DESCRIPTION

A. The General Conditions, Special Conditions and Division 1 through Division 32, as set forth in these specifications, are hereby incorporated into and shall become a part of the specifications for work under this title, insofar as they apply hereto.

B. Furnish material, labor, tools, accessories and equipment to complete and leave ready for operation all Electrical systems for this project as described in these specifications and as shown on the drawings, or as required.

1.4 SCOPE OF WORK

A. Work includes, but is not limited to:

1. Install new breakers in existing switchboards and panelboards. Extend new feeders from existing switchboards and panelboards to new mechanical equipment, as indicated on the drawings.

2. Furnish and install new variable frequency drives furnished by HVAC Contractor (AHU unit manufacturer). Extend new feeders as indicated on the drawings.

3. Extend new power branch circuits to all new mechanical equipment.

4. Provide certain new lighting fixtures and extend branch circuit wiring as indicated on the drawings. Provide manual transfer switch.

5. Provide new lighting control system consisting of relay panels, contactors, occupancy sensors, vacancy sensors, etc. and extend branch circuit wiring as indicated.

6. Provide new lightning protection system as part of Alternate Bid No. 3.

7. Remove certain existing convenience receptacles, provide new convenience receptacles and extend branch circuit wiring as indicated.

8. Modify and expand the existing fire and smoke detection and alarm system. Remove certain existing fire alarm devices in remodeled area. Provide new fire alarm devices in remodeled area and extend wiring as indicated. All existing fire alarm devices in remainder of building shall remain operational and shall become a part of the new fire alarm work.

9. Provide new voice fire alarm system, as part of Alternate Bid No. 2, while maintaining the existing fire alarm systems. Provide temporary interconnection of the existing systems to the new system to ensure complete notification coverage and detection throughout the multiple phases of the project. Include temporary relocation of existing fire alarm panels and equipment as needed to maintain full system operation throughout the duration of construction.

10. Provide communication and informational conduit system as indicated on the drawings.

11. Perform certain specialized Electric Work for the following other trades. Note, this listing is by no means meant to include each minute detail, but it is intended to alert the Electric Contractor to certain items. This contractor shall review each other division of work to ascertain the scope of electrical work specified therein:

    a. General Contractor and Owner Furnished Equipment.

        1. Refrigerators, Freezers, Ice Machines, Microwave Ovens, Toasters, Office Equipment, etc.: Provide convenience outlets, where required for ease of connection to each item, and extend 120 volt connection thereto.

    b. Mechanical Equipment:

        1. Extend power branch circuit wiring to new fan coil units, energy recovery ventilator, roof top unit, etc. as indicated on the drawing.

        2. Extend 120 volt dedicated circuit wiring to all DDC temperature control panel locations.

12. Perform start-up for all electrical systems and commission same in accordance with the commissioning requirement.

13. Provide and/or participate in training of Owner's personnel on the use of all new electrical systems.

14. The contractor shall exercise adequate protective and safety measures for all persons and property and shall be responsible for any damages or injuries arising from the execution of this work.

15. Alterations and additions to existing work shall include the requisite dismantling of the old equipment, rigging, wrecking, hauling, protections of permanent equipment and the building structures, and cleaning up. Care shall be exercised to keep dust and dirt to a minimum and to confine it to the area where the removal work is being performed. All debris shall be promptly removed.

16. If asbestos insulation is encountered on any existing wiring which is to be removed or remodeled, contractor shall immediately notify Owner of the existence of asbestos and Owner will arrange proper removal of same without cost to contractor.

17. Unless otherwise noted, remove all other existing equipment and piping, valves, fittings, etc. which will not be reused in the final arrangement. Unless otherwise noted, all items which will be removed by this this contractor and not reused shall become the property of the contractor and shall be promptly removed from the site by him.

18. The existing facility will be partially occupied and will remain in operation throughout the period that this work is being performed, and certain new work will be performed during this period. Unscheduled interruptions of the facility will not be tolerated. The contractor shall exercise extreme caution, shall thoroughly inform his workmen and subcontractors of the critical nature of this work, and shall continually review the work procedure being followed in order to prevent accidental interruption of service. Before performing any act which could result in interruption of service, the contractor shall notify the Owner and Engineer of the hazards involved and the contractor shall proceed in a manner and at a time specifically approved by the Owner and Engineer.

19. All work necessitating the temporary turning off or shutting down the operation of existing mechanical and/or electrical facilities shall be done at times specifically approved by the Owner and Engineer in advance of any disruption of existing facilities. Also, refer to Section 23 04 00 – General Electrical Requirements.

B. Demolition Work

1. Coordinate all Demolition with the Xavier University so that shutdowns occur at times agreeable to the Xavier University.

2. The Electric Contractor shall remove certain existing air handling systems. The existing plans are available for review at the Engineer's Office and the Owner will provide access to contractors desiring to verify existing conditions. The contractor shall be responsible to verify the extent of demolition work and shall include in their bid all demolition work affecting their trade.

1.5 EXCAVATION AND BACKFILLING AND RESTORATION OF SURFACES

A. Refer to Division 1 and Section 23 04 00.

1.6 EQUIPMENT

A. Any and all costs associated with piping, electric, wiring, conduit, supports, pads, or other modifications to accommodate installation for manufacturer's equipment that differs from equipment layout on drawings shall be included on contractor's bid. The contractor is responsible to insure that the equipment will fit within space allocated with appropriate clearances for maintenance, operation, servicing, and code.

1.7 DUKE ENERGY INCENTIVE PROGRAM

A. Comply with all requirements of the Duke Energy Incentive Program in order that the Xavier University will be able to obtain incentive monies from Duke Energy for this project. If Duke Energy requirements are more restrictive than the specifications, the Duke Energy requirements shall govern. A copy of the Duke Energy Incentive information for equipment is available on their web site. The contractor shall complete these forms, provide all requisite documentation, and present this information to the Xavier University for submission to Duke Energy. The incentive monies shall be solely available to the Xavier University.

1.8 QUALIFICATIONS

A. Installer: Company specializing in performing the work of this Section with minimum three years documented experience.

1.9 LICENSES

A. The installation of this Electrical work shall be made by Contractors and craftsmen licensed by the Governing Authorities.

B. Obtain all permits, plan revisions, inspections, and licenses required by code authorities having jurisdiction.

1.10 FEES

A. The Owner will obtain and pay for the building permit. The Contractor shall obtain all inspections or additional permits required by all laws, ordinances, rules, regulations or public authority having jurisdiction and obtain certificates of such inspections and permits and submit same to the Architect. The Contractor shall pay all fees, charges and other expenses in connection therein for Electric work including inspection fees, etc. associated with the building permit.

1.11 CODES, REGULATIONS AND STANDARDS

A. Unless otherwise noted, the following latest enforced Edition shall apply to this work:

Ohio Building Code

Life Safety Code

National Fire Protection Association

National Electrical Code

Ohio Fire Code

OSHA Requirements

EPA Requirements

1.12 QUALITY ASSURANCE

A. The Electrical Contractor shall be responsible for all costs caused by the change of equipment from the basis of design specified to other named manufacturers. The Contractor is responsible to insure that the other manufacturer named supplied equipment will fit within space allocated, with appropriate clearances for maintenance, operation, service, code requirements, etc. Any contractor utilizing a manufacturer other than basis of design shall be responsible for any additional requirements for electrical service, concrete pad size, physical space limitations, and capacities at no additional cost to the building Owner. If manufacturers are listed, no other manufactures except those listed within the Sections of this Division, that are able to comply with the contract document requirements and minimum standards of these specifications, will be acceptable.

B. Work provided or performed by the Contractor shall be guaranteed to be replaced and made good at his own expense any defects which may develop, within one (1) year after final payment and acceptance by the building Owner, due to faulty workmanship or material, upon receipt of written notification of the defect from the building Owner.

1.13 COORDINATION DRAWINGS

A. General:

1. The HVAC Contractor shall be in charge of the coordination drawing process and shall be responsible to resolve all conflicts and settle any disputes resulting from the coordination drawing process.

2. Contract drawings are diagrammatic. Included in the base bid shall be all offsets, fittings, etc. for a completed

project.

3. Field discrepancies shall be resolved by the field foreman. When discrepancies cannot be resolved, the signed-off coordination drawings shall be re-examined for rights.

4. Documented, coordinated, dimensioned work will have precedence. Owner will not pay for rework of a particular trade. Uncoordinated work will not be tolerated.

5. Coordination drawings shall be a phased process with the General Contractor, HVAC Contractor, Architect and Engineer determining the sequence of work.

6. Each Contractor shall coordinate the exact location of their work with the work of other trades prior to fabrication or installation of same. Verify all dimensions and elevations. Provide additional offsets and sections of material as may be required to meet the applicable job condition requirements. Coordinate with and review all related Construction Drawings and Shop Drawings of all equipment suppliers prior to start of work.

7. It is the responsibility of the Electric Contractor to coordinate between his equipment suppliers and his temperature control subcontractor and other subcontractors as to which control devices are supplied with equipment, required wiring and voltages, and other related coordination times, so as to ensure a complete, proper, and operable installation.

B. Process

1. The HVAC Contractor shall have precedence for the allotment of available space. Ductwork rerouting for gravity drain lines may be required and shall be approved by the Engineer.

2. The HVAC Contractor shall be responsible for all trades, pre-coordinating their layouts and shop drawings with each other, including the Electric Contractor.

3. The Sheet Metal Contractor shall prepare a BIM model (Revit or Navisworks). He shall be responsible for the base drawings to be used by all other Contractors. Base drawings shall include architectural, structural and reflected ceiling plan information.

4. The Sheet Metal Contractor shall prepare ductwork drawings, at a minimum scale of 1/4" = 1'-0", in a BIM model (Revit or Navisworks). After he has finished, a CD with base drawing and ductwork shall be circulated in the following order:

    a. Plumbing Contractor

    b. Piping Contractor

    c. Electrical Contractor

    d. General Contractor

5. Each Contractor shall use the CD for preparation of their installation drawings.

6. After all trades have completed the coordination process, the General Contractor shall hold a coordination meeting to resolve conflicts. Each Contractor shall have available a drawing of his layout to be used with a light table for overlaying purposes. A representative of each Contractor, the Architect and the Engineer shall attend. All conflicts shall be resolved at the coordination meeting. The Architect and Engineer shall resolve all major conflicts as to the degree each Contractor shall alter their layout in order to allow for sufficient space for installation of the work.

7. After all work is coordinated and all conflicts resolved, each contractor shall update coordination documents in order to reflect all required minor and major modifications.

8. When all coordination is complete, the HVAC Contractor shall distribute two (2) sets of prints of the revised coordination drawings to each of the trades involved in the project, one (1) set for the Owner's Representative and one (1) set for as-built drawings.

C. HVAC Contractor:

1. All horizontal ducts shall be located and dimensioned from column center lines. Each duct shall be drawn to scale with width, depth and bottom of duct elevation clearly noted.

2. All vertical ducts shall be located from column center lines in two (2) directions. When concealed in a shaft, each vertical duct shall be shown in its total length.

3. Terminal units, heating coils, fire dampers, grilles and diffusers shall be located and dimensioned. Terminal units shall be located so as to be readily accessible from removable ceiling panel or access panel. All necessary clearances, required by codes, shall be maintained.

D. Electrical Contractor:

1. Conduits less than 1" in size are not required to be indicated on coordination drawings; however, the Electrical Contractor is responsible for routing these conduits in a manner to not cause a conflict with other trades. Conduits not indicated on coordination drawings shall be field offset to avoid all conflicts.

F. General Contractor:

1. All furrings and holes shall be clearly noted.

2. All ceiling heights shall be clearly noted.

G. Service Areas:

1. Contractors shall indicate service areas for all equipment, terminal units, etc. by shaded areas on drawings.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

3.1 EXISTING WORK

A. Each Contractor shall locate existing site utilities, installed in previous phase, prior to beginning work. Provide adequate means of protection during work operations. Repair existing utilities damaged during work operations to the satisfaction of the utility owner and at Contractor's expense.

B. Should uncharted or incorrectly charted piping or other utilities be encountered during work operations, notify the Engineer immediately for procedure directions. Cooperate with utility companies in maintaining active services and facilities in operation.

3.2 OPENING LOCATIONS AND CUTTING

A. Each Contractor shall give the General Contractor locations and sizes of all openings required for the installation of new mechanical work before new walls, etc. are started.

B. All cutting through poured concrete slabs and walls shall be done with core drills. No jack hammers will be allowed. All cutting and patching by General Contractor that is coordinated by the Electric Contractor. All cutting and patching not coordinated by the Electric Contractor with the General Contractor shall be by the Electric Contractor.

3.3 CLEANING AND PAINTING

A. All equipment shall be kept dry and clean during the construction period.

B. Prime and paint by General Contractor, unless otherwise noted.

C. When all work is completed and all work has been satisfactorily tested and accepted by the Architect, mechanical equipment and other exposed surfaces shall be thoroughly cleaned.

C. Repair marred and damaged factory painted finish with materials and procedures to match original factory finish.

3.4 EXCAVATION AND BACKFILL

A. Provide all excavation and backfill necessary to get the work in place. Compaction and backfill materials are to be provided by this Contractor. Work to follow Division 31, Earthwork or Section 260400.

3.5 CONCRETE WORK

A. Each Contractor shall provide concrete pads required for equipment they have supplied. See Division 3 - Cast-in-Place Concrete or Section 260400.

3.6 PROTECTION AND DAMAGE

A. In addition to the provisions and stipulation of the General Conditions, each contractor and subcontractor shall provide various types of protection as follows:

1. Protect finished floors from chips and cutting oil by the use of metal drip receiving pan and oil proof floor cover.

2. Protect equipment and finished surfaces from welding and cutting splatters with baffles and splatter blankets.

3. Protect equipment and finished surfaces from paint droppings, insulation adhesive and sizing droppings, etc. by use of drop cloths.

B. All equipment shall be stored at the site with openings, bearings, etc., covered to exclude dust and moisture. All stock piled pipe shall be placed on dunnage and protected from weather and from entry of foreign material.

C. Conduit and construction openings and excavations required for Electrical work shall be covered when work is not in progress as follows:

1. Cap pipe openings with fittings or plugs.

2. Cover wall and ceiling openings with plywood, or canvas covered framing.

3. Cover floor openings and excavations with structural material of adequate strength to support traffic.

D. The Owner's property and the property of other Contractors shall be scrupulously respected at all times (including damage from leaks). Provide drop cloths and visqueen or similar barriers where dust and debris is generated, to protect adjacent area.

E. Contractor shall be held responsible for damage caused by his work or through neglect of his workmen. Repairing of damaged work shall be done by Contractor as directed by the Architect. Cost of repairs shall be paid by Contractor.

F. The Owner reserves the right to make emergency repairs as required to keep equipment in operation without voiding the Contractor's guarantee bond not relieving the contractor of his responsibilities during the bonding period.

3.7 SPECIAL ATTENTION

A. After all dust making procedures are performed and finishes cured, Electric Contractor shall start all air handling units in order to purge the building. Electric Contractor shall adequately protect each intake of air handling unit with disposable filter media to prevent damage to unit. Electric Contractor shall perform service maintenance; thoroughly clean all units including coils, and replace filters on all air handling units before the Owner occupies the space and at no additional cost to the Owner.

END OF SECTION 260000

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SECTION 260400 – GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 GENERAL

A. The following paragraphs are applicable to Division 26 and are complementary to other sections of specifications. Where items described in other sections of the specifications are repeated herein, it is done to call special attention to or to qualify them, but it is not intended that any part of the documents shall be assumed to be omitted if not repeated herein.

B. Where contradictions occur between this section and Division 1, the more stringent of the two shall apply. Architect/Engineer shall decide which is most stringent.

1.2 DRAWINGS AND SPECIFICATIONS

A. Electrical drawings are diagrammatic and indicate general arrangement of systems and work included in the contract and shall be adhered to insofar as possible. The drawings and specifications are complementary and are intended, without giving every minute detail, to cover a workable installation complete in every respect including, whether mentioned or not, all material and equipment usually furnished with such systems and/or needed to make a complete operational installation omitting only such parts as are specifically excepted.

B. Consult drawings and details for exact location of fixtures and equipment, and where not definitely indicated, request this information in writing.

C. The specification for this division of the work is written in sectional form for brevity and convenience in reference, without repeating in each section all applicable general clauses and/or pertinent data covered elsewhere in the specification, but it is not intended that any of the documents shall be assumed to be omitted if not repeated in this division.

D. Where specifications are written for brevity, with incomplete sentences, the omission of words or phrases, such as "this contractor shall", "shall be", "provide", "furnish", "all", etc. are intentional and such omitted words or phrases shall be supplied by inference; unless otherwise mentioned, such clauses, lists, and/or directives indicate work to be done by this contractor for that specific branch of work.

1.3 EXISTING WORK AND/OR VERIFYING CONDITIONS

A. The work under this contract occurs on the site of and within the existing facility. The Owner will continue to use the present building during the construction period. The work under this contract shall be scheduled and performed so as to provide a minimum of interference with the normal operation of the existing building.

B. Before submitting a proposal, Electrical Contractors shall visit the site, and shall also carefully examine all bidding documents including those for other branches of the work, to satisfy themselves as to the nature and scope of all work to be done. Prints showing the original building architectural, structural, mechanical, and electrical work are available at the Engineer's office for contractors' review

C. The submission of a proposal shall be taken as evidence that such an examination has been made and difficulties, if any, noted. Later claims for labor, work, material, and equipment required for any difficulties encountered which could have been foreseen, shall not be recognized, and all such difficulties shall be properly taken care of by this contractor at no additional expense to the Owner.

D. The accompanying drawings and specifications illustrate and describe the existing conditions, mechanical and electrical utilities, sewers, water mains, pipes, ducts, conduits, etc. that are particularly relevant to the new work insofar as these mains are shown on existing records or evident by field inspections and tests; however, it is not the intent that these documents shall be construed to guarantee to the contractor the exact location of these items. The

contractor shall verify and determine the exact location of these items in the field, and all work under this contract shall be executed to avoid conflict with or damage to existing work. The work shall be planned and executed to avoid interference, as much as possible, with the normal use of the existing building.

E. All work involving hazards to persons shall be suitably barricaded and provided with warning lights or signs, as required.

F. Where necessary for the performance of the contract, existing work shall be cut, altered, removed, or temporarily removed and replaced. Work that is altered or replaced shall match similar existing work and said work shall be performed by trade applicable to the work; if said work is NOT shown or noted the Drawings relating to applicable trade, cost shall be paid by contractor requiring said work. However, unless otherwise provided by the drawings or specifications, no structural members shall be cut or altered without authorization of the Architect and Engineer. Work remaining in place, which is damaged or defaced by reason of work done under this contract, shall be restored in kind equal to its condition at the time of award of the contract by applicable trade as hereinbefore specified.

G. Existing work shall not be disturbed further than necessary for proper installation of new work. New work to be connected or made integral with existing work shall be properly erected to secure solidity and be continuous in finish. Such new work in extension of existing work shall correspond in all respects with that to which it connects, or similar existing sound work, unless otherwise specified.

1.4 ALTERATIONS TO EXISTING WORK

A. Alterations and additions to existing work shall include the requisite dismantling of the old equipment, rigging, wrecking, hauling, protection of permanent equipment and the building structures, and cleaning up. Care shall be exercised to keep dust and dirt to a minimum and to confine it to the area where the removal work is being performed. All debris shall be promptly removed.

B. If asbestos insulation is encountered on any existing wiring which is to be removed or remodeled, contractor shall immediately notify Owner of the existence of asbestos and Owner will arrange proper removal of same without cost to contractor.

C. Unless otherwise noted, remove all other existing equipment and conduit, wires, boxes, etc. which will not be reused in the final arrangement. Unless otherwise noted, all items which will be removed by this contractor and not reused shall become the property of the contractor and shall be promptly removed from the site by him.

1.5 EXISTING MECHANICAL AND/OR ELECTRICAL FACILITIES

A. Where existing mechanical and electrical facilities and/or service lines occur in the area of the work and such facilities or lines are to be abandoned or changed, the contractor for the branch of work or trade involved shall cut off and properly cap the old lines, so as not to interfere with the new construction work. If any portions of such lines are required for the operation of the existing building the lines shall be altered and relocated to clear new construction and shall also be restored into service to provide continued operation of the existing building.

1.6 INTERRUPTION OF SERVICES

A. The existing facility will be occupied and will remain in operation throughout the period that this work is being performed, and certain new work will be performed during this period. Unscheduled interruptions of the facility will not be tolerated. The contractor shall exercise extreme caution, shall thoroughly inform his workmen and subcontractors of the critical nature of this work, and shall continually review the work procedure being followed in order to prevent accidental interruption of service. Before performing any act which could result in interruption of service, the contractor shall notify the Owner and Engineer of the hazards involved and the contractor shall proceed in a manner and at a time specifically approved by the Owner and Engineer.

B. All work necessitating the temporary turning off or shutting down the operation of existing mechanical and/or electrical facilities shall be done at times specifically approved by the Owner in advance of any disruption of existing facilities.

1.7 MATERIALS AND EQUIPMENT

A. All materials and equipment entering into the work shall be approved by the Architect and Engineer, and must be new, without defects, and of the sizes and capacities shown on the drawings or hereinafter specified. All manufactured materials or equipment shall bear the identification mark of the manufacturer or, if required by the Architect and Engineer, shall be certified by an approved testing laboratory. All equipment shall operate within the manufacturer's range of speeds, guaranteed capacities, performance, etc. as indicated by the manufacturer's latest catalog and/or engineering data, shall be of proper size and dimension for the allocated space, and shall be placed in the space allocated in the proper construction sequence. Special consideration will be given to equipment which has been in successful field use or similar applications for at least three (3) years (exclusive of field tests), and to equipment which has an extended guarantee period in lieu of long use period. This contractor shall submit with his bid complete data on equipment he proposes to use; failure to so submit, or to meet these requirements fully and those of the specifications, shall be grounds for rejecting the items.

B. All electrical materials, apparatus, and equipment shall be new, of the make and characteristics specified, shall conform to NEMA standards, and shall be designed to comply with and be installed in accordance with the latest rules and regulations of the National Electrical Code, and all of the legally constituted public authorities having local jurisdiction. Upon completion of the work, furnish a certificate of approved inspection from an approved electrical insurance inspector. Verify the exact voltage and current characteristics at the building before ordering motors or similar equipment.

C. Conduct such tests and adjustment of equipment as specified or necessary to verify performance requirements. Submit data taken during such tests.

1.8 QUIET OPERATION

A. The work shall be installed in such a manner that under all conditions of load it shall operate without sound or vibration which is objectionable in the occupied spaces, in the opinion of the Architect and Engineer.

B. In case of moving machinery, sound or vibration noticeable outside of the room in which it is installed or annoyingly noticeable inside its own room will be considered objectionable. Sound or vibration considered objectionable shall be corrected by the contractor.

1.9 PROTECTION

A. In performing this contract, safeguard workmen and the public and protect the work and equipment until final completion and acceptance. After delivery and before and after installation, protect work against theft, injury, or damage. Carefully store material and equipment received on site which are not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing materials. Protect related or adjacent work and the material of the other trades or the Owner from damage that might be caused by this work and make good any damage thus caused. Provide all safeguards, scaffolding, drop cloths, etc. as required.

B. No welding or soldering shall be done near combustible materials of any kind; all adjoining work, finished surfaces, glass, etc. shall be protected from flames, sparks, hot metal, etc. by metal guards or approved noncombustible drop cloths or barriers.

C. Each contractor shall replace any items or portions thereof wherever removed or damaged, in a manner equal to the original construction and finish, or where directed by the Architect and Engineer, contractor shall pay other trades to perform this work.

D. All mechanical and electrical equipment with a factory finish shall be protected during construction and must be free of dust, dirt, cement splatters, etc. when building is turned over to the Owner. Dents and marred finishes are to be repaired to the satisfaction of the Architect and Engineer, or a replacement furnished where necessary.

1.10 EXECUTION OF WORK

A. Promptly upon award of contracts, the Electrical subcontractor shall confer with the General Contractor and Engineer and the other subcontractors to prepare a time schedule for completion of the work. The electrical work shall be performed and coordinated with the program of the General Contractor and the other subcontractors. Each subcontractor shall proceed diligently with the work and shall cooperate with the General Contractor and the other subcontractors to maintain the approved project construction and progress schedule to the best of his ability and as conditions permit.

1.11 GENERAL SUPERVISION AND INSTALLATION OF WORK

A. Each contractor shall at all times give the work his best skill and attention, including adequate construction supervision over his work, employees, and sub-contractors, and he shall fully cooperate with and confer with the Architect and Engineer and other contractors so that the best possible installation shall be obtained. Exact locations and relations are to be determined in the field, subject to the approval of the Architect and Engineer, and with preference to the dimensioned drawings and approved shop and setting drawings.

B. Unless otherwise shown, conduits, etc. shall be exposed.

C. Install conduits, etc. in a neat and workmanlike manner, close to walls, generally as high as possible, true and square to the building, utilizing standard practices, and properly graded for correct functioning of the system involved; multiple lines in close proximity shall be coordinated and neatly grouped. Install work in proper construction sequence and arranged so as to be readily accessible for operation, maintenance, and repair; minor deviations from drawings may be made to accomplish this, but changes of magnitude or which involve extra cost shall not be made without approval. All fixtures, outlets, etc. shall truly center with the adjacent architectural finish. All work, both exposed and concealed, shall meet the approval of the Architect and Engineer regarding neatness of appearance, location, and practicability of installation. The Architect and Engineer reserve the right to direct the removal and replacement of any item which, in his opinion, does not present an orderly and reasonably neat and workmanlike appearance.

D. Each contractor shall cooperate with the General Contractor in the preparation of the "Coordination Drawings". The contractor shall familiarize himself with the work of the other contractors, shall lay out his work to meet conditions at the building, shall give freedom to and prevent conflict with the work of other contractors, and shall make reasonable modification in locations or arrangement from those indicated on the drawings if required to avoid conflicts or to conform to tile, wood, marble, or other architectural finish. From time to time as the work progresses, each contractor shall examine the work installed by others, insofar as it may affect his work, and he shall, before proceeding with the work, notify the Architect and Engineer in writing, and shall not proceed until directed by the Architect and Engineer, if any condition exists which prevents the successful installation of his own work.

E. If the contractor places any work in violation of any of the above mentioned requirements, and conflicting or unworkmanlike conditions result, he shall, without additional charge, remove and reinstall or satisfactorily readjust such portions of his work as may be necessary and as the Architect and Engineer may direct. The Architect's and Engineer's decision regarding such conditions shall be final.

1.12 ENGINEER'S OBSERVATION

A. Periodic observation of the work by the Engineer is only for the express purpose of verifying compliance by the contractor with the contract documents to the best of his knowledge. Such engineering observations and services rendered by the Engineer or his representatives shall not be construed as the supervising of construction; nor the assuming by the Engineer of the duties and responsibility of the contractors; nor making the Engineer responsible for providing a safe place or procedure for the performance of the work or for the contractors' employees or for sub-contractors.

1.13 EXCAVATION AND BACKFILLING OF TRENCHES, ETC.

A. Unless otherwise specified, each Electrical Contractor shall do all excavation of trenches for conduits, etc. in connection with his work, and after his work is in place and inspected by the Architect and Engineer and Civil Authorities, he shall backfill in layers of not to exceed six inches (6") in depth, thoroughly moistened, thoroughly rammed, tamped, and compacted to a density at least equal to the surrounding earth to minimize after settlement. If, in the opinion of the Architect or Engineer, the excavated material is unsuitable for backfilling, the contractor shall backfill with bank run gravel well compacted. Top of backfill or trench surface shall be level with adjoining ground or surface; furnish additional material if required to fill trenches. All surplus earth shall be moved by this contractor and disposed of as directed by the Architect or Engineer. Compact backfill in trenches within building lines the same as specified in architectural branches.

B. Any sheet piling or shoring or pumping necessary shall be done by this contractor at his own expense and all trenches shall be dug in a careful manner, with bottoms properly pitched to insure perfect drainage and to provide uniform bearing and support for each section of pipe on undisturbed soil along its entire length, except where it is necessary for the proper sealing of joints. These trenches shall be not less than 12" wider, nor more than 16" wider, than the outside diameter of the pipe or conduit to be laid therein; this requirement applies to the width at and below the level of the top of the pipe or conduit; the width above that level may be wider for proper sheeting and bracing and the proper installation of the work. Shoring, bracing, barricades, etc. shall be provided to protect the workmen and/or public amply.

C. Unless otherwise approved, the following minimum cover shall be provided above the top of underground pipes outside the buildings: Water lines, 4'-0"; gas lines, 3'-0"; electrical and telephone lines, 2'-0" above concrete encasement; sewers, refer to elevations on plans.

D. Whenever wet or otherwise unstable soil, that is incapable of properly supporting the pipe as determined by the Architect or Engineer, is encountered in the trench bottom, such soil shall be removed to a depth required and for the length designated by the Architect or Engineer, and the trench backfilled to trench bottom grade with coarse sand, fine gravel, or other suitable materials, properly compacted.

E. Excavation near or under building footings shall be backfilled with concrete installed under the direction of the Architect or Engineer.

F. Where contractor elects to have any excavation work performed by a subcontractor, subcontractor must be approved by the Owner prior to commencing any work.

G. Construction Fence

1. Refer to Division 1.

1.14 RESTORATION OF SURFACES AND CONCRETE WORK

A. Unless otherwise specified, all new concrete work for parking lots, driveways, pads, etc. shall be provided by the General Contractor. All surfaces such as concrete floors, walls, paving, sidewalks, roof deck, or other surfaces disturbed in the execution of work by this subcontractor, and which remain in use, shall be restored in kind by this subcontractor, or he shall pay the cost of such work.

B. Where each contractor has performed excavation work, each contractor shall backfill as hereinbefore specified in Paragraph 13.

C. In Landscaped Areas, such as grass or plantings, the final 6" of backfilling, grading, seeding, mulching, and planting shall be performed by a qualified, competent Landscaping Contractor. The Contractor shall include in his bid the cost of such landscaping services and shall warrant same as described under Paragraph 24.

1. This final 6" of backfill provided by the approved Landscaping Contractor shall consist of top soil complying with Ohio DOT 653.02; ph 6.0 to 7.0 or adjusted within these limits, raked to a uniform fineness and free of rock or stones 1" or greater in any dimension.

2. Where grass has been disturbed, the Landscape Contractor shall apply 8/32/16 organic fertilizer at rate of 1 lb. per 5 square yards and seed with 90-95% pure, 85% (minimum) germination seed of a mixture of 20% Rye grass, 40% creeping red fescue, and 40% Kentucky blue grass at a rate of 7 lbs. per 1000 square feet. Cover seeded areas with clean, weed free straw.

3. If shrubbery and plantings must be disturbed, the Landscaping Contractor shall either remove, maintain, and reinstall said plantings or the Landscape Contractor shall furnish healthy new shrubbery and plantings similar in kind to that which was removed. In either case, the Landscape Contractor shall fertilize and provide mulch around said plants.

D. In Blacktop Paved Areas, the work shall be performed by a qualified, competent Blacktop Contractor; bids shall be based on and work shall comply with the following:

1. All materials and workmanship shall comply with the latest edition of the State of Ohio Department of Transportation Construction and Material Specification.

2. Paved areas shall match existing slopes and shall be without dips or low spots. All seams in paving to be flush and tight.

3. Begin rolling when mixture will bear roller weight without excessive displacement. Repair surface defects with hot material as rolling progresses. Cut out and patch defective areas and roll to blend with adjacent satisfactory paving. Continue rolling until maximum density is attained and roller marks eliminated.

4. Protect newly placed material from traffic until mixture has cooled and attained its maximum degree of hardness.

5. Remove and replace mixtures that become contaminated with foreign materials and defective areas and fill with fresh, hot mix properly compacted. Remove deficient areas for full depth of course. Cut sides perpendicular and parallel to direction of traffic with edges vertical. Apply tack coat before placing new mixture.

6. Thickness of Paving shall be as follows:

a. Base: ODOT-301, compacted thickness 9".

b. Prime Coat (over base): ODOT-408, 3.0 Gallons/Square Yard.

c. Wearing Course: ODOT-404, two separate 1-1/2" layers each compacted; total compacted thickness 3".

d. Tack-coat: ODOT-407, 0.20 Gallons/Square Yard.

e. Restore all parking space lines and space numbers using materials in accordance with Ohio Department of Transportation Section 621 - Pavement Marking.

E. Concrete Work, shall be performed by a qualified, competent, Concrete Contractor, and work shall comply with the following:

1. Sidewalks shall be concrete, Class C, unreinforced, complying with ODOT 608. Width and finish shall match existing adjacent sidewalks. Sidewalks shall be the same depth as the existing adjacent sidewalks or 7" deep whichever is greater.

2. All other concrete for parking lots, driveways, and pads shall be 4000 PSI compressive strength concrete with reinforcing steel. Thickness of concrete for parking lots and driveways shall be not less than 7" thick. Reinforcing steel shall be 6" x 6" 58 pound welded wire fabric (WWF) top and bottom. All welded wire fabric shall be in flat sheets, not rolls.

1.15 SLEEVES, CUTTING, PATCHING, CLEANING, WATERPROOFING, ETC.

A. Provide and accurately set frames and Schedule 40 steel pipe sleeves for required openings in new work to minimize cutting. Perform all cutting, patching, etc. required to install the work. Use approved power operated boring machine for small holes wherever practical. Remove all rubbish incidental to the work. Where any work pierces waterproofing, provide all necessary sleeves, caulking, and flashing required to make openings absolutely watertight.

B. Refer to the ACI Code 381.71, Section 6.3 for limitations and requirements for penetrations and openings.

1.16 PATENTS

A. The contractor shall defend and guarantee the Owner against any expense, claims, litigation, etc. occasioned by the use in this work of any materials, devices, etc. covered by patents not owned by this contractor, or of which he is not a licensed user.

1.17 CONTEMPLATED WORK

A. The drawings and specifications for the mechanical and electrical portion of this project have been prepared by Motz Consulting Engineers, Inc., doing business as Motz Engineering.

B. The various items of work necessary for completion of this work are hereinafter specified under the respective section headings or shown on accompanying drawings, and shall be included in any contract or contracts made for completion of respective divisions of the work. Such contracts shall also include necessary details reasonably incidental to the proper execution and completion of such work.

1.18 MOVING MATERIALS

A. If it becomes necessary at any time during the progress of this work to move materials which have been temporarily located and which are to enter into the final construction, the contractor furnishing said materials shall, when so directed by the Engineer, move them or cause them to be moved. Cost of such moving shall be included in the contract price.

1.19 ACCIDENT PREVENTION

A. Precaution shall be exercised at all times for the protection of persons and property. The safety provisions of applicable law, building, and construction codes shall be observed. Machinery, equipment, and other hazards shall be guarded in accordance with safety provisions of the "Manual of Accident Prevention in Construction" published by Associated General Contractors of America to the extent that such provisions are not inconsistent with applicable law or regulations.

1.20 TOOLS AND MATERIALS

A. Tools and materials shall be stored on the premises at locations designated by the Owner.

1.21 PROPERTY PROTECTION

A. All hoisting shall be done with proper tag lines and buffers to prevent damage to the sides of the building. Where it is necessary to hoist materials to the roof, the parapets at top of the building and the roof where materials are landed from hoists shall be protected with heavy wood covers. Parapet protection shall be placed on both sides and top, and

shall extend far enough on either side of landing point to insure adequate cover. The roof, from the landing point at parapet to final location of material, shall be adequately protected by planks laid side by side on roofing and spiked together on outside edges with planks running at right angles to main planking. The roof shall be adequately protected against leaks at all times.

B. Where hoists are erected on the roof for hoisting material up the side of the building, the roof shall be adequately protected against abrasion or other damage. Materials stored on the roof shall be placed on planks or other protection approved by the Engineer and shall be placed only at locations approved by the Engineer.

C. If hoisted materials are taken through windows, the jams, head, and sill shall be adequately protected with wood planking or proper buffers.

D. Any work, equipment, or property damaged during construction of this project and due to operations under this contract shall be repaired or replaced by this contractor, without additional cost to the Owner. Upon completion of the work, the contractor shall remove all protections herein specified.

1.22 REMOVAL OF RUBBISH

A. It shall be each contractor's duty to keep the building and surrounding premises clean, free from rubbish of every description. No rubbish, crating materials, packing, or dirt shall be allowed to accumulate at any time, but shall be removed at once and hauled away.

B. Each trade shall be responsible for its own tools and materials during the periods of rubbish removal but contractors shall use reasonable care in removal of rubbish to protect the tools and materials of others against loss or damage. The Owner reserves the right, in the event that removal of rubbish is not promptly and properly carried out by the Contractors to have rubbish removed and to charge the cost of its removal to the contractor.

C. Also, refer to Division 1.

1.23 MATERIAL SAFETY DATA SHEETS (MSDS)

A. The contractor shall obtain and maintain on-site during the course of the project the Material Safety Data Sheets (MSDS's) for all chemicals or products containing chemicals that may be considered toxic or hazardous. The MSDS's are to be forwarded to the Office of Environmental Health and Safety upon completion of the project.

1.24 INSTRUCTION OF PERSONNEL

A. The Electrical Subcontractor shall provide free on site instruction in the proper use of installed equipment to designated representatives of the Owner, sufficient to ensure safe, secure, efficient, non-failing utilization, and operation of systems. This instruction shall include the following:

1. One Site Training: Provide a minimum of 24 hours of training for owner's staff. Submit a syllabus to the Engineer prior to the first session.

2. Support: Provide a minimum of 16 hours of support either on site or by telephone to answer operations questions.

PART 2 – (NOT USED)

PART 3 – (NOT USED)

END OF SECTION 260400

SECTION 260500 – GENERAL ELECTRICAL PROVISIONS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions, General Requirements, Division 1 Specifications, apply to this Section.

1.2 REFERENCE TO CONDITIONS OF THE CONTRACT

A. The Conditions of the Contract General, Supplementary and other Conditions and Divisions 1 through 31 and General Requirements, apply to the work specified in Division "26" and "28". Unless the specifications contain statements which are more definitive or more restrictive than those contained in the Conditions of the Contract, the specifications shall not be interpreted as waiving or overruling any requirements expressed in the Conditions of the Contract.

B. No claim or additional compensation shall be entertained on behalf of or paid on account of failure to be informed of the above conditions and requirements.

C. Should a bidder find discrepancies in or omissions from the drawings or specifications, or should he be in doubt as to their meaning, he should at once notify the Associate who shall send written instructions to bidders. If these are ignored by the Contractor, he shall be responsible for furnishing the proper or workable equipment as necessary.

D. Before submitting a bid, bidders shall be held responsible to have visited the site of work, attend the Pre-Bid Meeting, and fully inform themselves as to existing conditions and limitations, including rules, rates and fringe benefits, travel pay, affiliation fees and transportation expense prevailing in the local labor market, and no allowance shall subsequently be made on behalf of the bidder by reason of any error on his part.

E. Carefully examine the architectural, structural, heating, ventilating and air conditioning, plumbing and any other relevant contract documents. If any discrepancies occur within Contract documents, report such discrepancies to the Associate in writing and obtain written instructions as to the manner in which to proceed. No departures from the contract documents shall be made without prior written approval of the Associate.

F. Obtain any additional reference documents and/or information required for installation prior to installing equipment. Coordinate work with other trades making minor adjustments as required. Wiring or conduit layouts are schematic based and exact locations shall be determined by structural or other restricting conditions.

G. Minor details not usually shown or specified but necessary for proper installation and operation shall be provided in the Electrical Contractors estimate, the same as if herein specified or otherwise shown.

H. Coordination with the Utility servicing this facility including following and policies of the utility company shall be included in this bid. Where material and installation is deemed the responsibility of the Electrical Contractor by the Utility Company, such work shall be included within his bid.

I. Electrical Contractor bid submission shall give written notice to the Architect of record any materials or apparatus believed inadequate, in violation of laws, ordinances, rules, standard installation practices and any necessary item required or work omitted. In the absence of such written notice, it is mutually agreed that the Electrical Contractor has included the cost associated of all required item in his proposal and that he will be responsible for the approved satisfactory functioning of the entire system without extra cost compensation.

1.3 WORK INCLUDED

A. Provide and install a complete and operating electrical installation in accordance with these specifications and accompanying contract documents. This shall include required labor, material, apparatus and supervision.

B. Without limiting or restricting the volume of work and solely for convenience, the work to be performed will, in general, comprise the following:

1. Demolition of selected electric feeders, branch circuits and supporting equipment. Coordination of demolition work with other trades.
2. Provide new feeder and branch circuit wiring including overload and disconnecting means. Alterations to existing wiring systems per plans.
3. Provide wiring devices, covers, multi-gang plates and supporting back boxes and/or equipment.
4. Support and provide wiring of equipment and final connections of equipment furnished by others.
5. Grounding and bonding of equipment.
6. Modifications to or replacement of existing systems such as; Fire alarm, telephone, public address and security systems.
7. Coordination, handling, installation and test of Owner furnished equipment or materials.
8. Required material and labor necessary to complete project scope as indicated within project Contract documents.
9. Temporary services: construction lighting and power.
10. Fire alarm devices alterations including new device installation such as detectors, door holds, notification appliances, activation appliances, field information gathering, field required documentation, system programming alterations, testing, and coordination.
11. Phasing: The Electrical Contractor and any subcontractors thereof, shall conform project related electrical work to project phasing requirements as outlined in Division 1. Electrical work shall be coordinated and scheduled to provide feeders, branch circuits or equipment installation in advance (where applicable) to the next phase sequence. The intent is to minimize rework and removal of finished ceilings by extending temporarily capped raceways into the next defined phasing area. This Contractor shall provide required labor and material to effectively meet project-phasing requirements.

C. Items of labor, material, and equipment not specified in detail or shown within Contract documents, but incidental to or necessary for the complete installation and proper operation of the several branches of work and described herein, or reasonably implied in connection herewith, shall be furnished as if called for in detail by the specifications or Contract documents. This includes electrical work associated with mechanical and plumbing work whether indicated on electrical drawings or not.

D. This contractor is advised to carefully coordinate the delivery of large, awkward, heavy equipment, material or relevant items. Delivery limitations may require modifications, supporting means or structural modifications in order to set equipment or components. This contractor shall be responsible for all calculations, material, labor, equipment, machinery, deliveries, transportation or safety related equipment required for equipment such as but not limited to: transformers, switchgear, generator, site lighting, disconnects, staging materials, panelboards etc.

E. Electrical Contractor shall provide raceways, fittings, supports, feeders, branch circuits, overload/short circuit protection, relays, starters, terminals and related accessories to complete his work including installation and termination of items, equipment or controls furnished by other contractors unless specifically stated otherwise.

F. It is the responsibility of the Electrical Contractor to verify proper motor rotation and sizing of motor overload protection is in compliance with NEC and equipment manufacturer.

1.4 WORK NOT INCLUDED

A. The following items of Electrical Construction are not included in this contract:

1. Low voltage wiring of certain systems or devices shall be done by the respective Contractor such as temperature control wiring, interlock wiring and related control devices for HVAC equipment unless noted or otherwise. Raceways shall be provided by the Electrical Contractor.

2. Certain motors and equipment shall be provided by others, complete with motor and built-in or separate controllers as covered by such contracts such as packaged HVAC or plumbing equipment. The Electrical contractor shall provide feeders, branch circuits and/or disconnecting means as called for within the Contract documents.

1.5 DEFINITIONS AND ABBREVIATIONS

A. Definitions

1. "Furnish" shall mean supply and deliver to project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.

2. "Install" shall be used to describe operations at project site including unloading, packing, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning, and similar operations, as applicable in each instance.

3. “Installer” shall mean a company or individual specializing in performing work meeting the requirements of their trade with minimum of three (3) years of experience.

4. "Provide" shall mean furnish and install, complete and ready for intended use, as applicable in each instance.

5. "Directed" shall mean as directed by Owner or its Representative prior to installation of equipment.

6. "Indicated" shall mean "indicated on Contract Documents".

7. "Shown" shall mean "shown on Contract Documents".

8. "Section" shall mean one of the Specification Sections.

9. "Division" shall mean one of the Specification Divisions.

10. "Article" shall mean one of the numbered paragraphs of the Specification Section.

11. "Work" or "Electrical Work" herein includes products, labor, equipment, tools, appliances, transportation and related items, directly or indirectly required to complete the specified and/or indicated electrical installation.

12. "Code" shall mean any and all regulations and requirements of regulatory bodies, public or private, having jurisdiction over the work involved.

13. "Product" used in Division 26, 27 and 28 means material, equipment, machinery, and/or appliances directly or indirectly required to complete the specified and/or indicated Electrical Work.

14. "Standard Product" shall mean a manufactured product, illustrated and/or described in catalogs or brochures, which are in general distribution prior to the date of issue of construction documents for bidding. Products shall generally be identified by means of a specific catalog number and manufacturer's name.

15. "Wiring" shall mean fittings, conduits, wires, junction boxes, connections to equipment, splices, and other accessories required to complete the work.

16. Abbreviations and Symbols: See lists on drawings.

17. "This Contractor" shall mean the Contractor responsible for Divisions 26, 27 and 28 work.

18. Contract Documents: drawings, specifications, manufacturer’s specification/data sheets, bid forms,

addendum, and change orders.

19. Whenever the phrases "approved by the Associate or Owner's Representative," "approved equivalent," or "equivalent to" appear in these specifications, they shall be interpreted as meaning "as recommended by the Associate and approved by the Authority."

B. Reference to the latest editions of codes and standards shall mean:

Reference	Definition
NEC	National Electrical Code
ASTM	American Society for Testing Materials
NEMA	National Electrical Manufacturers Association
ANSI	American National Standards Institute
FS	Federal Specification, US Government
CS	Commercial Standards issued by US Department of Commerce
NESC	National Electrical Safety Code
NETA	National Electrical Testing Association
ADA	Americans with Disabilities Act
OBC	Ohio Building Code
NFPA	National Fire Protection Association
Owner	Owner / Owner's Representative

1.6 REGULATIONS

A. Electrical work, equipment, and materials furnished and installed under this contract shall conform to the requirements of the latest edition of the National Electrical Code, the National Fire Protection Association and any other governmental or local authorities having jurisdiction. Pay any fees required for the installation of this Division work. Certificates of approval shall be obtained in duplicate from any department or agency issuing same, and shall be turned over to OWNER or its representative at the completion of the work.

B. Provide any labor, materials, services, apparatus, CAD drawings and documents required to comply with applicable laws, ordinances, rules and regulations, whether or not shown.

C. Obtain certificates of inspection and approval from authorities having jurisdiction and deliver same to OWNER as a prerequisite for final acceptance of the work. Provide record copies of permit applications, permits and other items for which certification are indicated.

1.7 SPECIAL ENGINEERING SERVICES

A. In the instance of complex or specialized electrical systems such as fire alarm, security, telecommunication or similar systems; the installation, final connections and testing of such systems shall be made under the direct supervision of qualified authorized service engineers who shall be in the employ of the respective equipment manufacturer. Provide OWNER with copies of instruction manuals and booklets for each system and piece of equipment installed. Provide any additional instructions over and above that listed above in the care, adjustment and operation of parts of the electrical systems.

B. Pay any and all expenses incurred by these equipment manufacturers' representatives.

1.8 SUBMITTALS

A. Shop drawings, product data, and samples shall be submitted to the Associate for approval. Submit a minimum of (6) sets (or equivalent documentation in PDF format) of shop drawings and related specifications to the Associate in a bound set included with letter of transmittal.

1. Electrical Contractor must first review content for project specification compliance prior to submission. Drawings and specifications shall bear the Electrical Contractor's approval stamp indicating specification compliance. Sets received without Electrical Contractors approval stamp will not be reviewed.
2. Shop drawings shall be new drawings, and not reproductions or tracings of the Contract Documents. In preparing shop drawings, establish lines and levels for the work specified, and check the drawings to avoid interference with structural features and other work. Immediately call to the attention of the Architect any interference for clarification in writing.
3. Manufacturer's literature and data sheets shall be submitted indicating the necessary installation dimensions, weights, materials, and performance information. Each piece of literature shall be identified with the specific specification number, paragraph, and equipment schedule identification.
4. Engineer's review of Manufacturer documents or specifications shall not relieve the contractor from responsibility of errors or omissions in such submittals, schedules, drawings or deviations form contract documents.
5. Layout and detail drawings shall be submitted in the form of legible sepia reproducible and paper prints. Manufacturer's drawings shall be standard drawings. Equipment shop drawings shall show specific data and other special features required for review consideration.
6. Equipment shop drawings (8-1/2 by 11 inch sheets) shall be bound together in sets, in loose leaf binders, and shall be indexed in accordance with Specification Section. Additional shop drawings may be submitted at a later date for insertion therein, and the original submittal shall note which shop drawings shall be submitted later. Marked-up catalogs are not acceptable, and shall be rejected.
7. Materials and equipment shop drawings shall be submitted within 30 calendar days of Contract receipt.
8. Manufacturers' instruction manuals shall be submitted together with shop drawings. Furnish instruction manuals and parts listed for each piece of electrical equipment, on 8-1/2 by 11 inch sheets, or catalogs, suitable for loose leaf side binding, packaged separately, and clearly identified. Instructions shall include information pertaining to installation, operation, and maintenance of equipment as applicable. Each piece of literature shall be clearly identified with the specific job equipment identification. Literature shall be factory printed and not reproduced copies.
9. Any characteristic of any piece of equipment which deviates from the characteristics of the equipment specified shall be hi-lighted and circled in red.

B. Submit manufacturers' data, and/or shop drawings of the following:

1. Distribution panels, branch panelboards, and related equipment.
2. Emergency and safety related equipment.
3. Transformers.
4. Lighting Fixtures with ballast data.
5. Wiring devices.
6. Automatic transfer switches.
7. Lighting controls devices such as switches, contactors, motion, occupancy sensors and relevant control sensors.

8. Surge protection and waveform corrector equipment.
9. Disconnect switches, motor starters, and controls supplied by the Electrical Contractor.

1.9 OPERATING AND MAINTENANCE INSTRUCTIONS

A. After final tests and adjustments have been completed, furnish the services of qualified personnel to fully instruct the OWNER Maintenance representative in the operation and maintenance procedures for equipment installed. Operation and maintenance instructions for major items of equipment shall be directly supervised by the equipment manufacturer's representative. Supply qualified personnel to operate equipment for sufficient length of time as required to meet governing authorities' operation and performance tests and as required to assure that OWNER representatives are properly qualified to take over operation and maintenance procedures.

1. Notify the Associate, OWNER representatives and equipment manufacturers' representatives, by letter, as to the time and date of operating and maintenance instruction periods at least one week prior to conducting same.
2. Forward to the Associate the signatures of all present for the instruction periods.

B. Furnish three (3) copies of recommended equipment operation and maintenance procedures manuals as specified herein, assembled and bound together in 8-1/2 by 11 inch three-ring binders. The ring binders shall be submitted to the Associate in accordance with procedures established for shop drawing submittals.

1. The operation and maintenance procedures manuals shall include the following:
   a. Project Title
   b. Associate’s Name and Address
   c. Date Submitted
   d. Contractor's Name and Address
   e. Index (in alphabetical order, with page numbers)
   f. General Description of Each System
   g. Parts List, identifying the various parts of equipment for repair and replacement purposes.
   h. List of spares recommended for normal service requirements.
   i. Operating instructions outlining step-by-step procedures required for system start-up and operation. The instructions shall include the manufacturer's name, model number, service manual, and brief description of each piece of equipment and its basic operating features.
   j. Maintenance instructions describing routine maintenance and lubrication procedures and schedules, and simplified diagrams which illustrate the systems as installed.
   k. Wiring and control diagrams for each piece of equipment, showing "as installed" conditions.

1.10 SINGULAR NUMBER

A. References made to any item in the singular number shall apply equally to as many identical items that the work may require.

1.11 PROTECTION OF SERVICES

A. Repair, replace and maintain in service any new or existing utilities, facilities or services (underground, overhead, interior or exterior) damaged, broken or otherwise rendered inoperative during the course of construction. The method used in repairing, replacing or maintaining the services shall be approved OWNER and Associate. OWNER reserves the right to make emergency repairs as required to keep equipment in operation without voiding the Contractor’s guarantee bond not relieving the contractor of his

responsibilities during bond period.

B. OWNER's property and the property of other trades shall be scrupulously respected at all times include damage from leaks. This contractor shall provide drop cloths or similar barriers where dust or debris is generated protecting adjacent area.

C. This contractor shall be held responsible for damages caused by his work or through neglect of his workman or subcontractors. Repairing of damages shall be done in accordance by OWNER or its representative. Costs associated with repairs shall be paid by this contractor.

1.12 PROTECTION OF FLOORS, EQUIPMENT AND PERSONNEL

A. Protect flooring from damage during the construction period. Provide plywood or similar material under equipment or materials stored on floors, and in areas where construction may damage the floor surfaces. Replace floor surfaces (including sealer) damaged during the construction.

B. In addition to the provisions and stipulation of the General Conditions, each contractor and subcontractor of shall provide various types of protection as follows:

1. Protect finish floors from chips and cutting oil by the use of metal drip receiving pan and oil proof floor coverings.
2. Protect equipment and finish surfaces from welding and cutting splatters with baffles and splatter blankets.
3. Protect equipment and finished surfaces from paint droppings, insulation adhesives, grout, fire proofing and other related non-finished material.

C. All equipment shall be stored at the site with openings, bearings, etc., covered to exclude dust, moisture or foreign debris from entering.

D. Construction openings, trip hazards and unsafe conditions created by this contractor shall be scrupulously inspected for personnel safety and protection of property with strict compliance of OSHA work and construction practices.

E. Conduit and excavations required for electric work shall be covered when work is not in progress such as capping conduit openings, cover wall or floor openings with material of adequate strength supporting construction traffic, safety warning tape, warning lights and signs.

1.13 TEMPORARY LIGHT AND POWER SERVICES

A. Refer to the Division 1, General Requirements, of these specifications to determine responsibility for temporary lights, power, water and heat.

B. The Electrical Contractor is responsible for all temporary power and lighting requirements throughout construction. The Electrical Contractor shall review all associated phasing plans and schedules and provide any and all equipment, either temporary or permanent, required to maintain or provide temporary power and lighting to all areas of this facility, throughout the construction process.

C. In addition to minimal temporary lighting and power needed for construction operations, occupied areas throughout construction shall be provided with temporary power and lighting services that meet or exceed the existing services that currently serve these areas. Power interruptions to such areas shall be kept minimal and be scheduled 48 hours prior to alterations of service.

D. The electrical documents indicate the final arrangement for the power/lighting/communication/ signal/data systems and do not reflect equipment, devices, etc., needed to provide the required temporary power and lighting services.

E. At the completion of this project, all temporary lighting, temporary receptacles, and temporary wiring shall

be removed in their entirety.

F. Waste material generated by this contractor or relating to his work shall be properly disposed of in accordance to local, state and federal guidelines or requirements.

1.14 SUBSTITUTIONS

A. It is the intent of these specifications that wherever a manufacturer or product is specified, and the term "or approved equivalent" is used, the substituted item must conform in respects to the specified item. Consideration shall not be given to claims that the substituted item meets the performance requirements with lesser construction. Performance indicated in schedules, drawings and specifications shall be interpreted as minimum performance.

B. Note that where specific manufacturers' products are indicated in the Contract Documents, the associated systems have been designed on the basis of that product's physical characteristics. Where specific manufacturers' products are indicated in the Contract Documents and other manufacturers' names are listed, the associated systems have been designed on the basis of the first-named manufacturer's product. When products other than those used as the basis of design are provided, additional costs related installation, usage or modifications to the systems and/or structure required by the use of that product shall be paid by this contractor.

C. This Contractor shall be responsible for all costs associated with changes to sizes such as conduit, fuse, starter, wire, supports etc. caused by change of equipment from the basis of design including usage of other named manufactures. Space allocation due to usage of other manufacture shall be the responsible of the Contractor ensuring adequate clearances for maintenance, operation, service, code requirements are met.

D. Equipment of one type shall be the products of one manufacturer; similar items of the same classification shall be identical, including equipment, assemblies, parts and components.

E. Materials furnished shall be new, defect free, used in accordance to its listing and determined safe by a nationally recognized testing organization, such as Underwriters' Laboratories, Inc., or Factory Mutual Engineering Corporation, and materials shall be labeled, certified or listed by such organizations.

F. Where a specific manufacturer is specified and other manufacturers' names are listed as equivalent, the bid shall be based upon the specified or equivalent manufacturers only. Any substitutions shall be submitted to the associate no later than ten (10) days prior to the bid opening. Refer to Article I and the General Conditions of this specification for more information.

G. Final acceptance of substitutions shall be at the discretion of the associate.

1.15 PERFORMANCE OF EQUIPMENT

A. Materials, equipment and appurtenances of any kind, shown on the drawings, hereinafter specified or required for the completion of the work in accordance with the intent of these specifications, shall be completely satisfactory and acceptable in operation, performance and capacity. No approval either written or verbal of any drawings, descriptive data or samples or such material, equipment and/or appurtenance shall relieve the Contractor of his responsibility to turn over the same to OWNER in perfect working order at the completion of the work.

B. Any material, equipment or appurtenances, the operation, capacity or performance of which does not comply with the drawings and/or specification requirements or which is damaged prior to acceptance by OWNER shall be held to be defective material and shall be removed and replaced with proper and acceptable materials, equipment and/or appurtenances or put in proper and acceptable working order, satisfactory to the Owner, without additional cost to the Owner.

1.16 WEATHERPROOFING LOCATIONS (WP)

A. Electrical apparatus, such as outlet boxes, switches, thermal switches, manual starters, disconnect switches, combination switches and starters, motor control centers, and motor starters shall be weatherproof gasket type, NEMA Types 4 in the following instances:

1. On surface of exterior face of building, including areas where not under canopies, cast boxes with threaded hubs must be used and under canopies steel boxes with gasket connections to devices.
2. In any areas where specifically noted "WP" or required by the NEC or Electrical Regulations mentioned herein.
3. Within air conditioning enclosures.
4. In underground splice boxes.
5. On building roof.

1.17 CLEANING, PROTECTING AND ADJUSTING

A. Materials shall be stored in a manner that shall maintain an orderly, clean appearance. If stored on-site in open or unprotected areas, equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.

B. Equipment and material, if left unprotected and damaged, shall be repainted or otherwise refurbished at the discretion of the Owner. Equipment and material is subject to rejection and replacement if, in the opinion of the Associate or the manufacturer's engineering department, the equipment has deteriorated or been damaged to the extent that its immediate use or performance is questionable, or that its normal life expectancy has been curtailed.

C. During the construction period, protect ductwork, raceways, conduit and equipment from damage and dirt. Properly cap ductwork and conduit.

D. Vacuum cabinets, switch boards, distribution panels, lighting and power panels, etc., after completion of work.

E. Remove recorded construction measurements from equipment, panels, walls or other defaced surfaces.

1.18 ACCESSIBILITY

A. Coordinate to ensure the adequacy of the size of shafts and chases, and the adequacy of clearances in hung ceilings and other areas required for the proper installation of this work.

B. Locate equipment which must be serviced, operated or maintained in fully accessible positions. Equipment requiring access shall include, but is not necessarily limited to, motors, junction boxes, fire alarm devices, controllers and switchgear.

C. Provide, as required, the exact locations of access doors. Provide access doors in finished construction for installation by others. Locations of access doors in finished construction shall be submitted in sufficient time to be installed in the normal course of the work. Keep conduit and other electrical devices clear of access door openings to allow adequate space to work in or enter the concealed space.

D. Access panels shall not be smaller than 12 inches by 16 inches or as required by authority of jurisdiction and shall be all-steel construction with a No. 16 gauge wall or ceiling frame and a No. 14 gauge panel door with not less than 1/8 inch fireproofing secured to the inside of the door. Doors shall be provided with concealed hinges and be secured with suitable clips and countersunk screws. Outside of access panels shall finish flush with finished wall or ceiling surfaces. Covers shall be factory primed with two (2) coats of primer.

E. Working clearances: Provide at least 3'-0" of clear space in front of all electrical panels and as wide as the equipment with a minimum of 2'-6" wide. Height and width of working spaces shall be in accordance to Article 110.26 of National Electric Code.

1.19 GUARANTEE

A. Guarantee material, equipment and workmanship for a period of one (1) year from date of final acceptance by Associate and Owner's Representative. Replace defective material and workmanship furnished and installed and other work and equipment damaged thereby.

B. In addition to the one (1) year guarantee, furnish any warranties or guarantees that normally come with specific pieces of equipment that exceed the one (1) year guarantee. These additional warranties shall be given to OWNER for the time period specified.

1.20 COORDINATION

A. The General Contractor shall be in charge of the coordination drawing process and shall be responsible to resolve all conflicts and settle any disputes resulting from the coordination drawing process. Coordinate and furnish in writing to other Primes, including the Associate, any information necessary to permit the work of all contractors to satisfactorily complete installation of their work with the least possible interference or delay.

B. Each Prime Contractor shall participate in the preparation of coordination drawings. No installation of permanent systems shall proceed until the coordination drawings are approved by the General Contractor. No extra charges shall be allowed for changes required to accommodate installation of system by other contractors.

C. Coordination drawings shall be prepared in Revit 2014 format for each floor level and shall be of a scale not less than 1/4 inch - 1 foot. Coordination drawings shall include equipment, lighting, telecommunication, fire alarm, cable tray and raceway plans, with elevations with dimensions. Coordination drawings shall also include required access points through ceiling panels, access doors, cover plates, etc.

D. Field discrepancies shall be resolved by the field foreman. When discrepancies cannot be resolved, the signed-off coordination drawings shall be re-examined for rights. Any and all discrepancies in construction, phasing, etc., due to the lack of coordination shall be at the sole expense of the associated contractors and in no way will be passed on to OWNER.

E. Devices and appurtenances which are to be installed in finished areas shall be coordinated with the General Contractor and OWNER for final approval as it relates to location, finish, materials, color, and texture.

F. When work is installed without proper coordination, changes to this work deemed necessary by the Associate shall be made to correct conditions without any extra cost to OWNER.

G. Disciplines shall include in coordination: Electric, Telecommunications, HVAC, Mechanical, Plumbing, Fire Protection and Fire Alarm System.

H. Related coordination specification in Division 01.

1.21 PRE-BID SITE VISIT

A. Before submitting a bid, the Bidder is required to visit the site and fully inform themselves concerning all conditions affecting the scope of the work. Any discrepancies between the contract documents and the job site shall be brought to the Contract Officer's attention before bids are due. Failure to visit the site shall not relieve the Contractor from any responsibility in the performance of this Contract. No extra charges shall be allowed as a result of existing conditions.

1.22 DRAWINGS

A. The Electrical drawings are diagrammatic and indicate the general arrangement of fixtures, equipment, furniture and work included in this contract. Consult the project documents and details for locations and dimensions of such equipment. All dimensions shall be field verified prior to material ordering. Where such items are not dimensioned or properly detailed, contact the Architect for required information.

B. The Electrical Contractor shall follow the drawings in laying out work while checking drawings of other trades prior to installation. Maintain NEC required work clearances including overhead electric space requirements. Contact the Architect where clearances are inadequate prior to equipment installation.

C. Where directed by the Architect, the Electrical Contractor shall modify layouts as needed to prevent conflict of work with other trades. No additional charges shall be made for coordination. Failure to coordinate with other trades or within project documents shall not relieve the Electrical Contractor from his responsibility or necessity of furnishing material or performing his work as required by the contract documents.

PART 2 - PRODUCTS

2.1 MATERIALS AND WORKMANSHIP

A. Equipment shall be so built and installed as to deliver its full rated capacity at the efficiency for which it was designed. Equipment shall meet the detailed requirements indicated, and shall be suitable for the installation shown.

B. Surface mounted electrical equipment shall be installed on 3/4" thick, fire retardant mounting board. Mounting board shall bear UL classified mark indicating ASTM E 84 test compliancy. Backboard material shall have a final applied finish according to manufacturer specifications prior to mounting of electrical equipment. Finishing material may include but not limited to fire retardant coatings. Backboard material shall minimally extend 6” in all directions beyond grouping of electrical equipment. The Electrical Contractor may use discretionary expertise to provide fire retardant backboard for individual equipment such as standalone disconnect switches, starters and the like. Where said devices are grouped (starters, disconnects, contactors etc.) installation shall include fire retardant backboard. Fire retardant mounting board installed on perimeter outside walls to be shimmed 1/2" from wall with washers to permit back ventilation.

1. Approved manufacturer: Hoover Treated Wood Products Inc. - Pyro-Guard
2. Approved equal.

C. Where two or more units of the same class of equipment are furnished in same Section of Specifications, provide each from the same manufacturer. Furnish equipment and materials new and free from defects of size, make, type and quality herein specified, or as reviewed.

D. Work shall be installed in a neat and workmanlike manner. Raceway installations shall parallel exterior and interior walls and be level. Vertical runs shall be plumb.

E. Capacities, dimensions, or sizes specified or indicated are minimums, unless otherwise stated. Tolerances used in rating or testing standards specified shall not be allowed in determining capacities of equipment.

F. Materials shall be listed by the Underwriters' Laboratories, Inc. where applicable and shall be manufactured in accordance with applicable standards established by ANSI, NEMA, ASTM, and IEEE.

G. Any products judged not in accordance with the Specifications either before or after installation will be rejected. Costs associated with rejection shall be paid by this contractor.

H. Where products are specified with no reference to a particular manufacturer's product, the product used

shall meet or exceed industry construction and testing procedure standards applicable to the product, for life expectancy, performance and safety.

I. Where electrical products are a fabricated assembly, the fabricator shall assume responsibility for correct operation of the entire assembly and of its individual components.

J. Tools: Provide special tools for proper operation and maintenance of the equipment.

K. It's the responsibility of the Electrical Contractor to provide clean electrical equipment which is free from dirt, paint, blemishes or markings. Scratches to equipment or enclosures shall be touched up with factory-color paint matching field color. Acceptance to restoration shall be to the satisfaction of the Architect.

L. Required device or equipment adjustments shall be made by EC before and after equipment is in operation throughout the warranty period.

M. Job site cleanliness and site safety of the removal of electrical generated trash or debris is the responsibility of this contractor. All job site safety rules, regulations and requirements shall be followed and maintained.

2.2 IDENTIFICATION

A. Switchgear, panels, relays, terminal control cabinets, junction boxes, contactors, circuit breakers, safety switches, motor starters, and similar items shall be identified with a single nameplate. Nameplates shall be laminated phenolic with white surface and black core (red surface for emergency and white core). Use 1/16" thick material for plates up to 2" x 4" and 1/8" thick for larger sizes. The lettering shall be condensed gothic with space between the lines equal to the width of the letters.

B. Nameplate shall read as follows:

1. First line shall be 1/2 inch letters stating panel/equipment name.
2. Second line (if applicable) shall be 1/4 inch letters stating the existing panel name in parentheses ( ).
3. Third line shall be 1/4 inch letters stating voltage/phase.
4. Fourth line shall be 1/4 inch letters stating breaker number, panel number, and final room name/room number from which it is fed.
5. Fifth line shall be1/4 inch letters stating function and/or equipment which it controls.

C. Names and numbers shall coincide with those listed within Contract documents unless altered by Owner descriptors.

D. Nameplates shall be secured with screws, a minimum of one on each end.

E. Label receptacle plates with identification showing panel and breaker number from which it is fed. Labels shall be made using the Dymo RinoPro or an equivalent system.

F. Label junction boxes and pull boxes, showing circuit numbers contained in the enclosure. Use an approved marking device as noted.

G. Label wire with an identification tag showing panel and breaker number from which it is fed at splices, junctions, and terminations as explained in this specification.

H. Label fire alarm device bases with identification showing device address number assigned by fire alarm system manufacturer. Labels shall be made using the Dymo RinoPro or equivalent system.

I. Branch breakers shall be labeled by Owner provided room numbers and descriptors.

2.3 ANCHOR BOLTS

A. Provide and set in place, at the time of pouring of concrete foundations, necessary anchor bolts as required

for the equipment called for under these specifications. Anchor bolts shall be of the hook type, of proper size and length to suit the equipment. Anchor bolts shall be set in pipe sleeves of approximately twice the bolt diameter and one half the embedded length of the bolt. Assume full responsibility for proper emplacement of the bolts.

2.4 INSERTS

A. Provide inserts of an approved metallic type for hangers. Where two or more parallel conduits are installed, continuous inserts may be used. Where required to distribute the load on the inserts, a piece of reinforcing steel of sufficient length shall be passed through the insert.

2.5 SLEEVES

A. Provide sleeves in all roofs, floors, and any fire-rated walls. Each sleeve shall extend through its respective floor, wall or partition and shall be cut flush with each surface unless otherwise required.

B. Sleeves in bearing and masonry walls, floors and partitions shall be standard weight steel pipe finished with smooth edges. For other than masonry partitions, through suspended ceilings, and for concealed vertical piping, sleeves shall be No. 22 USG galvanized iron.

C. Sleeves shall be properly installed and securely cemented in place.

D. Floor sleeves shall extend 1 inch above the finished floor, unless otherwise noted. Space between floor sleeves and passing conduit shall be caulked with graphite packing and waterproof caulking compound.

E. Where conduits pass through waterproofed floor or walls, design of sleeves shall be such that waterproofing can be flashed into and around the sleeves.

F. Where conduits pass through roofs, sleeves shall be installed and flashed and made watertight by the General Contractor unless otherwise specified or shown within Contract documents.

G. Sleeves through exterior walls below grade shall have the space between conduit and sleeve caulked watertight using an approved method.

2.6 FIREPROOFING

A. Where sleeves, ducts, cable trays, or other penetrations pierce floors or walls having specific fire ratings, the space between the sleeves and passing conduit shall be fireproofed with an approved UL listed fire proofing assembly. Installation method shall be per manufacturer's recommendations and approved by the Associate.

B. Reference Division 7, section “Through-Penetration Firestop System”.

2.7 WIRE GAUGE

A. The sizes of conductors and thickness of metals called for herein or within other Contract documents shall be understood to be American Wire Gauge.

2.8 MISCELLANEOUS METAL AND STRUCTURAL STEEL

A. Scope of Work: Furnish labor, materials, equipment and services necessary for the installation of miscellaneous metal and structural steel work required to complete this contract. Erect structural steel required for the proper support of equipment required under this contract.

B. Supports, brackets, and clamps and other items specified herein shall be installed in strict accordance with the best practices and recognized code.

C. Materials: Structural steel members required under this part shall conform to ASTM Standard Specification

A-7. Other materials shall be as specified hereinafter.

D. Priming: steel and iron work shall be primed with Rust-Oleum 769 or approved equivalent. Before priming, metal shall be thoroughly cleaned free from scale, rust and dirt.

E. Anchors: Provide anchors, bolts, screws, dowels and connecting members, and do cutting and fitting necessary to secure the work to adjoining construction. Build in connecting members to masonry, concrete and structural steel as the work progresses.

F. Supports and Brackets: shall be neatly constructed to structural shapes to adequately support the equipment intended. Supports must be approved prior to installation. Attention is directed to the proper rigid support required for conduit. Field conditions shall regulate the type of support required.

G. Reference Division 7, Section "Spray fire-resistive Material" for coordination of hangers an applicable supports.

2.9 VIBRATION ISOLATION MOUNTS

A. Provide vibration isolation mounts for all substations, power centers, transformers or equipment subject vibrations in accordance with this or other applicable sections.

2.10 GRADING, FERTILIZING, AND SEEDING

A. Provide labor, materials, equipment, and services required to strip and store topsoil, replace topsoil, and rough and finish grade and fertilize and seed areas disturbed beyond the work area of the General Contract. Topsoil must be stored where directed on the site.

B. Reference Division 31, "Earthwork" for backfill and compaction requirements.

2.11 MOTORS

A. Motors shall be built in accordance with the latest standards of NEMA and as specified. Motors shall be tested in accordance with ASA C50 and conform thereto with respect to insulation resistance and dielectric strength.

B. Each motor shall be provided with conduit terminal box and adequate starting and protective equipment as specified or required. The capacity shall be sufficient to operate associated driven devices under conditions of operation and load and without overload, and shall be at least the horsepower indicated or specified. Each motor type shall be premium energy efficient and of quiet operation.

C. Motor starting equipment must be selected so that starting currents or transients do not have an adverse effect on lighting or other electrical equipment. This contractor shall provide devices or equipment required to snub or eliminate such electrical disturbances.

D. Motors shall be verified for proper rotation prior to service of equipment.

E. Motors connected to inverter controllers shall comply with the requirements of Division 23 Specification 230513 "Common Motor Requirements For HVAC Equipment" when included in Contract Documents.

F. Motors shall comply with Energy Independence and Security Act of 2007.

1. Motors shall comply with NEMA MG 1 table 12-11 and 12-12 unless noted otherwise.

G. Motors connected to inverter controllers shall be inverter rated containing shaft mounted grounding protection ring such as AEGIS bearing protection ring.

PART 3 - EXECUTION

3.1 GENERAL

A. Provide information to the General Contractor for any chases or openings required under this Contract. No cutting shall be done which may affect the building structurally or architecturally without the prior approval of the Associate. Damaged construction shall be restored to its original conditions and finished to match the surrounding work. Refer to "Supplementary General Conditions" for the disposition of Cutting and Patching.

B. Grades, elevations, and dimensions shown on the drawings are approximately correct; however, field check and otherwise verify such data at the site before proceeding with work.

C. The Contractor shall be entirely responsible for apparatus, equipment, and appurtenances furnished by him or his subcontractors in connection with the work and special care shall be taken to protect parts thereof in such manner as may be necessary or as may be directed. Protection shall include covers, crating, sheds or other means to prevent dirt, grit, plaster or other foreign substances from entering the working parts of machinery or equipment. Special care shall be taken to keep open ends of pipes closed while in storage and during installation. Where equipment must be stored outside the building, it shall be totally covered and secured with heavy weatherproofing tarps and kept dry at all times. Where equipment has been subjected to moisture, it shall be removed from the site and replaced with new equipment. Protect open excavating until covered over.

D. Due to the schematic nature and small scale of the electrical drawings, it is not possible to indicate exact locations, offsets, fittings, access panels, pull boxes, and miscellaneous parts which may be required to form a complete system. The drawings are generally indicative of the work to be installed. Arrange work accordingly furnishing necessary parts and equipment as may be required to meet the various conditions and to provide a complete circuit from end use device to circuit protective device in panel.

E. Within thirty (30) days after acceptance of bids, submit to the Associate for approval, a complete list of equipment and materials to be furnished under this contract, giving names and addresses of manufacturers and material cut sheets they intend to furnish.

3.2 CLEARANCES

A. Take caution when routing conduit and location of equipment. In many cases, ceiling (plenums) clearance is limited due to ductwork and other mechanical lines, systems and structural steel. The Contractor shall be responsible for routing around mechanical equipment and ducts in order that everything can remain concealed in finished areas.

3.3 CUTTING AND PATCHING

A. Provide cutting and patching necessary to install the work specified herein. Patching shall match adjacent surfaces. Refer to Section 01731, Cutting and Patching, for specific direction.

B. No structural members shall be cut without prior approval of the Associate, and such cutting shall be done in a manner directed by the Associate.

C. Provide ceiling removal and replacement where work above finished ceilings is required. Replace ceiling components damaged in the process.

D. Provide patching where electrical devices are removed from or through walls, ceilings or floors.

3.4 PAINTING

A. Finished painting shall be performed by this Contractor except for standard factory finishes.

B. Electrical motor's, pump casings, and other similar items shall be provided with three coats of machinery enamel at the factory, and shall be carefully cleaned, rubbed down, and oiled after installation.

3.5 LOCATIONS

A. Apply for detailed and specific information regarding the location of equipment as the final location may differ from that indicated on the drawings. Outlets, equipment or wiring improperly placed because of failure to obtain this information shall be relocated and re-installed without additional cost to the Owner. Determine the actual direction of door swings, so that local switches and other controls shall be installed at the lockside of doors, unless otherwise noted. Improperly located switches shall be relocated without additional cost to the Owner.

B. The design shall be subject to such revisions as may be necessary to overcome building obstructions. No changes shall be made in location of outlets or equipment without written consent of the associate.

C. Unless otherwise mentioned or indicated, mounting heights of outlets are shown on the drawings or in the specification. Dimensions given shall be considered to be from center of outlet to finished floor.

D. Coordinate the exact location and elevation of all electrical devices and fixtures with the architectural interior elevation plan and reflective ceiling plan prior to installation.

E. Properly rough in for the electrical conduit and equipment under this contract and modify as required for coordination during the construction period.

3.6 RECORD DRAWINGS

A. During the construction period, maintain in good order a complete set of as-built electrical contract drawings. Record the actual electrical installation as the work progresses. Include changes to the contract and to equipment sizes and types. Keep these drawings available at the site at all times for inspection.

B. Take proper caution against the use of superseded drawings. Check such copies and mark "void." Where drawings have been corrected by memorandum, assume the responsibility for marking all drawings so affected with the changes; such marked drawings shall remain in use until revised drawings are issued.

C. At the conclusion of the work, provide to the Associate a complete set of drawings which indicate precisely how the electrical system, single line, and riser diagram equipment has been installed. Return such reproducible drawings within 30 days to the Associate.

3.7 EQUIPMENT, FOUNDATIONS, SUPPORTS, PIERS AND ATTACHMENTS

A. Provide necessary foundations, supports, pads, bases and piers required for equipment specified in this division; submit drawings in accordance with Shop Drawing Submittal requirements prior to the purchase, fabrication or construction of same.

B. Provide concrete pads for base-mounted transformers and Electric Contractor provided rotating equipment and for other floor mounted electrical equipment. Pads shall be extended 6 inches beyond matching base in all directions with top edge chamfered. Inset 6 inch steel dowel rods into floors to anchor pads.

C. Construction of foundations, supports, pads, bases and piers, where mounted on the floor, shall be of the same materials and same quality of finish as the adjacent and surrounding floor material.

D. Equipment shall be securely attached to the building structure in an approved manner. Attachments shall be of a strong and durable nature and any attachments that are, in the opinion of the Associate, not strong and durable shall be replaced as directed. Reference Division 3 "Concrete".

3.8 SCAFFOLDING

A. Furnish and erect scaffolding and ladders required in the installation of wiring, raceways, cable tray, equipment and lighting fixtures.

3.9 ENVIRONMENTAL AIR PLENUMS

A. In spaces over suspended ceilings which are used for environmental air handling purposes as defined by Article 300.22C of the National Electric Code, power, data and communications cables must be in conduit or of the type cable rated for air plenum use. This Contractor shall be responsible to clearly define ceiling space used for environmental air purposes, provide material and installations meeting installation environment.

3.10 HAZARDOUS LOCATIONS

A. In hazardous locations as defined by Article 500 of the National Electrical Code, electrical work installed in these areas shall be installed in accordance with the requirements of Article 500 whether specifically called for or not. Fixtures, fittings, and devices shall be installed according to, be rated for area of installation and meet requirements of binding code, including devices, seal offs, etc. Determine such areas as defined by the NEC and NFPA and conform to requirements of the enforcing agencies.

END OF SECTION 260500

SECTION 260512 - ELECTRICAL POWERED EQUIPMENT

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION

A. This section of the specifications describes the principal electrical work related to the installation, connection, and control of electrical powered equipment furnished under other divisions. Should examination of related effort indicate discrepancies or omissions, request clarification prior to bidding, performing or omitting any required work.

B. Examine Contract documents and other divisions of these specifications to ascertain the extent of powered equipment covered by the drawings and specifications and the method by which each item of equipment shall be furnished, delivered to the site, installed, and the amount of electrical work which shall be included with the powered equipment. Verify the voltage and frequency requirements of electrical equipment as it is delivered to the site. If voltage and frequency are not compatible with the building electrical system, immediately inform the Associate in writing. Particular attention is called to the following items:

1. Mechanical equipment

2. Specialized equipment

3. Owner furnished equipment

C. Definition:

1. Wiring: Contactors, conduit, enclosures, connections, labor and miscellaneous material required to supply power to powered equipment and associated controls for proper operation.

D. Motor Installation and Connections: utility motors such as fans, pumps, etc., are furnished under applicable sections of specifications. Those not provided as an integral part of the mechanical equipment, shall be delivered to this contractor at the point of installation. Receive these motors, handle, store (if required), and provide power wiring, including a phasing rotation check for applicable motors. Connect each motor to a separate branch circuit, feeder and include disconnecting means except where noted. Terminate conduit to motors in final connection with liquid tight flexible conduit. Equipment frames shall be bonded per National Electrical Code.

E. Control Devices and Wiring: Control devices (such as pressure switches, floats, electrodes, P.E. switches, E.P. switches, relays, thermostats, etc.), prewired in packaged type equipment and/or control panels shall be provided by the appropriate contractor. Provide required interlocking control, time delay relays, control transformers, break-glass stations, remote pushbuttons required to perform functions indicated within Contract documents including requirements of local authorities.

F. Verify motor rotation for equipment before it is turned over to other Contractors or Owner.

G. Furnishing and installation of control devices, control panels, and control wiring for HVAC equipment shall be provided under Division 23.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Refer to other related sections of Division 23 for applicable materials. Particular attention is called to the following sections:

1. Section 262813, Fuses

2. Section 262913, Motor Starters

PART 3 - EXECUTION

3.1 ELECTRICAL WORK FOR MECHANICAL EQUIPMENT

A. Motors and Motor Controls: Pre-wired packaged type equipment, control devices, control panels and alarm panels for Mechanical Work, shall be furnished and installed under other sections of the specifications and wired under this section of the specifications, except as otherwise noted. Control devices which have piping connections shall be installed under other sections of the specifications. Where wall space is not available, provide suitable primed and painted angle iron framework supports for mounting of starters and controls. Power wiring shall be provided to motors, starters, variable frequency drives, consoles, and each refrigeration machine, electric boilers, and auxiliaries. Perform required adjustments, wiring modifications, in conjunction with any testing and operational system start-up procedures. In general, starters, disconnects, switches and fuses shall be furnished under Division 23 and wired under this division.

B. Responsibility: Electrical work specified in Division 23 as "by the Electrical Contractor" is an obligation of this contractor, the same as if specified herein.

1. Electric Heaters (Plumbing or HVAC): electric heaters are furnished under other Sections. Provide power wiring at heaters. Thermostats for heaters furnished under other sections.

2. Control Wiring for HVAC Systems: control wiring of HVAC equipment shall be under Division 23 unless noted otherwise.

END OF SECTION 260512

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SECTION 260519 WIRES & CABLE

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions, General Requirements, Division 1 Specifications, apply to this Section.

1.2 DESCRIPTION

A. Provide all wires and cables in accordance with the Contract Documents for service, feeders, branch circuits, lighting, systems, egress, control wiring and telecommunications.

B. This section includes cable requirements for systems below 600 volt insulation.

C. Conductors shall be soft drawn stranded copper having conductivity not less than 98 percent.

D. Aluminum conductors are not allowed.

E. All wiring and cables shall be installed in raceway unless otherwise noted.

F. Conductors shall be insulated for minimum of 600 volts. Motor conductors (T-leads) controlled by variable frequency drives shall have a minimum rating of 1000 volts for voltages over 240v.

G. All conductors shall be U.L. labeled and installed in accordance to the NEC.

H. Insulation types are the type referenced in NEC.

PART 2 - PRODUCTS

2.1 600 VOLT WIRE OR LESS

A. Conductors shall be “UL” approved stranded copper with a minimum insulating rating of 600v.

B. Manufacturers:
   1. Southwire Company
   2. General Cable Corporation
   3. American Insulated Wire Corporation
   4. Approved Equal.

C. Type of conductor insulation for general use shall be as follows, subject to limitation listed:
   1. Type THW – no restrictions
   2. Type THHN/THWN – restrictions as follows:
      a. Do not use for conductors in/under slab.
      b. Do not use in wet locations.
   3. Type XHHW – no restrictions.

4. Fixture wiring shall be single conductor, 600 volt, 200˚C, Type SF-2, stranded silicone rubber insulation with overall glass braid.

    a. Wiring routed within ballast trough shall be high ambient wire: single conductor, 600 volt, 125˚C minimum, Type SA stranded silicone rubber insulation with overall glass braid.

5. Fire alarm cable: EC to provide all power and signal circuits for the fire alarm system. Wire and cable requirements must meet NEC and that of fire alarm system Manufacturer. Refer to Specification 28 31 00 for cable types and usage.

2.2 TYPE MC CONDUCTOR CABLE

A. MC conductor cable usage is only approved for connections to ceiling grid mounted light fixtures (from overhead powered junction boxes). MC cable shall be constructed with insulated phase(s), neutral and one full size green conductors. Branch circuit type MC cable (14-6 AWG) shall use copper conductors. All MC conductors shall be type THHN/THWN-2 600v stranded.

B. Manufacturers:

1. AFC Cable System
2. General Cable
3. Alcan Cable
4. Southwire
5. Approved equal

2.3 PLENUM CONDUCTOR CABLE

A. Plenum conductor cable may be used for NEC Class 2 or 3 wiring if conductor cable is UL listed in accordance with UL 910 and UL 1820 and is installed in accordance with the NEC and is acceptable to the Authority having jurisdiction. Insulation types, UL listing, and written acceptance by the local authority shall be submitted for review.

B. Installation of cables shall be installed in a neat and workmanship like manner. Cables shall be supported conforming to the requirements of the latest edition of National Electrical Code and Electronics Industries Association and Telecommunications Industries Association.

2.4 CONNECTORS & LUGS

A. See Specification 262730 “Taps, Splices & Terminations”

2.5 ADJUSTABLE FREQUENCY DRIVES (AFD/VFD)

A. Motor Conductors for voltages greater than 240v and length exceeding 45ft from AFD/VFD:

1. Cable characteristics:

    a. As recommended by AFD manufacturer and meet minimum requirements: UL standard 44, 1277, MSHA & TC-ER approved, 600-1000 volt rated, 90˚C, XLPE insulation with copper tape shield with symmetrical grounds. Wire gage sized per NFPA 70-460.6(A).

    b. Manufacturer:

        1) LAPPUSA Olflex VFD Symmetrical

2) SAB Associated Wire Products (SAB North America)

3) Belden - Large VFD Symmetrical Design

4) Approved equal

2. Bending radius: Electrical Contractor shall provide means of maintaining motor conductor minimum bending radius throughout protective raceway, pull boxes and terminations.

2.6 MOTOR TERMINATIONS

A. Motor branch conductors larger than #10 AWG shall be connected to the factory motor leads with compression type connector. Field wiring and factory wiring shall be terminated with individuals crimp type, single indent terminal lugs. Crimp connections shall be sized fro the connecting wires, type and construction. Individual connections shall be joined through bolting with a combination of bolt, nut, flat and locking washer.

B. Conductive motor terminals shall be insulated and sealed with factory engineered motor connection kits. Connection kits shall be rated for voltage, insulation class and dielectric strength. Connection kits shall be rated for 90˚C continuous conductor operation. Motor connection kits shall be equal to type RVC or MCK as manufactured by Raychem Corporation or equal by 3M or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide circuit wiring complete as shown as called for within Contract documents, and as hereinafter specified or required. The minimum size of wire for branch circuits shall be No. 12, except 120 volt circuits over 100 feet in length shall be No. 10; 120 volt circuits over 150 feet in length shall be No. 8. Wiring shall be increased in size if so demanded by wattage of load.

B. Voltage drop calculations shall be performed by the electrical contractor. Conductors sized shall be increased where branch circuit calculations result in a voltage drop greater than 3%.

C. 600 volt wiring shall be color coded. Consistent phase identification of wires from service feeders to branch circuit wires shall be maintained as follows:

1. 120/208 volts - Normal - Phase A ..... Black
2. 120/208 volts - Normal - Phase B ..... Red
3. 120/208 volts - Normal - Phase C ..... Blue
4. 120/208 volts - Neutral ..... White
5. 120/208 volt - Ground Wire ..... Green
6. 277/480 volt - Phase A ..... Brown
7. 277/480 volt - Phase B ..... Orange
8. 277/480 volt - Phase C ..... Yellow
9. 277/480 volt - Neutral ..... Grey

D. Fire alarm wiring or cable color coding shall be RED or per manufacturer’s recommendation.

E. Labeling: Electrical contractor shall identify each termination via a permanent printed type “Brady” wire marker as noted.

F. Do not pull wires into raceways until raceways are permanently in place, thoroughly clean, and termination points are not subject to damage. Usage of pulling lubricants shall be applied sparingly.

G. Do not use uninsulated wire conductors.

H. Provide excess free conductor end length at termination points, adequate to make up splices and terminations, permitting neatly training conductors, and in any case not less than:

1. No. 14 through 10 AWG - 8 inches
2. No. 8 or 6 AWG - 12 inches
3. Larger than No. 6 AWG - 18 inches

I. Support vertical cables as required by Code. Use lock type cable support bushings having internal wedges and retaining collars. Locate support points in readily accessible pull boxes sized to code requirements.

J. Control circuit wiring in cabinets, panels, pull boxes, etc., shall be tied, bundled and held with Thomas & Betts Nylon Self-Locking Ty-Raps, or approved equal.

K. Large equipment pull, junction or terminal boxes shall contain suitable racks to support, arrange, and retain wire and cable in an orderly manner.

L. Equipment conductors smaller than No. 4 AWG, in wireways, gutters, pull boxes, terminations, etc., shall be identified with wire markers. Designate panel and circuit number on each individual marker.

M. Feeder or equipment conductors No. 4 AWG or larger, shall be individually identified with metal, fiber or fireproof linen tags or with wrap around markers. Designate panel circuit number on each individual marker. In addition, designate use of each set of conductors on a common tag or on each individual conductor marker. Tagging shall include panel source and feeder size of equipment supply.

N. Switchboard and distribution panelboards with ratings greater than 10,000 RMS symmetrical amperes shall have supply cables braced in accordance with board manufacturer bracing requirements where such panels are approved for bracing.

1. Wrapping of cables: Wrap line cables together with nominal 3/8-inch nylon rope or rope having a minimum tensile strength of 2000 pounds at 6 inches and 12 inches from the line terminals with minimum of five non-spaced wraps.
2. For electrical equipment that is not clearly marked as to whether or not cable bracing is required, contact the Manufacturer's representative.

O. Where the single pole work is used on branch circuits, circuit wiring shall have a dedicated neutral conductor. Do not gang or share neutrals. The Contract documents are schematic and diagrammatic and indicate the general method of installing circuit wiring and the outlets which are to be supplied.

P. Lighting and convenience outlet circuiting are indicated on the Contract documents separately as single pole work for clarity; however, the Electrical Contractor shall provide a minimum of 20 percent spare future capacity in each raceway.

Q. All branch circuits shall have a dedicated neutral conductor. Sharing neutrals is not permitted.

R. The minimum sizes of wire on an installation shall be as follows:

Emergency and Exit Circuits .....10 AWG

Lighting and Power Circuits .....12 AWG

Signal Circuits - with common or individual leads .....14 AWG

Remote Control Leads	As recommended by manufacturer
Low Voltage Light Control, Communication,	Twisted Pair, Shielded or as recommended by manufacturer
Data, and Fire Alarm Systems	Shielded or recommended by manufacturer
Fixtures	14 AWG Min. SF-2 and as required by Underwriters Laboratories and National Electrical Code

S. Install in each empty interior conduit, one nylon measuring fish line for the future installation of wire or cables.

T. Great care shall be exercised in pulling wires into the conduits so as not to injure the insulation. Only UL approved lubricants shall be used to assist in the pulling in of wires with an outer covering or braid.

U. Where switch boxes are used as the termination of the "home runs" in addition to the switch legs, not less than a two-gang box shall be used.

V. The size and general location of the various feeders or branch circuits are approximately shown. However, the electrical contractor shall determine and coordinate the exact location and routing at the site.

W. Seal around conduits penetrating fire-rated elements according to Division 7, Section "Through-Penetration Firestop Systems".

X. Communications, sound, dimming, fire alarm, data and other low voltage wiring shall be of size by the manufacturer of the equipment being served and cable type as required by the National Electrical Code.

Y. Branch circuits to be connected as numbered within Contract documents. Prior to energizing, test cable and wire for continuity of circuitry, and also for short circuits. Correct malfunctions when detected.

Z. In every pull or splice box and all other places where wires and cables may not be readily identified by nameplate on the equipment to which they connect, each circuit shall be identified with a permanent identification tag securely fastened to the conductors.

END OF SECTION 260519

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SECTION 260526 GROUNDING & BONDING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION

A. Provide all system equipment and static grounding in accordance with the Contract Documents and in full compliance with the latest edition of National Electrical Code, and the Authority having jurisdiction. Grounding requirements specified in this section may be supplemented by special requirements of systems described in other sections such as Section 27 10 00 “CABLE”.

B. Ground every device and metal part of the electrical system including all enclosures, fixtures, boxes, feeders and branch circuits over 40 volts shall include a copper grounding conductor sized in accordance with NEC Table 250.122 except not smaller than #12 for power and lighting circuits and #14 for control circuits.

1. All equipment ground conductors shall have green colored insulation.
2. Isolated ground conductors shall have green colored insulation with yellow stripe.
3. Feeders to have alternating, three (3) green and two (2) yellow bands of tape.

C. Maintain continuity of system and equipment grounds throughout the electrical installation unless specifically shown otherwise. Provide ground bushings and jumpers where normal metallic ground paths are interrupted or unreliable.

D. Grounding shall be accomplished by means required by NEC and generally outlined in the subsequent paragraphs.

E. Grounding shall be connected to the water feed service pipe such as water heater and piping systems likely to become energized. Install a separate equipment grounding conductor to each electric water heater or heat-tracing system complying with manufacturer’s installation specifications. Bond conductor to heater units, piping, connected equipment and relevant components.

F. All electrical equipment, cabinets, boxes, conduit, metal fixture poles and metal raceways shall be grounded in accordance with the NEC and as specified herein.

G. All connections to apparatus and conduits shall be made with an approved UL type of bolted or compression connector. Connectors shall be securely fastened to the equipment. All contact surfaces shall be thoroughly cleaned and bright before connections are made in order to insure a good metal-to-metal contact.

H. All underground ground cable splicing or connections shall be exothermic welded.

I. Tie all grounding systems together at their origins and as called for by the NEC or authority of jurisdiction.

J. A solid ground shall be provided for the complete conduit system, feeder neutrals, motor frameworks, transformer cases, neutral of 480 volt and 208 volt building services, heating equipment enclosures, telecommunications and other items as required.

1.3 GROUNDING SYSTEM

A. Grounding electrodes shall be installed and interconnected according to NEC Article 250.50.

1. Bond water supply piping system in accordance with NEC Article 250.52

2. Per NEC Article 250.52(A)(3), provide a concrete-encased foundation electrode and bond to other electrodes per NEC.
3. Provide building ground ring with connections to structural steel columns in accordance to NEC Article 250.52(A)(4) at locations as shown within Contract documents. Steel columns shall be connected to the grounding electrode system with bare stranded copper where shown on contract documents or required by NEC or Authority having jurisdiction. Size bonding conductor in accordance to NEC Article 250. Connections to steel columns shall be made above grade using exothermic connection within web of column.

B. Provide insulated copper grounding conductors in conduit for metal water service pipe from building's main service equipment, or grounding bus, to main metal water service entrance. Connect grounding conductors to main metal water service pipes by approved grounding connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

C. Where installed, vertical drops from the lightning protection loops shall be connected at points located on the lightning protection plan(s). Drops shall connect first to a driven ground rod outside building then to ground loop.

D. Individual grounding risers for power, data/communications, security, and fire alarm closets shall be of wire type and sized as required by manufacturer or as specified elsewhere in specifications. Telecommunication bus bar shall be provided by this contractor and installed per BiCSi and EIA/TIA standards.

E. Where any ground conductor required protection from physical damage, route conductor through a non-ferrous conduit or a steel conduit that's bonded at both ends.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Ground conductors shall be of size indicated or required by code.

B. Ground rods shall be copper-clad steel, 3/4 inch diameter and 10 feet long.

C. Connectors shall be as manufactured by Burndy, O.Z. Gedney, or Erico.

D. Exothermic welding shall be Erico, Burndy, or O.Z. Gedney.

E. Accessible connections shall be made with multiple bolt silicon bronze connectors specifically designed and approved for the connection to be made.

F. Lighting fixtures shall be grounded by the use of a manufacture-supplied ground lug or pigtail or by the use of manufacture approved ground connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The neutral wire for the electrical system shall not be used to ground miscellaneous conduits.

B. Ground wires required by the National Electrical Code shall be installed.

C. The resistance between the grounding system and absolute earth shall not exceed values as specified and shall be measured in the presence of the Owner's representative.

D. The equipment grounding terminal bars of the normal and emergency electrical system panel boards shall be bonded together with an insulated continuous copper bonding jumper not smaller than No. 6 copper or otherwise shown within Contract documents.

E. Steel columns

F. Electrically continuous metal raceway system shall not be used as the primary grounding or bonding conductor. A separate continuous grounding conductor shall be carried throughout the raceway system.

3.2 EQUIPMENT GROUNDING

A. Conduit system shall be electrically continuous. All locknuts shall cut through enameled or painted surfaces on enclosures. Where enclosures and non-current carrying metals are isolated from the conduit system, use bonding jumpers with approved clamps. Where reducing washers are used and where concentric or eccentric knockouts are not completely removed, bonding bushings shall be required. Conduit crossing building expansion joints shall have provision for maintaining ground continuity.

B. Cable shielding, metallic conduits, wireways, cable boxes, electrical equipment housings and all noncurrent carrying metallic parts shall be grounded. Run a separate ground wire to all equipment.

C. All conduit stub-ups shall be grounded and where multiple stub-ups are made within an equipment enclosure, such as a switchboard, conduits shall be equipped with grounding bushings and bonded together and to the enclosure ground bus.

D. Provide bonding devices, fittings or jumpers at expansion fitting, isolation sections or wherever continuity of ground is broken.

E. Install all grounding conductors with sufficient slack, to avoid breaking due to settlement or movement of conductors or attached points. Installation of bonding straps or jumpers shall be provided for vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

F. Motors shall be grounded by means of a grounding conductor located in the same raceway with the motor feeder connected to a grounding bushing at the motor terminal box and the ground bus from source of power or to the incoming conduit grounding bushing of an individually mounted motor starter.

G. Where flexible medal conduit is used for all or part of a conduit run, except lighting branch circuits, a grounding conductor shall be provided in the conduit and connected to grounding bushings at each end of the run.

H. Usage of steel core Liquid-Tight conduit shall have an exterior spiral wrapped green THHN bonding conductor terminating to external type grounding fittings using a minimum green #10 copper conductor.

I. Under no circumstances shall a neutral conductor or neutral bar in an enclosure be used for grounding purposes.

3.3 FEEDER GROUNDING

A. Run a separate insulated ground for feeders.

B. Size grounds in accordance with the NEC or as noted within Contract documents whichever is more stringent.

3.4 FIELD QUALITY CONTROL

A. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.

B. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two (2)

full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 8l.

C. Provide to Architect of record plan drawings locating each ground rod and ground rod and ground rod assembly and other grounding electrodes, identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

1. Equipment Rated 500 kVA and Less: 10 ohms.
2. Equipment Rated 500 to 1000 kVA: 5 ohms.
3. Equipment Rated More Than 1000 kVA: 3 ohms.
4. Substations and Pad-Mounted Switching Equipment: 5 ohms

D. Excessive Ground Resistance: If resistance to ground exceeds specified values, suitable and approved methods to reduce ground resistance shall be provided by this contractor.

END OF SECTION 260526

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SECTION 260529 - SUPPORTING DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

B. Reference Division 7, section “Spray Fire-resistive Material” for coordination of all hangers or applicable supports.

1.2 DESCRIPTION

A. Provide products to suspend, attach, support and otherwise retain in location, electrical work.

1. The specified requirements herein include support and hardware information of a general nature. Where additional requirements are stated elsewhere in the specification related to specific products and conditions, such additional requirements shall supersede these general specifications.

B. Approvals: Obtain approval before cutting, drilling, or welding to, structural members. Where cutting, drilling, or welding is permitted, this work, as required for product support, is a part of product installation electrical work.

C. Welding: Use certified welders for welded installation. Steel in weld area shall be cleaned before and after welding operations, and refinished after welding.

1. Do not weld raceway pipe straps to structure.
2. Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.3 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."

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use expansion shield anchors or toggle bolts of the following manufacturers:
1. Phillips Drill Company, Inc. "Red Head Self Drilling"
2. Rawl Products Company "Saber Tooth"
3. McCulloch Industries "Kwik Bolt"

B. 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. Cooper B-Line, Inc.; a division of Cooper Industries.
   b. Thomas & Betts Corporation.
   c. Unistrut; Tyco International, Ltd.
2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
5. Channel Dimensions: Selected for applicable load criteria.

C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1) Hilti Inc.
        2) MKT Fastening, LLC.
        3) Simpson Strong-Tie Co., Inc.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
        1) Cooper B-Line, Inc.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti Inc.
        4) ITW Ramset/Red Head
        5) MKT Fastening, LLC.
3. Mechanical Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

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.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: 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. Touchup: Comply with requirements in Division 09 Section "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 INSTALLATION

A. Provide common support trapezes for parallel raceways.

B. Use manufactured preformed U-Channel system having accessory connecting and clamping devices available where parallel raceways are to be supported. Load channel system not to exceed manufacturer's recommendation.

C. Fabricate supports for transformers, panel boards, cable tray, lighting fixtures, cabinets, pull and junction loads, and similar electrical products from preformed U-Channel systems. Load on channel system not to exceed manufacturer's recommendations.

D. Support panelboards, disconnect switches, telecommunications, equipment, security, fire alarm panels, grounding bars and all other wall mount electrical equipment via ¾" primed and fire treated plywood. Electrical equipment shall be mounted on said plywood in computer, telecommunication or electric rooms unless noted otherwise.

E. Use preformed U-Channel concrete inserts preset into forms to secure hangers suspended from slabs.

F. Use concrete expansion shield anchors or preformed U-Channel cast-in-place concrete inserts for attaching electrical products to concrete walls.

G. Support loads from stud anchors or concrete inserts at not to exceed manufacturer's live loading recommendations.

H. Do not drill holes or install driven fasteners in concrete at less than 12 inches from prestressed steel.

I. Do not use nylon or similar concrete inserts without prior approval, except for supporting 1 inch or smaller individual runs of conduit or tubing.

J. Use toggle bolts to attach supports for electrical products to hollow masonry walls. Do not attach products weighing more than 50 pounds to hollow masonry walls, without prior approval.

END OF SECTION 260529

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SECTION 260533 - RACEWAY & BOXES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions, General Requirements, Division 1 Specifications, apply to this Section.

1.2 DESCRIPTION

A. Provide concealed or surface mount raceway as required to complete work indicated on the Contract Documents. Installed raceways shall be plumb and level. Raceways and backboxes shall be provided for Technology, Fire Alarm, Security and Other Trades in non-residential spaces.

1. Raceways and backboxes shall be “RED” in color for all fire alarm related wiring.
2. Raceways and backboxes shall be “YELLOW” in color for all emergency circuits derived from emergency panelboards as noted within Contract documents.

B. All wiring shall be in conduit unless otherwise noted. Conduit shall be concealed in finished areas and may be exposed in unfinished areas such as mechanical and electrical areas. Conduit runs shall be continuous from outlet to outlet, fitting, pull or junction box, to cabinet or panel; and shall be mechanically secured electrically continuous.

C. Minimum conduit size is 3/4”. Where required, maximum lengths of 3 feet of ½” flexible conduit may be used for connecting instruments, sensors or associated control components.

D. Provide outlet boxes in the raceway systems wherever required for pulling wires and cables, making connections, mounting devices, lighting fixtures, controls or connecting miscellaneous equipment. Boxes installed shall be level and flushed mounted within wall cavities/partitions for wall mount devices as noted on plans.

E. Certain backboxes for the fire alarm systems shall be supplied by the respective equipment suppliers. Any boxes required for the respective systems and not furnished by the respective equipment suppliers shall be furnished and installed. It is this Contractor's responsibility to determine what boxes are and are not furnished by the respective equipment suppliers.

F. EC to provide all backboxes for Mechanical, HVAC and Plumbing equipment power and/or control devices.

G. Provide plaster rings as required in gypsum board partitions.

H. Coordinate box sizes with other equipment supplier as required.

I. All boxes associated with plastic conduits shall be PVC boxes with cast aluminum covers, complying with NEMA OS2.

J. Unless otherwise noted, backboxes for telecommunication, technology and security devices shall have extra deep capacity with a minimum size of 4”x4”.

1.3 GENERAL

A. Wherever the terms "conduit" or "raceway" appear hereinafter it shall be understood to mean any one, or combination of, the following type:

1. Rigid Galvanized Steel
2. Electrical Metallic Tubing
3. Flexible Metallic Conduit

4. Square Steel Raceway Duct
5. Liquid Tight Flexible Conduit with External Wrap Ground Wire
6. Surface Mounted Raceway
7. Metal Duct Wireway
8. Intermediate Steel Conduit
9. PVC Coated Rigid Steel Conduit
10. Rigid Non-Metallic Conduit (PVC)

B. The electrical contractor shall precisely record location of all feeders on legible submitted “As Built” plans at end of project.

C. Conduits shall not be supported by wire ties. All components including backboxes, pull boxes, panels and the like shall be independently supported from raceway.

D. Backboxes shall be suitably sized for device mounting, splicing and contain required volume for entering conductors.

E. Cuts made to metallic supports, equipment or field made conduit threads shall be sprayed with "cold-galvanize" or equivalent rust protection prior to assembly. Electrical contractor shall not leave untreated metal exposed to weather.

1.4 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. Maintain required safe working clearances and required dedicated equipment space as defined by the latest edition of National Electrical Code.
2. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
3. To provide for ease of disconnecting the equipment with minimum interference to other installations.
4. To allow right of way for piping and conduit installed at required slope.
5. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed.

C. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping.

E. Coordinate backbox requirements for technology and telecommunication devices as specified in Division 27.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Rigid Steel Conduit

1. Smooth surfaced heavy wall mild steel tube, of uniform thickness and temper, reamed and machine threaded at each end and protected inside and out with galvanizing, sherardizing, or equivalent process. Rigid steel conduit shall comply with Article 344 of NEC.

2. Non permitted usage:
    a. Hazardous or corrosive environments.

B. Electrical Metallic Tubing (EMT)

1. Smooth surface, thin wall, mild steel tube, of uniform thickness and temper, galvanized or sherardized on the outside, and enameled on the interior. EMT shall comply with Article 358 of NEC.
2. Non permitted usage:
    a. Poured concrete.
    b. Exposed to weather.
    c. Underground.
    d. Exposed in mechanical or similar equipment rooms below 8ft from finish floor.
    e. Hazardous or corrosive atmosphere.

C. Flexible Metallic Conduit

1. Interlocking single strip, steel construction, galvanized inside and out, after fabrication. Conduit shall comply with Article 348 of NEC.
2. Allowed usage:
    a. Connection to lighting fixtures not over 3 feet in length.
    b. Narrow movable partitions where other raceways are not practical, when approved by Owner's representative.

D. Steel Square Raceway Duct

1. Square raceway duct shall be 4 x 4 inch minimum or sized as shown on plan. Duct shall be primed and finished gray baked enamel. Duct shall conform to Federal Specifications and have a hinged access cover on one side. Properly support from building. Complete with all necessary fittings.

E. Liquid Tight Flexible Conduit With Exterior Spiral Wound Ground Wire

1. Raceway with a circular cross-section having an outer liquid tight, non-metallic, sunlight-resistant jacket over an inner flexible metal core. Conduit shall comply with Article 350 of NEC.
2. Allowed usage:
    a. Connection to motors, controllers or panels located on dynamic equipment and transformers. All motor connections shall be water and dust tight with grounding lug fittings approved for wet location usage. Maximum length: 3 feet.

F. Surface Mounted Raceway

1. Surface mounted raceways shall be used only where existing block, existing concrete or other approved existing conditions preventing a concealed installation with sizes required by the National Electrical Code. Raceways shall be totally enclosed and shall be complete with sectional barriers, connectors, fittings, bridges, couplings, conduit adapters, clips, hangers, transition fittings and required device plates for a complete installation.
2. Surface mounted raceways shall be of one manufacture with finish and construction type of ivory unless noted otherwise.
3. Any unused openings to be closed by the Electrical Contractor with blank faceplates.
4. Raceways shall be installed in a neat and symmetrical manner using mechanical fasteners. Feeds to raceways shall be concealed in walls, unless prohibited by wall construction. Installation shall comply with Article 386 of NEC.

G. Metal Duct Wireways

1. Wireways shall be used only where indicated with usage for mounting groups of switches and/or starters. Wireways shall be the standard manufactured product of a company regularly producing wireway and shall not be a local/remote shop-assembled/fabricated unit.
2. Wireways shall be of screw or hinged-cover types, UL listed, and of sizes indicated or otherwise required by the NEC. Finish shall be light-gray enamel over rust inhibitor.
3. Wireways installed in interior spaces shall be NEMA 12 or 3R if installed in an exterior environment.
4. Wireways shall be routed, provided with all necessary components and sized by the Electrical Contractor to accommodate all cables and wires per NEC.

H. Intermediate Steel Conduit

1. Smooth surface, intermediate wall, mild steel tube, of uniform thickness and temper, threaded at each end, and protected inside and out with galvanizing or equivalent process. Conduit shall comply with Article 342 of NEC.
2. Non permitted usage:
   a. Hazardous or corrosive environments.

I. Rigid Non-Metallic Conduit (PVC)

1. Rigid non-metallic conduit shall be designed for installation below ground and with or without concrete encasement. Rigid non-metallic conduit shall comply with Article 352 of the NEC.
2. Limited usage:
   a. In or under concrete slabs on grade.
   b. Exterior use when encased in 3 inch concrete.

J. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

K. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

L. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
   b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

M. Outlet boxes specified herein refer generally to cast or pressed steel boxes of less than 50 cubic inch internal volume per gang. Refer to "Junction and Pull Boxes" for larger box specifications.

N. Outlet boxes where exposed to water or weather shall be approved for this use and shall be made of cast iron.

O. All exterior outlet boxes shall be watertight and dust tight with hinged gasketed covers similar to Thomas & Betts “WTD” Series, Crouse-Hinds or TayMac for two (2) GFCI outlets with integral lock and shall be cast aluminum and threaded for rigid conduit similar to Thomas & Betts “LT” Series. There must be a gasket between the enclosure and the mounting surface and between the hinge cover and the mounting base plate. Enclosure shall be marked “UL listed” and “Suitable for wet locations while in use”.

2.2 ACCEPTABLE MANUFACTURERS

A. Rigid Steel Conduit: O-Z/Gedney, Wheatland Tube, Allied Tube and Conduit.

B. Intermediate Steel Conduit:, O-Z/Gedney, Wheatland Tube, Allied Tube and Conduit.

C. Electrical Metallic Tubing: O-Z/Gedney, Wheatland Tube, Allied Tube and Conduit. Steel compression type only, concrete tight with non-insulated throat.

D. Flexible Metallic Conduit: ACME, International, Electri-Flex

E. Flexible Conduit, Liquid Tight: Anaconda "Sealtight," National Electric, Coleman Cable and Wire Company.

F. Steel Square Raceway Duct: Square D, Hoffman Engineering Company, Cooper B-Line.

G. Surface Mounted Raceway: Wiremold v700 series “ivory” or dual channel non-metallic 5400 series, “white” (unless noted otherwise within Contract Documents), Siemon or Panduit Corp.

H. Wireways: Hoffman, Hammond Manufacturing, Panduit or approved equal.

I. PVC coated rigid steel conduit; Occidental Coating Company, Robroy Industries, or equal.

J. Rigid Non-Metallic Conduit (PVC): Allied, Cantex, Prime Conduit

K. Pressed Galvanized Sheet Steel Boxes: Appleton Electric, Bowers Manufacturing Company, Steel City, or equal.

L. Cast Iron Boxes: Crouse Hinds, Appleton, Thomas & Betts, or equal.

M. Outlet boxes manufactured to provide mounting for special devices are specified with the product affected.

N. Outlet boxes for nonmetallic conduit: Carlon Electric Sciences, Inc.

O. PVC coated outlet boxes; Occidental Coating Company, Robroy Industries, or equal.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, non-corrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 USE

A. The following shall be used as a minimum guideline for the installation of raceways:

1. In metal stud and masonry walls:
    a. Electrical Metallic Tubing (EMT).
    b. Intermediate Steel Conduit (IMC).
    c. Rigid Steel Conduit.
2. Above plaster, drywall, lay-in and furred ceilings:
    a. Electrical Metallic Tubing (EMT).
    b. Intermediate Steel Conduit (IMC).
    c. Rigid Steel Conduit.
3. Where exposed in dry locations:
    a. Electrical Metallic Tubing (EMT).
    b. Intermediate Steel Conduit (IMC).

c. Rigid Steel Conduit.

4. Where exposed in dry locations of storage rooms, mechanical equipment rooms, electrical equipment rooms, etc.
   a. Intermediate Steel Conduit (IMC).
   b. Rigid Steel Conduit.
5. Feeders and service entrances encased in concrete:
   a. Rigid Steel Conduit.
   b. Rigid Non-Metallic Conduit (PVC).
   c. Rigid Poly-Vinyl Chloride (PVC) Coated Steel Conduit.
6. Branch circuits in direct contact with earth.
   a. Rigid Steel Conduit.
   b. Rigid Non-Metallic Conduit (PVC).
   c. Rigid Poly-Vinyl Chloride (PVC) Coated Steel Conduit.
7. Where installed in non-conditioned type areas such as parking garages, transformer vaults, loading docks, etc.:
   a. Rigid Steel Conduit. (RSC).
   b. Rigid Poly-Vinyl Chloride (PVC) Coated Steel Conduit.
8. All interior feeders in excess of 600 volts:
   a. Rigid Steel Conduit (RSC).
9. In short lengths (not to exceed 3'-0") for final connections to equipment subject to vibration:
   a. Flexible Metallic Conduit.
   b. Liquidtight Flexible Metallic Conduit (Sealtight).
10. In locations where structural or existing conditions prevent the use of rigid conduit, intermediate metallic conduit or electrical metallic conduit. (In cases where flexible conduit is used, prior written approval of the Owner's representative shall be required):
    a. Flexible Metallic Conduit.
11. Where exposed to weather on rooftops, sides of buildings, etc.:
    a. Rigid Steel Conduit (RSC).
    b. Rigid Non-Metallic Conduit (PVC).
    c. Rigid Poly-Vinyl Chloride (PVC) Coated Steel Conduit.
12. In short lengths for final connections (not to exceed 3'-0") to equipment subject to vibration and exposed to oil or moisture.
    a. Liquidtight Flexible Metallic Conduit (Sealtight).
13. For connections (not to exceed 3'-0") to kitchen equipment, lab equipment, etc.
    a. Liquidtight Flexible Metallic Conduit (Sealtight).
14. Branch circuits in direct contact with earth and under roadways.

a. Rigid Steel Conduit encased in concrete.

b. Rigid Non-Metallic Conduit encased in concrete.

c. Rigid Polyvinyl Chloride (PVC) coated steel conduit encased on concrete.

15. Use 3/4 inch minimum trade size conduit unless otherwise noted or specified. In any case, use conduit of sufficient cross section to prevent insulation damage by abrasion and deformation during pulling.

16. Use rigid non-metallic conduit from SPD to building system ground.

3.2 INSTALLATION

A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

B. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

C. The actual runs and locations of conduit, lines, and equipment shall be determined on the site and shall be installed to meet the various conditions at the building. Any changes necessary to conceal conduit or clear existing pipes, equipment or construction shall be made.

D. Do not reduce conduit sizes where indicated as larger than required by Code for conductors indicated to be installed. Electric design may have over-sized raceway to permit future added conductors.

E. Raceways shall be installed plumb, level, parallel or right angles to nearby surfaces or structural steel following surface contours as much as possible. Use insulating bushing to protect conductors when joining raceways with fittings designed and approved for that purpose. Joints hall be made wrench tight.

F. Support individual conduit 1 inch and smaller by securing with one-hole malleable iron or pressed steel type straps. Use screws and inserts on concrete or masonry construction, approved clamps or clips on steel construction, or other approved means.

G. Attach conduit larger than 1 inch to framing members, using approved split ring pipe hangers or 2-hole malleable iron or pressed steel straps.

H. Use 3/8 inch minimum hanger rod for 2 inch and smaller individual conduit support and 1/2 inch rod for larger individual conduit support. Use preset concrete inserts to support hanger rods. Where inserts are required after placement of concrete, use expansion shield type anchors.

I. Do not use perforated plumbers tape to support conduit.

J. Use beam clamps of steel, cadmium-plated or galvanized for attachment to beams and columns.

K. Do not employ running threads for conduits.

L. Cut ends square, ream and shoulder in fittings.

M. Provide conduit expansion fittings at building expansion joints, where necessary to compensate for thermal expansion and contraction or where continuous conduit runs exceeds distances as recommended by manufacturer. Metal raceways shall remain electrically continuous by means of approved bonding jumpers where expansion fittings are used.

N. Install conduit and tubing in a manner which shall not trap moisture due to coupling leakage or condensation. Make conduit joints in earth, concrete, masonry, or exposed on exterior, gas tight.

O. Conduit shall be supported at intervals of not more than 10 feet or as otherwise required by National Electrical Code. Flexible steel conduit shall be supported at intervals of not more than 3 feet. No conduit or outlet boxes shall be attached to ductwork, piping, or mechanical equipment, unless specifically approved. Support 1-1/4 inch and smaller size within 18 inches of outlets, and 1-1/4 inch or larger sizes within 36 inches of terminations. Do not support conduit from ceiling suspension systems, except that short lengths of flexible conduit for lighting fixture connections may be so supported.

P. Use cast metal boxes and cast metal fittings for right angle direction changes and for tee, or cross-connections for exposed conduit except where pressed steel boxes are permitted by this Specification. Use factory elbows or field bends only when approved to fit job conditions.

Q. Do not install bends visibly deformed from true circular cross-section. Make field bends with conduit hand or power bender. Minimum bending radius for power, lighting, and the fire alarm shall be as required by Code.

R. Minimum bending radius for telephone and data shall be:

1. Not less than 10 times diameter for conduit 2-1/2 inches and larger.

2. Not less than 20 times diameter for conduit 2 inches and smaller.

S. Clearance from all mechanical piping including steam, gas, refrigeration, hot water, chilled water, etc., shall not be less than 6 inches and 4" from cross piping.

T. Conduits to motors in Mechanical Equipment Rooms shall run exposed.

U. Exposed conduits shall be plumb, level, parallel with or at right angles to building line, beams, or ceilings. Symmetrical bends or metal boxes shall be placed at changes in direction or taps. Positively no conduit shall be run exposed on the exterior face of building unless otherwise pre-approved by the Architect.

V. Conduit terminals at boxes, cabinets, and in general to wiring enclosures, shall be rigidly secured with double locknuts and bushings or approved fittings. Conduits shall be screwed in and shall engage at least five threads in hub where conduit boxes with threaded hubs are used. Insulating bushings shall be used for conduits 1-1/4 inch or larger, and for conductors larger than 10 AWG, and in cases where wiring is subject to vibration.

W. Provide independent support for conduit rising from floor for motor connection if over 24 inches above floor. Do not support to a motor or ductwork which may transmit vibration.

X. Close ends and openings against entry of construction debris, until access is required for installation of conductors or pull wires.

Y. Do not install across ventilation openings or other foreign systems in electrical clearance areas as specified in NEC Article 110.26.

Z. All wiring, unless otherwise noted, shall be installed in rigid metal conduit, intermediate metal conduit or EMT as outlined in this specification and subject to the restriction of the NEC. Minimum size raceways shall be 1/2 inch unless otherwise noted or specified. In any case, use conduit of sufficient cross section to prevent insulation damage by abrasion and deformation during pulling.

AA. All surface and flush mounted panelboards shall have a minimum of six (6) 1" diameter conduits stubbed to nearest accessible ceiling location.

BB. Empty conduit runs shall have heavy nylon, polypropylene or monofilament pull cord with not less than 200 lbs. tensile strength. Leave at least 12" of slack at each end of pull cord tied to end of each raceway.

CC. Field bend non-metallic conduit in accordance with the manufacturer's recommendations using heater and bending devices designed and approved for the purpose. The use of torches or other flame-type devices shall not be permitted. Use internal bending plugs on 2 inch conduit and larger to prevent crimping.

DD. To make joint in non-metallic conduit, use Solvent Cement as recommended by the conduit manufacturer. Be sure conduit ends are clean, dry, and cut at the right angle to the centerline of the conduit. Apply coat of Solvent Cement the length of the socket to be attached. Push conduit firmly into fitting while rotating conduit slightly about one-quarter turn to spread cement evenly. Allow joint to set before proceeding.

EE. Vertical conduits through floor slabs shall be through sleeves sealed with DOW "RTV" or "Chase Foam". Sleeves shall extend 1" above the finished floor. Multiples of conduit risers may be run through floor openings with concrete or metal curbs of 4 inches in height and closed with insulated fire proofing steel plates. Seal water and moisture tight all conduits entering from outside the building to a conditioned space.

3.3 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. 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.

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 (2 inches) above finished floor level.

G. Size pipe sleeves to provide (1/4-inch) annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants.

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work. Roof mounted equipment shall have conduit routed to the equipment within the equipment curb where possible. If a roof penetration must be made, it shall be installed with a pipe seal flashing kit designed for the purpose.

L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.4 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.5 UNDERGROUND WORK

A. Underground work shall include excavating, concrete envelopes, raceways, cables, and backfilling required under this Contract unless noted otherwise. The Electrical Contractor shall be responsible for clearing new and/or existing underground service lines such as gas, water service, sanitary and storm water piping. Excavation shall be as set forth under "Special Conditions/Requirements." Excavations shall be properly barricaded and protected to protect persons from injury. Follow rules of authorities having jurisdiction for safety standards. Excavation shall be on an unclassified basis.

B. Trench excavations shall be made open to proper alignment and grade. Trenches shall be of sufficient width to provide free working space on each side of the raceway structure for concrete envelope forms if required. In earth excavation, the trench shall be carried to a point 6 inches below the bottom of the structure envelope. Raceway structures shall not be allowed to rest directly upon rock, but shall be cushioned by a 6 inch layer of selected crushed stone or gravel. The on-site Owner's representative shall govern the number of points at which the Contractor shall be permitted to work and the length of continuous open trench.

C. Raceways shall be firmly supported above the trench bed and separated from each other by means of approved spacers installed at intervals not exceeding 5 feet.

D. Raceway banks shall be encased in minimum of 3000 PSI concrete envelope not less than 3 inches thick all around the outside limits of the raceway group. In all instances, the concrete shall be not less than 3 inches between any surfaces of a raceway. Underground structures shall be so installed that the top of the enclosing concrete envelope shall not be less than 30 inches below finish grade or otherwise required by code or local AHJ's. Exiting of raceways from concrete slab shall be made with rigid galvanized steel elbows.

E. Concrete envelopes shall be reinforced at points where they cross fill or loose soil, foreign piping, or under vehicular roadways. Reinforcing shall be of size and extent indicated within Contract documents and shall extend 6 feet beyond each limit of fill, roadway, and/or foreign pipe. Where excavation for building purposes is below required grade for duct and manholes, and fill is to be placed under another contract, the Electrical Contractor shall be responsible for determination of satisfactory bearing conditions, and construct in accordance with preceding requirements.

F. Excavations shall be backfilled to finished grades. Backfill shall consist of screened excavated materials approved for backfilling consisting of earth, loam, sandy material, soft shale, or other approved materials, free from large clods of earth or stone. Backfill shall be brought up on approximately 6 inch layers and compacted. Any trenches improperly backfilled or where settlement occurs shall be reopened to the depth required for proper compaction, then refilled and compacted. Refer to Division 3 "Concrete" and Division 31, "Earthwork" for backfill and compaction requirements.

G. Open trenches under roadways or paved areas shall be backfilled as specified above, except that the entire depth of trench shall be backfilled in 6 inch layers, each layer moistened and compacted to a density at least equal to that of the surrounding earth and in such manner as to permit rolling and compaction of the filled trench together with the adjoining earth to provide the required bearing value so that paving of the area can proceed immediately after backfilling is completed.

H. Identification for conduits for medium voltage feeders.

1. Provide self adhesive or painted sign reading "HIGH VOLTAGE" red on white, size ½ height of conduit diameter.
2. Signs shall be provided at 20 foot intervals on accessible conduits and on armored cable in cable trays.

3.6 OUTLET BOXES

A. Do not install boxes smaller than permitted by National Electrical Code. Where no outlet box size is indicated or specified, install a box of not less than 4 inches square by 1 1/2 inches deep dimensions. In dry locations, use pressed galvanized steel boxes, with drilled and tapped ears, and manufacturer's pre punched knockouts. In wet locations, for exposed interior locations below 4 feet above floor, and where poured into exterior concrete, use cast metal boxes with threaded hubs.

B. Provide pressed steel outlet boxes with tile ring where installed in brick, tile, marble, and similar material and in masonry block walls. Equip with plaster rings where plaster or drywall finish is indicated. Select rings of proper depth to place front of ring even with the plane of the finish surface. Select style of ring to match device and finish plates to be installed. Boxes shall be installed plumb, level and flush with wall surface.

C. Close unused openings in pressed steel boxes with knockout closure and in cast boxes with threaded plugs.

D. Gaskets for cast metal boxes may be omitted where installed in dry locations.

E. Use concrete type boxes where required to clear and not displace reinforcement.

F. Use multiple gang boxes for grouping devices at one location. Provide barriers between different systems and between adjacent devices when the voltage between adjacent exposed live parts exceeds 300 volts to ground.

G. Support ceiling outlet boxes flush with the ceiling plane. Use approved bar hanger or other approved means to provide adequate support for lighting fixtures or other products attached to ceiling outlet boxes. Equipment boxes with fixture studs where required by the lighting fixtures to be installed. Support boxes in suspended ceiling systems from main runner channels, or joists or other structural members. Do not support from the ceiling suspension system support wires or tile support tees or similar light weight ceiling components, unless the components are designed and approved for this purpose.

H. Provide outlet boxes used as junction boxes with blank device plates if installed flush, and with blank galvanized covers if installed on the surface. Use raised covers on surface boxes in finished areas. Flat plates may be used on surface boxes in machine rooms, electrical rooms, and similar unfinished areas.

I. Provide outlet boxes with bushed cover plates where used for systems requiring an exposed cable connection from the box.

J. Locate outlet boxes so that they shall be readily accessible. Boxes over suspended ceiling systems are considered readily accessible if the ceiling tile removal permits ready access to such boxes.

K. Use PVC coated junction boxes in conjunction with PVC coated rigid steel conduit and fittings.

L. Individual circuits are shown on plans for clarity. Branch circuit "home runs" maybe grouped together (unless noted otherwise) and extended to panels as shown.

3.7 FLOOR BOXES

A. Provide box with protective removable concrete cover. Pour and trowel concrete so cover is flush with concrete. Remove cover after concrete is set and adjust box flush with final floor surface. Where installed in "other" floor types box shall be fully supported and secured with final assembly matching surface of finish floor. Installation of floor box must conform to manufacturer's specifications and shall be flush with final floor finish. Box type and configured service ports as specified in Section 262726 "Wiring Devices".

3.8 PROTECTION

A. Provide final protection and maintain conditions that ensure coating, 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 manufacture.

B. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacture.

END OF SECTION 260533

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SECTION 260534 - JUNCTION & PULL BOXES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION

A. Provide junction and pull boxes in accordance with Contract Documents. Wherever possible, use outlet boxes for junction and pull boxes Fuses in equipment shall be furnished by the respective contractor supplying the device and installed under this Division.

B. Provide cabinets in accordance with the Contract Documents. Cabinets for same type of use shall be the product of a single manufacturer. Do not install surface mounted cabinets in finished areas, unless indicated. Where conflicting data is indicated, verify mounting requirements prior to ordering cabinets.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Sheet Steel Junction and Pull Boxes: Hoffman, Hammond Mfg, Steel City or approved equal.

B. Cast Iron Junction and Pull Boxes: O.Z. Electric Manufacturing Company, Crouse Hinds Company, or equal.

C. Rigid Nonmetallic Junction and Pull Boxes: Carlon Electric Sciences, Inc. Hubbell, Cantex Industries or equal.

D. Cabinets: Products of the following manufacturers are acceptable. Other products shall be approved as equal.

1. Cabinets for General Use: Hoffman Engineering Company, Hammond Manufacturing, or equal.

2. Cabinets for systems and/or products, use cabinets furnished by manufacturer with system or product. Where system or product cabinets do not comply with these specifications, submit cabinet shop drawings, indicating deviations, and obtain approval for their use.

2.2 MATERIALS

A. Fabricate sheet metal junction and pull boxes of galvanized, Code gauge, sheet steel. Include angle iron framing where required for rigidity. Boxes shall not deflect or deform when covers are removed after conduit and conductors are installed, and any deflection occurring shall not prevent the easy installation and removal of cover attachment screws.

B. Size junction and pull boxes to not less than minimum National Electrical Code requirements. Increase size above Code requirements where necessary to provide space for pulling, racking, or splicing enclosed conductors, or where specified or indicated dimensions exceed Code requirements.

C. Metal junction and pull boxes exposed to weather shall be listed for use such as (and not installed in or below grade) raintight, weatherproof or waterproof. Boxes shall contain gaskets with removable covers. Use boxes constructed to meet NEMA 3R requirements or otherwise noted or required by code. Equivalent gasket boxes or boxes of similar design permanently rendered weatherproof. Raintight or weatherproof boxes shall use threaded watertight hubs for top or side entry and may use knockout for bottom entry only. For exterior pull boxes, use a minimum of 14 gauge galvanized sheet steel. Apply galvanizing by the hot dip process after fabrication.n

D. Surface sheet metal junction and pull boxes with covers aligning with the sides of the box and equip flush boxes with covers extending 3/4 inch all around the perimeter of the back box. Provide sufficient cover attachment screws

to ensure that box covers contact the surface of the box for the entire perimeter of the enclosure. Use brass or stainless steel screws to attach covers to boxes.

E. Use brass screws only to attach junction and pull box covers to interior floor boxes or boxes located where moisture may be present.

F. Do not use single covers for junction and pull boxes having cover length or width dimension exceeding 3 feet so specified, indicated, or approved. Sectionalize covers that exceed 3 feet in either dimension into two or more sections.

G. Provide barrier between pull boxes for cables of different voltage and to separate cables connected to the emergency and normal power.

H. Provide split or hinged covers on junction/pull boxes when the cover exceeds eight (8) square feet in area.

I. This contractor shall paint all fire alarm system junction boxes, pull boxes and covers in red paint in accordance to Ohio Building Code.

J. Indoor Cabinets:

1. Construct of cold rolled quality steel, with metal gauges and construction methods conforming to National Electrical Code requirements, and Underwriters' Laboratory standards.
2. Finish doors, trims, and back boxes for surface mounted cabinets in finished areas, by applying a rust resistant treatment, prime coat, and a final coat of manufacturer's standard enamel or lacquer finish. Galvanize all other sheet metal components of cabinets, excepting non ferrous metal parts, or steel parts provided with cadmium plating or equivalent protective plating.
3. Equip doors with concealed or semi concealed hinges and with flush or semi flush spring catch type flush cylinder locks. Key cabinet doors of similar use alike, and provide two keys with each lock.
4. Set cabinet doors flush into cabinet trim. Equip trim with adjustable clamps or other approved means to fasten trim to cabinets. Fastening method shall permit adjustment for aligning the trim of flush cabinets to a plumb position. Trim for flush cabinets shall extend not less than 3/4 inch beyond the perimeter of the back box.
5. Do not use factory furnished knockouts with surface back boxes. Punch or drill required openings during installation. Equip flush back boxes with manufacturer's standard pattern of knockouts.

K. Outdoor Cabinets:

1. Cabinets shall be constructed of 12 gauge, Type 304 stainless steel, reinforced as necessary in large sizes.
2. Cabinet shall have gaskets, etc., required to meet NEMA Type 4 and UL 508 requirements.
3. Cabinets shall be of size indicated within Contract documents meeting minimum code requirements plus 25 percent growth.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Locate interior junction and pull boxes in machine rooms, equipment rooms, storage rooms, electrical rooms, and similar utility spaces, unless otherwise indicated or approved. Fasten plates to boxes with countersunk flat head screws. Provide plates with 3/4 inch trim all around.

B. Do not exceed the equivalent of three 90deg bends between general wiring pull and junction boxes, and reduce to not more than the equivalent of two 90deg bends where telephone or other multi conductor cable shall be installed.

C. Install junction boxes and pull boxes in a manner to insure that equipment ground continuity is maintained.

D. Junction and pull boxes shall be accessible.

E. Boxes shall be installed every 100 feet in major feeders.

F. Underground junction boxes shall be installed according to manufacturer's instructions.

G. Support all junction/pull boxes with 1/2 inch all-thread rod from floor above or joists or structural members. If mounted tight to floor above, use approved anchors. Tie wire used to support, suspend, or secure junction/pull boxes is not acceptable.

H. Cabinets:

1. Set cabinets at heights indicated or specified. In the absence of such information, set cabinets at not to exceed 6 feet 6 inches from finished floor to top of cabinet.
2. Level and align the tops of cabinets in sight of each other at a uniform height.
3. Install cabinets (and other enclosure products) plumb with building construction. Install flush enclosures so that the trim shall rest against the surrounding surface metal around the entire perimeter of the enclosure.
4. Fastenings shall be made by means of not smaller than 3/16 inch diameter bolts, expansion bolts, or toggle bolts; not smaller than No. 9 x 1 inch wood screws. Fastenings, where exposed to weather or moisture, shall be galvanized. Not less than four fastenings shall be used to secure each cabinet. Do not use nails, or wooden fiber inserts in masonry.
5. On masonry or concrete walls, columns or flooring, fastenings shall be made by means of lead expansion shields not smaller than shield size 3/8 inch diameter by 5/8 inch long for use with No.10 24 round head machine screws. Machine screws shall be not less than 1-1/4 inches long for installation on ceiling and not less than 1 inch long elsewhere.
6. Holes for lead expansion shields shall be carefully and accurately drilled, using sharp drills to a depth which shall afford the maximum practical engagement of threads (depth equal to screw length not less than 1 1/4 inches past plaster into solid concrete). Installation shall develop full strength of screws.

END OF SECTION 260534

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SECTION 260535 - RACEWAY & FITTINGS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions, General Requirements, Division 1 Specifications, apply to this Section.

1.2 DESCRIPTION

A. Provide all raceway fittings, supports and back boxes required to complete work indicated on the Contract Documents.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Subject to general requirements and use as specified in Section 260533 “Raceway and Boxes”.

B. For fittings of specialized type, use the products as scheduled for each type under "Manufacturers," or approved equal.

2.2 MANUFACTURERS

A. General Use Fittings: Steel City, Thomas & Betts, O.Z. Electric Manufacturing Co., Carlon, Sealing Fittings: Appleton Electric, Crouse-Hinds.

B. Liquid-Tight Flexible Conduit Fittings: Thomas & Betts, Appleton Electric, Steel City.

C. Expansion Fittings: O.Z. Type "DX" or approved equal of Appleton, Thomas & Betts, Crouse Hinds.

D. Cast Metal Straight, Tee, Cross, and Fittings: Crouse-Hinds, Appleton Electric, Killark.

E. Rigid Nonmetallic Conduit Fitting: Carlon Electrical Sciences, Inc. Cantex Industries, Hubbell.

F. PVC coated fittings: Occidental Coating Company, Robroy Industries, Ocal (Thomas & Betts) or equal.

PART 3 - EXECUTION

3.1 USE

A. Use threaded fittings for rigid and intermediate metal conduit.

B. Compression or drive-on watertight fittings shall be used for metallic tubing. Fittings with set screws for trade size smaller than 2 inch is not approved for use.

C. Fittings for flexible conduit as approved by the enforcing Code official.

D. Use fittings made of the same material and corrosion resistance as the raceway except:

1. Malleable iron and steel are interchangeable.
2. Die cast fittings may be used for flexible steel conduit, and for factory manufactured offsets.
3. Use insulated bushings for conduit trade sizes.
4. Use steel insulated throat connectors for electrical metallic tubing.

E. Use steel fittings that are galvanized, cadmium-plated, or have other approved protective coating.

F. Use double locknuts for terminating rigid conduit at sheet metal enclosures and equipment conduit ends with bushings.

G. Provide expansion fittings on every raceway larger than 1-1/2 inches, and use a 2 foot piece of seal tight on all conduit routings 1-1/2 inches and smaller where it crosses any building expansion joints. Expansion fittings shall be provided for conduit thermal expansion or contraction in accordance to tables specified in NEC. Verify exact location of building expansion joints prior to installation of raceway with project Architect.

H. Where an expansion fitting is used, conduit bonding shall be continuous by means of a flexible braided copper bonding strap with ground clamps. Bonding strap and clamps shall be provided for grounding continuity as required by NEC. Strap shall be of sufficient length to allow full expansion. Manufacturer Crouse-Hinds XJ or XJG-EMT or approved equal.

I. Use PVC coated fittings for rigid PVC coated steel conduit.

J. Provide moisture barrier fittings for conduit routing entering conditioned spaces from non-conditioned spaces. This contractor shall fill fitting with an approved material preventing circulation and formations of moisture in the conduit system.

K. Where conduit is subject to collection of condensation or moisture, provide a low point combination breather/drain such as Crouse-Hinds ECD or equal.

END OF SECTION 260535

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SECTION 260553 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Schedule of Nomenclature: An index of electrical equipment and system components used in identification signs and labels.

C. Samples: For each type of label and sign to illustrate color, lettering style and graphic features of identification products.

1.3 QUALITY ASSURANCE

A. Comply with ANSI C2.

B. Comply with NFPA 70.

C. Comply with ANSI A13.1 and NFPA 70 for color-coding.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE LABELS

A. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

1. Color: Black letters on orange field.

2. Legend: Indicates voltage.

B. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend over-laminated with a clear, weather- and chemical-resistant coating.

C. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1inch to 2 inches wide.

D. Provide conduit labels for voltages greater than 115 volts. Labels to indicate voltage and shall be pre-tension acrylic/vinyl construction coiled to completely encircle conduit diameters through five inches or pre-molded to conform to the circumference of six inch conduits.

2.2 NAMEPLATES AND SIGNS

A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

B. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.

2. Punched or drilled for mechanical fasteners.

C. Fasteners for Nameplates and Signs: Self-tapping, stainless steel screws of No. 10/32, stainless steel machine screws with nuts and flat and lock washers.

2.3 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.

1. Minimum Width: 3/16 inch.

2. Tensile Strength: 50 lb. minimum

3. Temperature Range: Minus 40 to plus 185° F.

4. Color: According to color-coding.

5. Paint: Formulated for the type of surface and intended use.

    a. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.

    b. Primer for Concrete Masonry Units: Heavy-duty resin block filler.

    c. Primer for Concrete: Clear, alkali-resistant, binder-type sealer.

    d. Enamel: Silicone-alkyd or alkyd urethane as recommended by primer manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Lettering, Colors and Graphics: Coordinate names, abbreviations, colors and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout project.

C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before applying.

E. Color Banding Raceways and Exposed Cables: Band exposed and accessible raceways of the systems listed below:

1. Bands: Colored adhesive tape. Make each color band 2 inches wide, completely encircling conduit and place adjacent bands of two-color markings in contact, side by side.

2. Band Locations: At changes in direction, at penetrations of walls and floors, at 50 feet maximum intervals in straight runs, and at 25 feet maximum intervals in congested areas.

3. Apply the following colors to the systems listed below:

    a. Fire Alarm System: Red

    b. Fire Suppression Supervisory and Control System: Red and yellow

    c. Mechanical and Electrical Supervisory System: Green and blue

    d. Telecommunication System: Green and yellow.

F. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.

G. Circuit Identification Labels to be installed internally on backside of wall plates for each wiring device and outlet.

1. Labeling Legend: Permanent, waterproof description of panelboard and branch circuit feeding wiring device or description of source origination (IT Rack, switch, etc).
    a. Exposed Outlet Boxes: Pressure-sensitive, permanent self-adhesive plastic label on wiring device cover. Installed plumb and level uniformly throughout project.

H. Color Coding of Secondary Phase Conductors: Use the following colors for feeder and branch circuit phase conductors.

1. 208/120-V Conductors:
    a. Phase A: Black
    b. Phase B: Red
    c. Phase C: Blue
    d. Neutral: White
    e. Ground: Green

2. 480/277-V Conductors:
    a. Phase A: Brown
    b. Phase B: Orange
    c. Phase C: Yellow
    d. Neutral: Gray
    e. Ground: Green

I. Factory-apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG.

1. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6” from terminal points and in boxes where splices or taps are made. Apply last two (2) turns of tape with no tension to prevent possible unwinding. Use 1 inch wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.

J. Power-Circuit Identification: Metal tags or aluminum wrap- around marker bands for cables, feeders and power circuits in vaults, pull and junction boxes, manholes and switchboard rooms.

1. Legend: 1/4” steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.

2. Tag Fasteners: Nylon cable ties.

3. Band Fasteners: Integral ears.

K. Apply identification to conductors as follows:

1. Conductors to be extended in the Future: Indicate source and circuit numbers.

2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number and phase. Use color-coding to identify circuits' voltage and phase.

3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding or cable marking tape.

L. Apply warning, caution and instruction signs as follows:

1. Warnings, Cautions and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.

2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8" high lettering for emergency instructions on power transfer and other emergency operations.

M. Fire alarm junction boxes: All fire alarm system junction boxes and cover plates shall be painted red.

N. Service Equipment:

1. Plaque: Provide directory plaque in accordance to NFPA 70-225.37 where building has more than one service.

2. Disconnecting Means: Each service disconnect means shall be permanently identified meeting the requirements of NFPA 70-230.70(B).

O. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes distribution, branch, lighting, communication, signal and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2" high lettering on 1-1/2" high label; where two (2) lines of text are required, use labels 2" high. Use black lettering on white field. Apply labels for each unit of the following categories of equipment using mechanical fasteners.

1. Panelboards, electrical cabinets and enclosures

2. Access doors and panels for concealed electrical items

3. Electrical switchgear and switchboards

4. Emergency system boxes and enclosures

5. Automatic transfer switches

6. Lighting control panels

7. Motor-control centers

8. Disconnect switches

9. Enclosed circuit breakers

10. Motor starters

11. Push-button stations

12. Contactors

13. Remote-controlled switches
14. Dimmers
15. Control devices
16. Transformers
17. Fire alarm master station or control panel
18. Variable frequency drives
19. Manual motor starting switches
20. Manual operation switches
21. Dedicated circuits

P. Panelboard Schedules:

1. Panelboard schedules shall be revised reflecting final alterations, additions and load balancing. Schedules shall include identification of service loads, wattage and/or HP, pole quantity, amperage and shall be type written. Compliance shall be in accordance to NEC article 408.4.

END OF SECTION 260553

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SECTION 260800 – COMMISSIONING OF ELECTRICAL 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.

B. Refer to Section 01 91 13 “Commissioning” for all specific requirements required associated with the commissioning process that will be required as part of this work. As part of this project, participation in the commissioning process as described in Section 01 91 13 shall be required.

1.2 SUMMARY

A. Section includes commissioning process requirements for electrical systems, assemblies, and equipment.

B. Related Sections:

1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. CxA: Commissioning Authority.

C. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.

D. DDC: Direct Digital Controls.

E. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 ALLOWANCES

A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Division 01 Section "Allowances."

1.5 UNIT PRICES

A. Commissioning testing allowance may be adjusted up or down by the "List of Unit Prices" Article in Division 01 Section "Unit Prices" when actual man-hours are computed at the end of commissioning testing.

1.6 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase coordination meetings.

C. Attend testing review and coordination meetings.

D. Participate in Electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.7 CxA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual Electrical systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.8 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.

2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.

3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for Electrical systems, assemblies, equipment, and components to be verified and tested.

4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.

5. Certificate of readiness certifying that Electrical systems, subsystems, equipment, and associated controls are ready for testing.

6. Test and inspection reports and certificates.

7. Corrective action documents.

8. Verification of testing reports.

1.9 SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

1.10 COMMISSIONING AUTHORITY

A. Motz Engineering acting in conjunction with the Xavier University will take the role of the Commissioning Authority for this project. The Commissioning Authority will respond to all issues directly to the Owner and shall have the authority to grant final acceptance of each system commissioned.

1.11 COMMISSIONING PLAN

A. The project Commissioning Plan is included in Section 01 91 13 as a reference for information only. This section and sections in other Divisions shall outline the work required for the project, consistent with the Commissioning Plan. Any discrepancies between the Commissioning Plan and the Project Manual sections shall be brought to the attention of the Commissioning Agent for clarification.

1.12 COORDINATION

A. All Prime Contractors and appropriate Subcontractors shall be responsible for cooperating and coordinating their work during the installation and commissioning process. Refer to the specific requirements and other sections for required work associated with coordination of installation work and preparation of Coordination Construction Drawings by the contractors.

B. The Commissioning Authority will participate in the coordination of installation work as necessary to insure the installation of system components meet the Owner's project requirements and will provide a facility that has appropriate access and means for future maintenance and service by Owner.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Certify that Electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that Electrical 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 that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

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 TESTING VERIFICATION

A. Provide technicians, instrumentation, and tools to verify testing of Electrical systems at the direction of the CxA.

1. The CxA will notify Electric Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.

2. The Electric Contractor shall use the same instruments (by model and serial number) that were used when original data were collected.

3. Failure of an item includes a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing.

4. 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 Electrical testing shall include entire Electrical installation.

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 and the fire alarm system.

D. Tests will be performed using design conditions whenever possible.

E. 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.

F. The CxA may direct that set points be altered when simulating conditions is not practical.

G. 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.

H. If tests cannot be completed because of a deficiency outside the scope of the Electrical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

I. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 ELECTRICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

A. The following Electrical systems shall be commissioned:

1. Lighting Control Systems.

END OF SECTION 260800

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

B. Reference specification Division 26 Section 262726 “Wiring Devices”.

1.2 SUMMARY

A. This Section includes the following lighting control devices:

1. Indoor occupancy/vacancy sensors.
2. Lighting contactors.
3. Cover plates: All cover plates shall be stainless steel.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

C. US: Ultrasonic.

D. DT: Dual technology PIR & US

1.4 SUBMITTALS

A. Product Data Sheet: Submit data sheet(s) for each type of lighting control, sensors, required relays and controllers.

B. Shop Drawings: Provide installation plan drawing with layouts and details for each room or area having lighting controls. Each drawing shall include location of controls, light fixtures, sensors and other required equipment. Include bill of material identifying products used with cross-reference to product data sheets. Wiring schematics shall be included for each type of control scheme.

C. Operation and Maintenance Data: Provide for each product used within project shall have operation and maintenance manuals.

1.5 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.

1.6 COORDINATION

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

PART 2 - PRODUCTS (SELECTED TYPES WHERE APPLICABLE)

2.1 INTERIOR DIMMING SWITCHES (NOT IN PROJECT)

2.2 TIME SWITCHES (NOT IN PROJECT)

2.3 OUTDOOR PHOTOELECTRIC SWITCHES (NOT IN PROJECT)

2.4 INDOOR OCCUPANCY/VACANCY SENSORS

A. It's the responsibility of the Electrical Contractor to ensure that sensors meet or exceed the specifications included herein. Sensors and their subcomponents shall operate as intended and under load conditions as shown within Contract documents.

1. Building Codes: All units shall comply with applicable, local building codes.
2. All sensors shall be FCC compliant where applicable.
3. Manufacturer shall 100% test all equipment prior to shipment. Sample testing is not acceptable.
4. UL listed having standard warranty of 5 years.
5. This contractor shall provide low voltage communication cable (type per manufacturer specification) from low voltage sensor to remote power pack or fixture per installation details. Cable shall be rated for plenum use.
6. Controls shall be recessed to limit tampering and provide user adjustable settings for time delay and sensitivity.
7. All office & classroom area will require occupancy sensor relay for connection to the HVAC. Refer to Lighting & mechanical drawings.
8. Refer to lighting control diagrams for dimming requirements.

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

1. Watt Stopper
2. Sensor Switch
3. Hubbell Building Automation
4. Cooper Controls

C. Submittals:

1. Bill of Materials: Complete list of all parts needed to fully install selected occupancy sensors.
   a. Product Data: Submit product data, including catalog cut sheets for specified products.
   b. Shop and Wiring Drawings: Submit shop drawings detailing all mechanical and electrical equipment including one-line diagrams, wire counts, coverage patterns, and physical dimensions of each item.
2. Documentation & Commissioning
   a. Field terminations shall be identified indicating wire originations. Point-to-point wiring diagram shall be provided and shall include "As-Built" conditions. Submit in duplicates to Owner and Project Architect.
   b. EC shall provide System Manufacturer on-site configuration and programming of lighting system. EC to provide training of Owners representative.
   c. Fixture Compatibility: List of ballasts and lamp combinations compatible with occupancy sensors, by manufacturer and catalog number.
   d. Control cabling specifications.
3. Low Voltage Switch Requirements

4. The programming for the digital switch shall reside in the switch itself and shall communicate to system components via RS 485. Switches shall provide capabilities to be locally programmed. Each individual switch button being programmed for On only, Off only.
5. Switches installed shall be rated for high abuse areas and shall be vandal resistant, contain no moving parts, and be touch sensitive and available with up to three buttons in a single gang.
6. Low voltage switch plates to be stainless steel.

D. Switches must be capable of handling electrostatic discharges of at least 30,000 volts (1cmspark) without any interruption or failure in operation

E. Wall Switches:

1. Switch shall be rated at 120/277V in one unit with no minimum load requirements.
2. Cover plates to be stainless steel.
3. Walk through feature shall shut off lights within 2.5 minutes after momentary occupancy.
4. Automatically adapt to changing room conditions—with the ability to disable adaptive features.
5. Shall save learned and adjusted settings in non-volatile memory that retains all settings during power outages.
6. Maximum adapted time-out shall not exceed 30 minutes.
7. Switch sensor shall utilize PIR, ultrasonic or by combining both sensing technologies pending application of switch.
8. Dual operation: Automatic - on/off and manual on/off or automatic only operation.
9. Zero point switching.
10. Shall have a 3-position service switch: off, auto, and on when configured for dual operation or no switch for automation only operation.
    a. Single circuit
        1) Shall recognize motion detected within 20 seconds of turning off lighting as a false off. In response to a false off, the microprocessor shall increase the time-off setting.
        2) Rating: 1800W/VA @ 120V, 4000VA @ 277V, and 1/4HP @ 120VAC.
    b. Dual Circuit
        1) Shall provide switching for 2 separate banks from a single unit.
        2) Shall offer two modes of operation:
            a.) Only one relay responds to photocell.
        3) Both relays respond to photocell and lights return to the previous state on the next cycle.
        4) Ratings: Primary Relay - 800W @ 120V, 1200VA @120V, 2700VA @ 277V @ 120VAC; Secondary Relay - 800W @ 120V, 800VA @120V, 1200VA @ 277V.
11. Unless otherwise noted within contract documents, the Electrical Contractor shall provide wall occupancy switches with the minimum features:
    a. Dual sensor technology
    b. Single circuit
    c. Automatic and Manual operation
    d. Shall meet other requirements of project documents.

12. The Electrical Contractor, as part of the work of this section, shall coordinate, receive, mount, connect, and place into operation all occupancy related equipment. The Electrical Contractor shall furnish all conduit, wire, connectors, hardware, and other incidental items necessary for properly functioning lighting control and occupancy sensors as described herein and shown within contract documents. The Electrical Contractor shall maintain performance criteria stated by manufacturer without defects, damage, or failure.

F. Ceiling Occupancy/Vacancy Sensors

1. Shall use microprocessor for motion signal analysis and internal, adaptive self-adjustment. Shall automatically adapt to changing room conditions.
2. Shall identify, record and learn a room's normal occupancy cycles to automatically adjust the sensitivity threshold.
3. Shall save learned and adjusted settings in non-volatile memory that retains all settings during power outages.
4. Shall accept Class 2 wiring.
5. Shall mount on the ceiling.
6. Shall provide a concealed bypass switch to force on lighting.
7. Shall save learned and adjusted settings in non-volatile memory that retains all settings during power outages.
8. Shall be equipped with tamper resistant cover.
9. All controls shall be accessible from front of unit.
10. Rugged, plastic housing shall be available in white.
11. Shall incorporate a real-time motion indicator LED, which is visible from the front of unit.
12. Provide white ceiling mount occupancy sensors with accessories and required components as specified within Contract documents by one manufacturer. All color choices shall be confirmed with Architect.
    a. Dual Sensor
        1) Shall incorporate Doppler shift ultrasonic and passive infrared motion detection technologies.
        2) Shall be available in 360º coverage patterns. Infrared lenses shall have a 360º field of view.
        3) Sensor shall have two modes of operation:
            a) Multi-technology mode: where the sensors send infrared signal to the microprocessor, which makes the decision to turn on lighting based on the level of the signal.
            b) Single technology mode: where the user chooses technology that will turn on lighting.
        4) Shall have mask inserts for PIR rejection to prevent false tripping.
    b. Single Sensor - Ultrasonic
        1) Shall utilize Doppler shift ultrasonic detection technology.
    c. Single Sensor – PIR
        1) Shall utilize passive infrared motion detection.
        2) Shall automatically adapt to changing background PIR levels.
        3) Infrared lenses shall have 360º field of view.
        4) Shall have mask inserts for PIR rejection to prevent false tripping.

13. Wall Switch Sensors

    a. Provide a white wall mount occupancy switch by one manufacturer. All color choices shall be confirmed with Architect prior to ordering.

        1) Sensor Switch

        2) Hubbell

        3) Cooper Controls

        4) Watt Stopper

    b. Wall switch sensors shall recess into single-gang switch box and fit a standard GFI opening.

    c. Wall switch sensors shall have optional features for photocell/daylight override, vandal resistant lens, and low temperature/high humidity operation.

    d. Wall switch sensors shall be stainless steel.

    e. Wall switch sensors shall be the following Sensor Switch model numbers, with device color and optional features as specified:

        nWSD (PIR, 1 Relay)

        nWSD PDT (Dual Technology, 1 Relay)

        nWSD 2P (PIR, 2 Relays)

        nWSD PDT 2P (Dual Technology, 2 Relays)

        nWSD NL (PIR w/ Night Light, 1 Relay)

        nWSD PDT NL (Dual Technology w/ Night Light, 1 Relay)

        nWSD LV (PIR, No Relay)

        nWSD PDT LV (Dual Technology w/ Night Light, No Relay)

14. Line-Low Voltage Power Pack

    a. Shall be compatible with incandescent, magnetic or electronic low voltage, and magnetic or electronic fluorescent, as well as motor loads.

    b. Relay function shall not require more than 5-ma control current to operate.

    c. Shall be installed inside a standard 4” x 4” junction box.

    d. Ratings:

        1) 20A incandescent, 20A fluorescent @ 120vAC, 20A fluorescent @ 277vAC

        2) HVAC Relay – SPDT 500ma@24VDC three-wire isolated. Ratings: 0.5A, 125VAC; 1A, 30VD

15. The Electrical Contractor, as part of the work of this section, shall coordinate, receive, mount, connect, and place into operation all occupancy related equipment. The Electrical Contractor shall furnish all conduit, wire, connectors, hardware, and other incidental items necessary for properly functioning lighting control and occupancy sensors as described herein and shown within contract documents. The Electrical Contractor shall maintain performance criteria stated by manufacturer without defects, damage, or failure.

2.5 LIGHTING CONTACTORS

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

1. Allen-Bradley/Rockwell Automation

2. ASCO Power Technologies
3. Eaton Electrical Inc.; Cutler-Hammer Products
4. GE Industrial Systems; Total Lighting Control
5. Square D; Schneider Electric

B. Description: Mechanically held combination type complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250 rated for area where installed.
4. Provide with control and pilot devices as indicated within Contract documents, matching the NEMA type specified for the enclosure.

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 95 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions. Provide back boxes, mounting brackets, guards, trims plates or other required finishes to provide a complete and functional unit.

B. The locations and quantities of sensors indicated within Contract drawings are diagrammatic and indicate only the rooms which are to be provided with sensors. The contractor shall provide additional sensors if required to properly and completely cover the intended area while meeting 95 percent coverage. It is this contractor’s responsibility to arrange a pre-purchase/installation meeting with the manufacturer’s factory authorized representative, at the owner’s facility, to verify placement of sensors and installation criteria.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Wire & Cables." Minimum conduit size shall be 3/4 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Cable type, pair quantity or sizing of conductors according to lighting control manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

E. It is this contractor’s responsibility to insure exposed cables are properly bundled, supported, protected and rated (plenum) for area of installation.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices which fail tests and inspections are considered defective work and shall be replaced at no cost to the project.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training." Provide no less than (3) three complete set of operation and maintenance manuals at time of training.

END OF SECTION 260923

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SECTION 262416 – SWITCHBOARDS AND 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.

1.2 SUMMARY

A. This Section includes the following:

1. Service - Switchboards.
2. Distribution panelboards.
3. Lighting and appliance branch-circuit panelboards.
4. Surge protective devices on panelboards.

B. Provide electric services with capacity and voltage requirements per contract documents.

C. Interrupting Capacities: Panel boards to have interrupting capacity capable of handling fault current which is available at the point in the circuit where the panel is installed.

D. Interrupting ratings are listed within Contract documents. These capacities are based on feeder sizes and panel locations shown within Contract documents. If changes are made, these ratings must be adjusted by the Electrical Contractor.

E. Source Limitations: Obtain switchboards, panelboards, overcurrent protective devices, components and accessories through one source from a single manufacturer.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. RFI: Radio-frequency interference.

D. RMS: Root mean square.

E. SPDT: Single pole, double throw.

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, overcurrent protective device, surge protection device, accessories, and components 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. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:
    a. Enclosure types and details for types other than NEMA 250, Type 1.
    b. Bus configuration, current, and voltage ratings.

c. Short-circuit current rating of panelboards and overcurrent protective devices.

d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Panelboard Schedules: For installation in panelboards.

D. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

3. Selective coordination and series rating charts.

1.5 QUALITY ASSURANCE

A. If an independent testing agency is required, see Division 01 Section "Quality Requirements" for general testing and inspecting agency qualification requirements. If additional control is needed, use one of first two paragraphs below to specify 29 CFR 1910.7 or other more specific criteria (e.g., NETA). 29 CFR 1910.7 defines a nationally recognized testing laboratory as it applies to testing and inspecting for safety, and lists, labels, or accepts equipment and materials that meet certain OSHA criteria.

B. 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.

C. Product Options: Project documents indicate size, profiles, and dimensional requirements of panelboards and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

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 PB 1.

F. 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 exceeding 104 deg F.

2. 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 (Where Applicable): Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner’s representative no fewer than 2 days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without written permission by all affected parties.

1.7 COORDINATION

A. Coordinate layout and installation of panelboards and components with other potential construction interferences such as wall penetrations, supports, including electrical and other types of wall mounted equipment, raceways, piping, and other miscellaneous encumbrances. Electrical Contractor shall maintain NEC workspace clearance requirements.

B. Coordinate size and location of Electric Contractor provided concrete bases with Utility Provider and various equipment manufacturers. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

C. Electrical Contractor shall coordinate with local utilities and general contractor in preparation of and installation of all underground electric including manholes, handholes and raceways associated with: electric services, telecommunications, fire alarm monitoring points, site lighting and feeders or branch circuits.

1.8 EXTRA MATERIALS

A. Provide panelboard nameplate per "Electrical Identification" specification 26-05-53.

B. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: (6) six spares for each type of panelboard lock.

C. Permanently provide Stainless Steel plaque containing directory of each service complying with NEC Article 230.2(E). Coordinate plaque verbiage with Project Engineer.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

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

1. Switchgear, Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
    a. Square D (base of design)
    b. Cutler-Hammer
    c. Siemens

2.2 SHORT-CIRCUIT RATING

A. Equipment shall be fully rated to interrupt symmetrical short-circuit current available at terminals.

2.3 GROUND FAULT PROTECTION

A. The ground fault and overload trip mechanisms shall be of the static type with adjustable, long-time, short-time, and instantaneous both in time and current setting. Ground fault protective circuitry hall be provided in accordance with NEC requirements. Adjustment shall be provided by this contractor.

B. Provide ground fault protection for service per Contract Documents.

2.4 SERVICES

A. The utility electric services and utility metering to the facility are existing to remain.

2.5 CONDUIT

A. Conduit joints shall be sealed with waterproof joint compound. Schedule 40 PVC conduit shall transition to rigid galvanized steel conduit prior to exiting final grade. All conduit bends shall be factory made large radius elbows. Conduits shall be cleaned and free from internal debris prior to assembly. Full bore conduit opening shall be continuous in length and maintained at all times. All foreign matter must be removed from raceways. Provide a pull cord in each conduit.

2.6 SWITCHBOARDS

A. Not used in this project.

2.7 DISTRIBUTION PANELBOARDS

A. Distribution panelboards shall be of construction by Square D Type ILINE or an approved manufacturer, 3 phase, 4 wire, voltage as specified within Contract documents.

B. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.

C. Doors: Secured with tumbler lock; keyed alike.

D. Main Overcurrent Protective Devices: 100% rated circuit breaker or as called for within contract documents.

E. Branch Overcurrent Protective Devices:

1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
2. For Circuit-Breaker Frame Sizes Larger Than 125 A: plug-in circuit breakers as furnished by panelboard manufacturer.

2.8 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Lighting and appliance panelboards shall be 3 phase, 4 wire, unless called out otherwise in the Contract documents. Provide voltage and branch circuit quantity as specified within Contract Documents.

B. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

C. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

D. Available Manufacturers:

1. Square D Type “NF” or “NQ” (Basis of Design)
2. Cutler-Hammer
3. Siemens

2.9 PANELBOARD ACCESSORIES

A. Accessories: Provide all required accessories required for a complete assembly and as noted but not limited to the following: lug kits, ground and neutral bars, filler plates, breakers, shunt trip devices, breaker handle attachments, circuit ID strips, completed directory card etc.

2.10 SURGE SUPPRESSION

1) Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.

2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

2) Surge Protection Device: IEEE C62.41-compliant, externally mounted, bolt-on, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:

1. Fuses rated at 200-kA interrupting capacity.
2. Integral disconnect switch.
3. Redundant suppression circuits.
4. Redundant replaceable modules.
5. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
6. LED indicator lights for power and protection status.
7. Audible alarm, with silencing switch, to indicate when protection has failed.
8. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
9. Four digit, transient-event counter set to totalize transient surges.
    a. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.
    b. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.
        1) Line to Neutral: 70,000 A.
        2) Line to Ground: 70,000 A.
        3) Neutral to Ground: 50,000 A.
10. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
11. Protection modes and UL 1449 SVR for grounded wye circuits with 208Y/120-V, three-phase, four-wire circuits shall be as follows:
    a. Line to Neutral: 400 V for 208Y/120.
    b. Line to Ground: 400 V for 208Y/120.
    c. Neutral to Ground: 400 V for 208Y/120.
12. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:
    a. Line to Neutral: 400 V.
    b. Line to Ground: 400 V.
    c. Neutral to Ground: 400 V.
13. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
    a. Line to Neutral: 400 V, 800 V from high leg.

b. Line to Ground: 400 V.

c. Neutral to Ground: 400 V.

14. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

a. Line to Line: 1000 V for 240 V.

b. Line to Ground: 800 V for 240 V.

2.11 OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker: UL 489, with interrupting capacity to meet available fault currents.

1. Provide overload protection for each devices or circuits deriving from panels according to plans or schedules. Where specific circuit has not been assigned to a device or equipment, a properly sized circuit for load served shall be provide at no additional cost to the project.
2. 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.
3. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
4. Electronic trip-unit circuit breakers shall contain:

a. UL listed as field replaceable

b. Upgradable without special adjustments

c. To be true RMS current sensing

d. Field-replaceable rating plug

e. Advance relay protection (voltage under/over, phase loss, current imbalance, etc.)

f. Field-adjustable settings:

1) Instantaneous trip

2) Long- and short-time pickup levels.

3) Long- and short-time time adjustments.

4) Neutral protection

5) Ground-fault pickup level, time delay, and I2t response.

5. Switchgear main breaker trip unit shall be Square D Micrologic 6.0P or approved equal.
6. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
7. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
8. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
9. Shunt Trip: Panels in areas where shown on plans shall be equipped with breakers featuring shunt trip coils operating at 120vAC. Coil shall be energized from separate circuit, set to trip at 75 percent of rated voltage unless specified elsewhere or subject to code compliance.

10. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.

11. Auxiliary Contacts: One SPDT switch with "a" contacts mimic circuit-breaker contacts.

12. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function and compliance with NEC 2014 240.87 for all potions for the system with 1200 amp or larger overcurrent devices.

13. Multipole units enclosed in a single housing or factory-assembled to operate as a single unit.

B. Branch Breakers

1. Branch circuit portions of each panel board shall comprise the required and indicated number of interchangeable bolt on non combustible thermal magnetic circuit breaker sections; single or multiple pole, rated not less than 20 amperes, 125 volts and higher as noted. Breakers are required to provide I.C. sym. amp as shown on the panel schedule(s).

2. Circuit breakers shall be readily removable from the front of panel board without disturbing adjacent units. They shall have quick make and quick break toggle mechanisms, non fusible contacts, with inverse time, short circuit characteristics. Breakers shall trip free on overload. They shall indicate clearly whether they are in the open, tripped or closed position. Multipolar units shall have thermal element in each pole and shall have a single handle. Closely grouped circuit breakers and thermal tripping devices mounted in a common cabinet shall be de rated when necessary in accordance with NEMA standard recommended practices for high ambient temperatures.

3. Circuit breakers protecting circuits supplying receptacles, signaling devices, clocks, special equipment and other similar circuits not requiring switch control shall be equipped with an approved breaker locking device as called for within Contract documents.

4. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

5. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity. Provide 30-mA trip sensitivity for electric heating equipment conforming to the NEC.

6. Breakers in panelboards used for switching of circuits shall be rated for switching duty.

7. Breakers loads which include high intensity discharge (HID) lighting systems, such as mercury vapor, metal halide or high-pressure sodium shall be HID rated.

8. Lighting applications or other applications where high inrush current exceeds standard tripping conditions, high-magnetic circuit breakers shall be used. Consult branch breaker manufacturer for applications requiring such.

9. Neutral sharing for multiphase panelboards is not an approved wiring method. All branch circuits shall be wired with a dedicated neutral sized in accordance with the NEC.

2.12 REQUIRED ACCESSORY COMPONENTS AND FEATURES

1) Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Customer Metering (Main and Branches)

1. Provide a separate customer metering compartment with front hinged door containing a solid state monitoring system.

2. The customer metering device shall have the following features:

a. All startup parameters shall be stored in nonvolatile memory and retained in the event of a control power interruption.

b. The meter shall provide the following, true RMS metered quantities:

1) Current, per phase and neutral.

2) Current demand – maximum per phase and neutral.

c. Voltage, per phase (L-L, L-N).

d. Power, per phase, 3 phase total (kW, kVA, kVAR).

e. Power factor, 3 phase total.

f. Power demand,(kWd) present and peak.

g. Power demand, (kVARd, kVAd) present and peak.

h. Real energy (kWh).

i. Energy, IN and OUT (kWh, kVARh, kVAh).

j. Minimum/maximum readings, currents, voltages, frequency, power factor, and total harmonic distortion.

10. Power demand calculation capabilities.

11. Minimum and maximum value collection with the following recorded attributes:

a. Date/time of minimum/maximum values.

b. Minimum/maximum value.

c. Phase of recorded minimum/maximum (for multi-phase quantities).

d. All minimum/maximum values shall be available via communications and display.

12. Accuracy of the meter shall comply with ANSI C12.20 Class 0.5 and IEC 60687 Class 0.5 including:

a. Accurate to 0.25% of reading plus 0.025% of full scale for power and energy.

b. Voltage and current shall be accurate to 0.075% of reading plus 0.025% of full scale.

c. Power factor metering shall be accurate to ± 0.002 from 0.5 leading and to 0.5 lagging.

d. Frequency metering shall be accurate ± 0.01 Hz at 45-67 Hz.

13. Meter shall provide steady state waveform captures of voltage and current channels which shall be stored in non-volatile memory.

14. Meter shall be supplied with one digital input and one digital solid state output.

15. Meter shall have logging capability for alarms, waveform, and three separate custom data logs.

16. Meter shall have capability for user definable alarm conditions.

17. Meter shall have output relay control.

18. Meter shall be field upgradeable to enhance functionality. Upgrades shall not require disassembly or changing of integrated circuit chips and it shall not be necessary to de-energize the circuit or equipment to perform the upgrade.

19. Communicate externally via Ethernet TCP/IP and Modbus (DDC) protocols. Coordinate communication package with DDC system installer.

20. Meter shall be equipped with a back lit LCD display and shall be anti-glare and scratch resistant. The display shall have the following capabilities:

    a. Provide viewing of four values on the screen simultaneously.

    b. Provide viewing of a summary screen.

    c. Provide local access for metered quantities.

    d. Provide for reset of electrical parameters.

    e. Provide for setup for system requirements.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1. Mounting shall be plumb and rigid without distortion of box.

B. Surface mounted electrical equipment shall be installed on 3/4" thick, fire retardant mounting board. Mounting board shall bear UL classified mark indicating ASTM E 84 test compliancy. Backboard material shall have a final applied finish according to manufacturer specifications prior to mounting of electrical equipment. Finishing material may include but not limited to fire retardant coatings. Backboard material shall minimally extend 6” in all directions beyond grouping of electrical equipment. The Electrical Contractor may use discretionary expertise to provide fire retardant backboard for individual equipment such as standalone disconnect switches, starters and the like. Where said devices are grouped (starters, disconnects, contactors etc.) installation shall include fire retardant backboard. Fire retardant mounting board installed on perimeter outside walls to be shimmed 1/2" from wall with washers to permit back ventilation.

    1. Approved manufacturer: Hoover Treated Wood Products Inc. - Pyro-Guard

    2. Approved equal.

C. Mount top of panelboard cabinets 72 inches above finished floor, unless otherwise indicated.

D. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

E. Install overcurrent protective devices and controllers.

    1. Set field-adjustable switches and circuit-breaker trip ranges.

F. Install filler plates in unused spaces.

G. Stub four 1-inch empty conduits from lighting/receptacle panelboards into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

H. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

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. Prepare for acceptance tests as follows:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. 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.

C. Load Balancing: After Substantial Completion, but not more than 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 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. Submit all branch circuit changes to the engineer.

4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.5 CLEANING

A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions, General Requirements, Division 1 Specifications, apply to this Section.

1.2 DESCRIPTION

A. This section covers power-related devices such as receptacles, switches, and plug strips.

B. Devices listed in this section may or may not be used on this project. Specifications for devices not included in the Contract Documents are included in case they are needed during construction phase.

1.3 LOCATION OF DEVICES

A. The approximate schematic location of devices is given within Contract documents. The exact location shall be determined at the building as the work progresses. Refer to Architectural plans for any special details, elevations, and reflective ceiling plan. Verify door swings at job site. In no case shall switches be located behind door swings. Any switch so located shall be changed. Field verify equipment location and adjust locations to avoid inaccessibility. Relocate inaccessible outlets.

B. This contractor shall be responsible for installations of wiring devices meeting ADA requirements where applicable.

C. Unless otherwise indicated or otherwise decided at the site or required to meet ADA requirements, outlet boxes in walls shall be located with centerline at elevation above the finished floor as noted below:

D.

Fire Alarm Telephone	4 feet 9 inches (unless directed by AHJ)
Fire Alarm Notification	6 feet 8 inches or 6 inches below ceiling in low ceiling areas
Fire Alarm Pull Stations	3 feet 6 inches (to activation handle)
Fire Alarm Speaker	Ceiling mounted or 8 feet or 6 inches below ceiling in low-ceiling (wall mounted) areas
Fire Alarm Annunciator	5 feet 2 inches (unless directed by AHJ)
Fire Alarm Control Panel	6 feet (to top of panel)
Wall Switch Outlets	4 feet 0 inches
Convenience Outlets (general)	1 foot 6 inches
Convenience Outlets (mechanical areas)	4 foot 0 inches
Counter Outlets	8 inches above countertop
Desk Telephone Outlets	1 foot 6 inches

Wall Telephone Outlets ..... 5 feet 0 inches

Telephone Outlets above Counter ..... 8 inches above countertop

Thermostat ..... 4 feet 4 inches

Public Telephone Outlets ..... Coordinate with telephone company

Plug In Strip ..... To be determined at the site

Exterior and Interior Wall Brackets ..... To be determined at the site

1. **The Architect and Owner's representative reserve the right to change the location of any outlet, before installation.**

1.4 DESCRIPTION

A. Wiring Device Requirements

1. Use the products of a single manufacturer for each type of wiring device.
2. Receptacles for general equipment or Owner's-Furnished Equipment: match cord-plug configurations.
3. Use the products of a single manufacturer of all wiring and device plates. Obtain prior approval for any variations from this requirement, except that plate variations are allowed for the following devices:
    a. Where the selected plate manufacturer does not manufacture a suitable finish plate.
    b. For heavy-duty receptacles rated at more than 30 amperes.
    c. Where the raceway system enclosure employs a non-standard finish plate.
    d. Where non-standard plates are specified or indicated.

B. Cover Plates

1. Unless otherwise prohibited by wiring device, cover plates shall be stainless steel as define within section 2.7 of this document.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Representative general purpose wiring devices and device plates as listed herein are intended to indicate type, function, and quality of the products. Provide the products as specified.

1. Industrial/Institutional construction type:
    a. Receptacles, toggle and snap switches: Hubbell, Pass & Seymour, Leviton, Cooper Wiring Devices
    b. Lighting Control; Dimmers & Occupancy Sensors: Hubbell, Leviton, Wattstopper, Lithonia, Cooper Wiring Devices
    c. Time Switches: Intermatic Inc., Tork, MH Rhodes
    d. Exterior/Cast: Crouse-Hinds, Appleton, Hubbell, Cooper Wiring Devices

2. Hospital Grade:

    a. Tamper-resistant duplex receptacles. Manufacturer as named above.

2.2 STANDARDS

A. Straight-Blade-Type Receptacles: Comply with NEMA WD 1, NEMA WD 6, DSCC W-C-596G and UL 498.

B. GFCI Receptacles: Straight blade, non-feed-through type, with integral NEMA WD 6, complying with UL 498 and UL 943-2003. Design units for installation in a 2-3/4" deep outlet box without an adapter.

C. Pendant Cord/Connector devices shall have matching, locking-type plug and receptacle body connector, NEMA WD 6, Configurations L5-20P and L5-20R, Heavy-Duty grade.

1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

D. Single- and Double-Pole Switches: Comply with DSCC W-C896F and UL 20.

E. Wiring device color unless specifically noted within contract documents are to be determined for finished spaces by the Interior Designer except the following:

1. Black within equipment rooms (electrical, mechanical, technology closets)
2. Red fed from emergency or standby power circuits
3. Yellow for exterior weather resistant duplex receptacles

2.3 SWITCHES

A. General:

1. Device (general use) color: White within finished areas, White for lighting controls within finished areas, Ivory mounted in surface mounted raceways or black within unfinished areas. All color choices shall be confirmed with Architect.
2. Switches mounted vertically shall have the "ON" position at the top and horizontal-mounted switches shall have the "ON" position at the left. Unless otherwise indicated switches shall be mounted in the vertical position.
3. Tumbler switches shall be the AC heavy-duty, specification grade, 120/277 volts, flush toggle type switch rated at 20 amperes, Underwriters' approved and meeting NEMA Standard WD-1 1965 and Federal Specifications W-S-896d (Type III). The operating mechanism shall be totally enclosed in a high-heat, non-inflammable, non-hygroscopic molded compound case with terminal screws located on the side of the switch. Operating handles shall be made of high heat phenolic compound. Switches shall have wide plaster ears.
4. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on/off switch and audible frequency and EMI/RFI filters. Architectural grade, preset slide control, plate kit, AC dimmer with minimal wattage (after derating) and specified voltage for intended load. Contractor provided dimmer shall be compatible with fluorescent ballast manufacturer.

    a. 120v Hubbell AS-103, AS-153, AS-203 (White) P&S, Leviton

    b. 277v Pass & Seymor 93271, 93472, 93673, 93874 (White) – Magnetic, Hubbell, P&S

c. 277v Leviton MNX20-7L, MNX30-7L (White) – Electronic, Hubbell, P&S.

B. Occupancy/Vacancy Sensors:

1. See specification 260923 "Lighting and Control Devices".

C. Manufacturers:

1. Single pole toggle switch, 20 ampere, 120-277 volt, institutional grade, Hubbell Catalog No. HBL1221, Pass & Seymour, Cooper Wiring Devices or Leviton equal.
2. Keyed single pole toggle switch, 20 ampere, 120-277 volt, industrial-institutional grade, Hubbell Catalog No. HBL1557L, Pass & Seymour, Cooper Wiring Devices or Leviton equal.
3. Three-way toggle switch, 20 ampere, 120-277 volt, institutional grade, Hubbell Catalog No. HBL1223, Pass & Seymour, Cooper Wiring Devices or Leviton equal.
4. Four-way toggle switch, 20 ampere, 120-277 volt, institutional grade, Hubbell Catalog No. HBL1224, Pass & Seymour, Cooper Wiring Devices or Leviton equal.
5. Double pole toggle switch, 20 ampere, 120-277 volt, institutional grade, Hubbell Catalog No. HBL1222, Pass & Seymour, Cooper Wiring Devices or Leviton equal.
6. Single pole key lock switch, 20 ampere, 120-277 volt, institutional grade, Hubbell Catalog No. HBL1221-L, Pass & Seymour, Cooper Wiring Devices or Leviton equal.
7. Single pole toggle switch with pilot light on with load off, 20 ampere, 120 volt, institutional grade, Hubbell Catalog No. HBL1221-PL, Pass & Seymour, Cooper Wiring Devices or Leviton equal.
8. Three-way toggle switch with pilot light on with load off, 20 ampere, 120-277 volt, institutional grade, Hubbell Catalog No. HBL1223-IL, Pass & Seymour, Cooper Wiring Devices or Leviton equal.
9. Momentary contact switch, 3-position, 2-circuit, center off, 20 ampere, 120-277 volts, institutional grade, Hubbell Catalog No. HBL1557.
10. Maintained contact switch, 3-posistion, 2-circuit, center off, 20 ampere, 120-277 volts, institutional grade, Hubbell Catalog No. HBL1385.
11. Fan switches — coordinate with fan supplier (switch is normally provided by fan supplier; if not, provide single-pole switch listed above or provide manual motor starter per specification 262913 where motor overload protection is not provided).

D. Miscellaneous Switch Appurtenances:

1. Weatherproof cover - Hubbell 1795
2. Locking cover - Hubbell 96061
3. Pass & Seymour, Leviton equal.

2.4 CONVENIENCE RECEPTACLES

A. Receptacles for convenience outlets shall be duplex self-aligning grounding type rated for 20 amperes at 125 volts. Contacts shall be made of heavy spring copper or bronze so designed as to securely grip both sides of each receptacle blade and shall be enclosed in high heat, non-inflammable, non-hygroscopic molded compound case, provided with wide plaster ears. Each terminal shall be provided with two (2) binding screws located on the side of the receptacle. Hubbell Catalog No, IG5362GY, Pass & Seymour, Cooper Wiring Devices or Leviton equal.

B. Where noted within Contract documents, tamper-resistant convenience outlets shall be rated for 20 amperes at 125 volts with integral shutter or reciprocating contact system meeting minimum requirements as noted above. Nylon

face shall visually identify unit as tamper resistant; Hubbell Catalog No, HBL8300SGGYA, Pass & Seymour, Cooper Wiring Devices or Leviton equal.

C. USB Receptacles (Where noted within Contract documents): Shall be tamper-resistant Decora type rated for 20 amperes at 125 volts with integral shutter or reciprocating contact system containing (2) high powered 5vDC 3.6A USB 2.0 Type A integral charging ports. Leviton T5832, Hubbell, Pass & Seymour or Copper Wiring or equal.

D. Manufacturers:

1. Generator fed receptacle (derived from “E” or “S” type panels), 20 ampere, 125 volt, 2 pole, 3 wire grounding type, NEMA 5-20R, red in color and connected to the normal/emergency/standby system; Hubbell Catalog No. HBL5362R, Pass & Seymour, Cooper Wiring Devices or Leviton equal. The stainless steel cover plate shall have the word "Generator" engraved at the top with red filled lettering.
2. Ground fault interrupter type duplex receptacle, 20 ampere, 125 volt, 2 pole, 3 wire grounding type, NEMA 5-20R; Hubbell Catalog No. GFR5352-__ST, Pass & Seymour, Cooper Wiring Devices or Leviton equal.
3. Safety type duplex receptacle, 20 ampere, 125 volt, 2 pole, 3 wire grounding type, NEMA 5-20R. Pass & Seymour Catalog No. SG-62
4. Duplex receptacles fed from computer panelboards shall be of color white, 20 ampere, 125 volt, 2 pole, 3 wire grounding type, NEMA 5-20R, Hubbell Catalog No. 5362OW (white), Pass & Seymour, Cooper Wiring Devices or Leviton equal.
5. Single receptacle, 20 ampere, 125 volt, 2 pole, 3 wire grounding type, NEMA 5-20R ("EWC" denotes electric water cooler-coordinate mounting height with the equipment supplier); Hubbell Catalog No. 5361-BK, Pass & Seymour, Cooper Wiring Devices or Leviton equal.
6. Exterior duplex receptacles shall be yellow in color weather resistant type. Leviton WBR20-Y, Pass & Seymour or Hubbell equal.

E. Appurtenances:

1. Weatherproof covers - use Hubbell WP26 or WPSF26, Pass & Seymour Catalog No. WPH8 or Bryant Catalog No. 4510D for GFI-WP locations; or Hubbell 5205WO or 5206WO, Pass & Seymour Catalog No. WPH26 for non-GFI-WP locations. Leviton equal.

2.5 PROTECTED RECEPTACLES

A. Receptacles shall be ground fault and/or arc-fault protected in accordance to Articles 210.8 and 210.12 of 2011 National Electric Code.

2.6 SPECIAL PURPOSE RECEPTACLES

A. Special purpose receptacle, size and type as called for within Contract documents. (Each receptacle shall be provided with one matching plug for installation on the associated piece of equipment.)

B. 30 ampere, 125 volt, 1 phase, 2 pole, 3 wire grounding type, single receptacle, with black face, NEMA 5-30R. Hubbell Catalog No. 9308. (Plug-Catalog No. 9309), Pass & Seymour, Cooper Wiring Devices or Leviton equal.

C. 20 ampere, 250 volt, 1 phase, 2 pole, 3 wire grounding type, single receptacle, with brown face, NEMA 6-20R. Hubbell Catalog No. 5461. (Plug-Catalog No., 5466-CA), Pass & Seymour, Cooper Wiring Devices or Leviton equal.

D. 30 ampere, 250 volt, 1 phase, 2 pole, 3 wire grounding type, single receptacle, with black face, NEMA 6-30R. Hubbell Catalog No. 9330. (Plug-Catalog No. 9331), Pass & Seymour, Cooper Wiring Devices or Leviton equal.

E. 50 ampere, 250 volt, 1 phase, 2 pole, 3 wire ground type, single receptacle, with black face, NEMA 6-50R. Hubbell Catalog No. 9650. (Plug-Catalog No. 9650-ANP), Pass & Seymour, Cooper Wiring Devices or Leviton equal.

F. 50 ampere, 125/250 volt, 1 phase, 3 pole, 4 wire grounding type, single receptacle with black face NEMA 14-50R. Hubbell Catalog no. 9450-FR. (Plug Catalog No. 9452- ANP), Pass & Seymour, Cooper Wiring Devices or Leviton equal.

G. 20 ampere, 250 volt, 1 phase, 2 pole, 3 wire grounding type, single twist, single twist-lock receptacle, with black face, NEMA L6-20R. Hubbell Catalog No. 2320. (Plug-Catalog No. 2321-CA), Pass & Seymour, Cooper Wiring Devices or Leviton equal.

H. 30 ampere, 250 volt, 1 phase, 2 pole, 3 wire grounding type, single twist-lock receptacle, with black face, NEMA L6-30R. Hubbell Catalog No. 2620. (Plug-Catalog No. 2621-CA), Pass & Seymour, Cooper Wiring Devices or Leviton equal.

I. 50 ampere, 125/250 volt, 1 phase, 3 pole, 4 wire grounding type, single twist-lock receptacle, with black face, NEMA L6-50R. Hubbell Catalog No. CS6369. Hubbell Catalog No. 6365, Pass & Seymour, Cooper Wiring Devices or Leviton equal.

J. 30 ampere, 125/250 volt, 1 phase, 3 pole, 4 wire grounding type, single twist-lock receptacle, with black face, NEMA L14-30R. Hubbell Catalog No. 2710. (Plug-Catalog No. 2711-CA), Pass & Seymour, Cooper Wiring Devices or Leviton equal.

K. 50 ampere, 125/250 volt, 1 phase, 3 pole, 4 wire grounding type, single receptacle with black face NEMA 14-50R. Hubbell Catalog No. 9450-FR. (Plug Catalog No. 9452-ANP), Pass & Seymour, Cooper Wiring Devices or Leviton equal.

L. 20 ampere, 250 volt, 3 phase, 3 pole, 4 wire grounding type, single twist-lock receptacle, with black face, NEMA L15-20R. Hubbell Catalog No. 2420. (Plug-Catalog No. 2421), Pass & Seymour, Cooper Wiring Devices or Leviton equal.

2.7 COVER PLATES

A. Unless otherwise specified, toggle switch, wall mounted occupancy/vacancy sensors, receptacles, special purpose outlets, wall mount telephone and other wiring device plates shall be Bureau of Standards No. 302-18.8 brushed or satin stainless steel with beveled edges so as to lie flat against the wall. Where more than one (1) switch or receptacle occurs at one point, use a single multi-gang plate.

B. Zinc-coated plates may be used in unfinished spaces.

C. Plates shall be set true and plumb and shall fit tight against finished wall surfaces and outlet boxes.

1. Manufacturers: Hubbell 97000 Series, Pass & Seymour, Cooper Wiring Devices or Leviton equal.

D. Identification: Plates shall be marked with panelboard and branch circuit serving wiring device on inside of plate as directed by Specification 260553 “Electrical Identification”.

2.8 FLOOR BOXES

A. Floor boxes are flush floor mounted of type noted at locations shown on plans or otherwise scheduled.

B. Floor boxes shall be of proper type as called for and sized as required by the NEC and shall be secured firmly in place and set true and flush with the final finished floor surface.

C. Floor boxes shall be fully fitted with required number of receptacles, modular communication connectors (phone, data, video, audio etc), separators, partitions, plates, sub plates, trim rings, metal covers and other necessary items required for a complete assembly. Other specifications requirements by particular manufacturer.

1. Characteristics: Complete factory assembled unit consisting of floor fittings, cover assembly, application plates and suitable for both on or above grade applications. Assembled unit having a UL listed 514A and 514C for scrub water requirements. Final cover plate shall match final floor finish or as noted on architectural documents. Where required, assembly shall have UL listing for use in fire rated floors. Floor boxes are rated and acceptable for use in environmental air handling spaces per NEC article 300.22(C). Separate raceways and sections for power and communications with minimum power size of 3/4" and 1" for communications.

2. Sub-plate: Provide a complete fully fitted plate meeting minimum requirements as shown within Contract documents. Furnished sub-plate shall include receptacles, data, video, audio or furniture feeds as required.

D. Manufacturer:

1. Hubbell : S1CFB cast box, S1CFCBRS or S1TFCBRS brass cover, S1SP4X4 or other sub-plate configuration to met project requirements.

2. Hubbell: B2437 or B4214 cast box, brass screw cover plate for tile or terrazzo floors such as but not limited to: S3625, S2825 or S3425.

3. Manufacture and model as called for within Contract Documents. Include required plates, sections, faceplates, terminations including specified construction.

4. Approved equal from Leviton or Pass & Seymor.

2.9 EXTRA MATERIALS

1. Provide (10) additional cord reels matching those cord reels specified on the electrical power plans.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Devices shall be flush mounted unless otherwise noted. Properly align level and plumb devices including plates. Plates shall fit flat against wall and tight against device surface without straining or buckling the plate.

B. Devices to be recessed mounted flush and level in CMU (Concrete Masonry Unit) walls in all areas except mechanical and electrical rooms. Devices shall be installed in a neat and workmanlike manner. Holes for device boxes shall be saw-cut and uniform. Cuts shall be plumb and level, with minimal space around perimeter of boxes that will require grout. Boxes shall be grouted in place.

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

D. Code sized (#12 minimum) bonding jumper shall connect grounded outlet box to receptacle grounding terminal on flush-mounted units.

E. Where receptacles are indicated as split-wired and half of the receptacle is on a wall switch, the top receptacle shall be switched and bottom shall be on normal power.

F. Switches mounted vertically shall have the "ON" position at the top.

G. Receptacles shall be mounted in the vertical position with the ground terminal on bottom.

H. Install wall dimmers achieving minimum wattage of connected load including sufficient capacity after de-rating for ganging according to manufacturer's written instructions. Sufficient clearances shall be maintained where dimmers are ganged. Provided dimmers controlling fluorescent ballasts shall be compatible.

I. Devices installed in areas for use by physically disabled persons, such devices shall be mounted in accordance to Americans Disabilities Act. Refer to architectural drawings, Architect or on-site representative for ADA designated areas.

J. Wiring devices shall have power feed wiring labeled within device box with circuit and panelboard source.

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports when requested.

1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.

2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

B. Remove malfunctioning units, replace with new units and retest as specified above.

END OF SECTION 262826

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SECTION 262730 - TAPS, SPLICES & TERMINATIONS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Special Conditions, General Requirements, Division 1 Specifications, apply to this Section.

1.2 DESCRIPTION

A. Provide taps, splices and termination devices approved and sized for copper cables at voltage and current rating matching characteristics of terminating conductor.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Conductors splices in No. 10 AWG and smaller wire to be made with Minnesota Mining Manufacturing Co. insulated "Scotch Locks", Ideal Co. "Wing Nut", T. & B "Piggy" connectors, or with mechanically crimped sleeves as manufactured by T & B or Ideal Company, which shall be insulated with pressure sensitive electrical tape equal to Scotch No. "33+" or No. 88. Splicing components shall be rated for copper and aluminum conductors.

B. Conductors #8 AWG and larger shall be terminated, spliced, and tapped with Thomas & Betts color-keyed compression connector's series 54000 or equal. The manufacturers recommended tools and dies shall be used.

C. Copper cable lug connections #8 and larger to copper bus bar mains and branches shall use copper solderless connectors having either 2-bolt cast copper clamps or compression connectors, Thomas & Betts Series 54000 with manufacturer's recommended hexagonal dies and hydraulic compression tools.

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

E. Connections to equipment shall be made with pressure type terminals. Stranded wire shall use spade type terminals or terminal approved for use. Connections shall contain one conductor unless otherwise rated for multiple conductors.

2.2 MANUFACTURERS

A. 3-M, O.Z., Thomas & Betts or approved equal.

2.3 WIRE LABELS

A. Each cable or wire termination shall be identified as noted on drawings, schedules or where not indicated, label shall note applicable branch circuit, phase and/or connected equipment. Labels shall be pressure sensitive or clip on PVC type. Approved Manufacturers: Brady, 3M or approved equal.

2.4 TERMINAL BLOCKS

A. Where terminal blocks/strips are indicated or otherwise required, provide a complete assembly of blocks/strips having each terminal equipped with two clamp type pressure lugs or two washer bead binding screws. Use terminal strips with voltage and ampere rating sufficient to carry intended loads. Provide a white marking strip along the center line of each row of terminal for identification. Use strips having plastic barriers between adjacent terminals. Provide indicated terminal quantities or otherwise required. If quantity is not indicated, provide one

terminal for each conductor entering enclosure plus 20 percent spare terminals. Type or otherwise mark the identification strip to identify each connected circuit. Relate identification to wiring diagrams, panel schedules and other terminals in a logical manner, where specific identification requirements are not indicated. Under no circumstances shall more than one wire be terminated under each terminal unless rated otherwise. Use only approved type jumper to mechanically connect terminals to each other.

1. Approved Manufacturer: Allen Bradley, Ilsco, Marathon or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Make taps, splices, and terminations at junction boxes, pull boxes, switches, panel boards, and any other electrical equipment, etc. Wires shall be continuous between outlet to outlet, or from panel board to the first outlet, etc.

B. Backboxes, device boxes, fittings or junction boxes shall be suitably sized permitting adequate conductor fill capacity per Article 314 of the National Electrical Code.

C. All taps and splices shall be fully insulated meeting minimum insulating values of wire or conductors used.

D. After splices are mechanically secure, provide listed electrical tape to insulate splice to equal the original insulation voltage rating of the wires, or utilize Thomas & Betts heat shrinkable insulators Series H.S. If the type of connector installed provides equivalent insulation, taping may be omitted.

E. EC shall provide and install all feeders and branch circuit wiring to all disconnect switches, equipment, controllers, motors and wiring devices. Terminations shall be in full compliance with project documents and meet the installation requirements of the manufacturer.

END OF SECTION 262730

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SECTION 262813 - FUSES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DESCRIPTION

A. Provide fuses in accordance with the contract documents in motor starters, switchgear assemblies, panel boards, disconnect switches, control devices, lighting fixtures or other required components or equipment.

B. Fuses shall be provided and installed in equipment being furnished by the respective contractor.

C. This Section includes: Cartridge fuses rated 600 V and less for use in equipment or components as specified or noted within contract documents.

D. Provide a complete set of three (3) spare fuses for each fuse size and type used.

E. All fuses provided shall be of the indicating type, employing either an indicating window or a mechanical indicator striker pin where available.

F. Where ambient temperature to which fuses are directly exposed is less than 40 degF or more than 100 degF, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

G. Fuses shall be current limiting with 200,000 ampere interrupting capacity and UL labeled or as specified by manufacturer.

H. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Obtain fuses from a single manufacturer.

B. Fuses shall be of the high interrupting rating, current limiting type and manufactured by the Bussman, Mersen, Cooper Edison or Littelfuse.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment in accordance to the National Electric Code.

B. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

C. Ensure that fuses are firmly and completely inserted into fuse holders and that mechanical joints are tightened.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following individually mounted, enclosed switches and circuit breakers:

1. Fusible switches.
2. Non-fusible switches.
3. Molded-case circuit breakers.
4. Enclosures.

1.3 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

1. Shop Drawings: Diagram power, signal, and control wiring.
2. Field quality-control test reports.
3. Operation and maintenance data.

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.

1. Comply with NFPA 70.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

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

1. Eaton Corporation; Cutler-Hammer Products.
2. Square-D/Group Schneider
3. Cooper/Bussmann – Power Module

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

A. Fusible Switch, 1200A and Smaller: NEMA 12, heavy duty type , with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

B. Non-fusible Switch, 600A and Smaller: NEMA-12, heavy duty type, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit (where required): Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

D. Elevator (New Installation Only)

1. Provide Elevator Control Switch in a single NEMA 12 enclosure with all necessary relay(s), control transformer and options (as listed below) and as shown within Contract Documents. The Elevator Control Switch shall be constructed, listed and certified for use with elevator control. The Elevator Control Switch shall have an ampere frame rating meeting minimum ampere requirements of selected elevator and shall include a horsepower rated fusible switch with shunt trip capabilities. The ampere rating of the switch shall be based upon elevator manufacturer requirements and utilize Class J Fuses which are provided by the Electrical Contractor. The Elevator Control Switch shall include 100 VA control power transformer with primary and secondary fuses. The primary voltage rating shall match the incoming elevator supply voltage with a 120 volt secondary. It shall also contain an isolation relay (3PDT, 10 amp, 120V). The coil of the isolation relay shall be 120v. A normally open dry contact shall be provided by the Fire Alarm Safety System to energize the isolation relay and activate the shunt trip solenoid (140 VA @ 120vAC). The switch shall include a 120 volt key to test switch and a 1-NO/1-NC mechanically interlocked auxiliary contact rated 5A, 120vAC as standard. The switch shall contain the following options:
    a. "ON" Green pilot light
    b. Isolated Full Capacity Neutral Lug
    c. Fire Alarm Voltage Monitoring Relay (Needed to comply with NFPA 72)
    d. Main Switch Auxiliary Contacts (1 NO/1 NC)

2.3 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Molded-Case Circuit Breaker: NEMA-1, with interrupting capacity to meet available fault currents.

B. 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 250A and larger.

1. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
2. Current-Limiting Circuit Breakers: Frame sizes 400A and smaller and let-through ratings less than NEMA FU 1, RK-5.
3. GFCI Circuit Breakers: Single- and two-pole configurations with 5mA trip sensitivity.

C. Molded-Case Circuit-Breaker Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style with lug kits suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
5. Shunt Trip: 120V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.

2.4 ENCLOSURES

A. NEMA-1 minimal rating or otherwise required meeting environmental conditions at installed location.

1. Outdoor Locations: NEMA 250, Type 4.
2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

1. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical Systems," and concrete materials and installation requirements are specified in Division 03.

B. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

C. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Electrical Identification."

3.2 FIELD QUALITY CONTROL

A. Prepare for acceptance testing as follows:

1. Inspect mechanical and electrical connections.
2. Verify switch and relay type and labeling verification.
3. Verify rating of installed fuses.

B. CLEANING

1. On completion of installation, inspect interior and exterior enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 262816

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SECTION 262913 – MOTOR STARTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SCOPE

A. Provide motor starters in accordance with the Contract Documents. Motor starters may or may not be furnished under this Division, but shall comply to the requirements indicated in this section. Receive, install and connect motor starters not pre-assembled and pre-wired by equipment manufacturer. Notify Associate if any starters do not conform to these requirements. Motor starters in heating equipment shall be supplied under Division 23 and installed under this Division.

B. Where motor horsepower is equal-to or greater than five, motor controllers shall be provided with integral phase loss protection. Under phase-loss conditions, the phase detection device shall remove power from all phases of the connected motor.

C. Related Work Specified Elsewhere: This specification describes the electrical work related to manual motor switches, manual motor starters, magnetic motor starters and combination motor controllers external to Motor Control Centers.

1.3 STANDARDS

A. Conform to NEMA voltage rating for motors and motor control equipment.

B. Motor branch circuit protective devices shall meet requirements of NEC 430.

C. UL 98 - Enclosed and Dead Front Switches

D. NEMA KS 1 - Enclosed Switches

E. NEMA 250 - Enclosures for Electrical Equipment

1.4 SUBMITTALS

A. Shop Drawings: Submit general shop drawings, brochures, catalog cuts, dimension sheets and full data schedule of starters to be furnished.

B. Wiring Diagrams: Submit full starter wiring diagrams showing project remote operating controls, interlocks, safeties, freeze stats, pressure switches, etc. Separate wiring diagram shall be provided for each type motor or by function.

C. Operational Data: Submit descriptions of working parts, list of replacement parts and adjustment instructions for components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified.

1. General Electric

2. Allen Bradley

3. Square D

4. Eaton Electric

2.2 COMBINATION MOTOR STARTERS

A. Combination starters shall be combined with motor overload, short circuit protection and disconnecting means. Manufactured to NEMA standards with UL listing at 480vAC rated 100,000 amps fault current.

B. Disconnecting means via flange mount operating handle capable of being locked in the open position. Disconnect switches shall be heavy duty, quick make, quick break and interlocked with operating handle. Combination starter to be fusible, non-fusible, thermal magnetic breaker or supplied with motor circuit protector (MCP). Fuses where provided shall be class RK5 with 1-set furnished as spare. Settings of MCP type breaker shall be based on field installed motor nameplate amperage ratings following manufacturer adjustment procedures.

C. External manual reset mechanism provided for each combination starter as required to reset the single block three-coil motor overloads. Motor overloads shall be provided and correctly sized based upon nameplate data of field installed motors. Do not size over loads based upon typical rating charts.

D. Each starter shall have an extra auxiliary NO/NC contact for future control purposes.

E. Where not otherwise indicated, magnetic starters shall contain flange mounted stop start push button stations. Where remote automatic control is indicated a HAND-OFF-AUTO selector switch shall be mounted in the face or flange of each starter enclosure. The selector switch shall be so wired that when it is in the HAND or AUTO position, all safeties are wired in series with the selector switch; control devices shall be wired in the AUTO position only.

F. Control voltage shall be maximum voltage of 120vAC. Each starter enclosure shall have a suitable secondary control transformer fused separately on each phase of the primary and secondary, and the secondary grounded. Where indicated within Contract documents, 120v control voltage maybe sourced separately otherwise shall be internally sourced.

G. Each starter shall have a transformer type green pilot light mounted in the face at the starter enclosure indicating motor operating status: “Running”. The pilot light shall be wired so it will be on when the motor is energized.

H. Magnetic starters shall be furnished for motors, one-half horsepower and greater or any three-phase motor, unless indicated otherwise within Contract documents. Motor controllers shall have integral phase-loss protection and phase failure relays with auxiliary NO/NC contacts.

1. Motor monitoring shall include phase loss, phase reversal, voltage unbalance and under voltage. Features may include adjustable trip and restart delay, restart lock-out function and adjustable voltage unbalance settings.

2. Phase loss module shall be provided by the electrical contractor by being an integral part of motor controller, mounted within motor controller or mounted in a labeled enclosure mounted adjacent to motor controller.

3. Unless otherwise restricted via manufactures installation requirements, wiring of phase loss module shall be on the load (motor leads) side. Line side monitoring is not preferred.

4. Manufacturers: Subject to compliance, provide phase-loss module by one (1) of the manufacturers specified.

a. Same approved manufacture as motor controller/combination starter.

b. ABB - HLMU Series

c. Time Mark Corp. - Model 269R

d. Macromatic - PMP (plug-in)

e. Allen Bradley, Square D or GE approved equal.

I. Minimum starter size of NEMA 1 or as otherwise called for within Contract documents. Where installation restriction requires IEC style enclosure and equipment, approval of usage shall be obtained prior ordering. Starter control devices shall consist of Allen Bradley 800T/H components or approved equal by Square D or GE.

J. Remote control stations or related control components not mounted in cover of motor starter shall be heavy duty units of required devices mounted in an enclosure rated for area for which it's installed. Control stations shall be assembled using Allen Bradley 800T/H components.

K. Square D Class 8500 or General Electric CR208, Allen Bradley Type 500, 800T/H.

2.3 MANUAL MOTOR SWITCHES

A. Provide for fractional horsepower motors where no remote control is required. Toggle switches may be used for controlling single phase motors of 1/8 horsepower or less and shall be equipped with integral thermal protection. Said switches shall include neon, LED or other indicating pilot light. Provide Square D, Class 2510, General Electric Type CR101, Allen Bradley Type 609.

B. Enclosures shall be rated for area where installed or as otherwise called for within Contract documents.

2.4 VARIABLE FREQUENCY CONTROLLER (AFD's)

A. Variable frequency controllers furnished by others shall be installed including power wiring by the Electrical Contractor. Control wiring shall be provided by the Temperature Controls Contractor. Programming of variable frequency drive by Electrical Contractor under the direction of Temperature Controls Contractor.

B. The Electrical Contractor shall provide all variable frequency controllers, cabinets, mounting hardware, cooling, heating, grounding, noise suppression and wiring. Programming of variable frequency drive by Electrical Contractor under the direction of Temperature Controls Contractor where required. Refer to Specification 26 29 23 and relating specifications in Division 26.

C. Installation and wiring of controller shall strictly confirm to the manufacturer installation requirements. No exceptions. Deviations taken by the Electrical Contractor may void drive or other related sub-components warranty resulting in financial responsibility of the Electrical Contractor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Overload heater charts shall be furnished mounted inside doors of cabinets or separately framed and mounted outside the equipment. Also provide in service manual.

B. Motors whose inrush current exceeds 40 percent of the building transformer rating shall be equipped with reduced voltage or soft start starter.

C. Connect hand off auto selector switches so that automatic control only is bypassed in "manual" position. All safety controls are maintained whether in the auto or manual position.

D. Where indicated, and approved by Code, motor controllers may be omitted when horsepower rated thermostat, float, or pressure switches and similar devices are provided which can control the motor directly. Omit motor

controls only where starting and running motor protection is established by other means satisfactory to conform to National Electric Code Requirements. Motor overload protection on all phases is a requirement.

E. Install motor switches in flush enclosures in finished areas unless otherwise noted.

F. Examine schedules, control diagrams, and manufacturer's shop drawings before ordering motor controllers. Order controllers to satisfy diagrams and project document requirements. Should conflicting data exist in specifications, drawings, and diagrams, request corrected data prior to placing orders.

G. Where motor starting equipment is shown or required to be free standing, provide suitable galvanized steel framing to support required equipment.

H. Provide a raised 4 inch concrete slab to mount freestanding motor equipment.

I. Separately mounted motor starters furnished under Division 23 shall be installed by this contractor meeting respective manufacturer requirements.

END OF SECTION 262913

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SECTION 269999 – DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

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. Fire-alarm control unit. Modify and expand existing.
2. Manual fire-alarm boxes. Reuse existing devices.
3. System smoke detectors.
4. Heat detectors.
5. Notification appliances.
6. Audio source unit with local microphone in main control panel.
7. Amplifiers.
8. Remote annunciator.
9. Addressable interface device.
10. Digital alarm communicator transmitter.
11. Control, monitor and signal modules.

B. SCOPE OF WORK

1. The scope of work or this project is as follows:

a. Provide engineering for design of system and for the permit submittal package by NICET certified, state licensed, and manufacturer certified designer.

b. Application for permit including submittal package with system layout, wiring diagram, battery calculations, and devices cut sheets. Includes fees associated with the application for permit and acceptance testing during normal business hours.

c. Includes close out documents including as-built drawings, device cut sheets, and pertinent project information.

d. Includes performing acceptance testing with the authorities having jurisdiction during normal business hours during an academic break.

e. Includes furnishing EST3 fire alarm control panel and remote booster power supplies for the distribution of power throughout the facility for visual notification devices and auxiliary power for the sounder base notification in the dormitory rooms. Booster power supplies will be centrally located on each floor with (2) notification circuits going in each direction and (2) auxiliary power circuits to supply the sounder bases with supervise power. Booster power supplies in the Basement or Ground Level Floors will only utilize (2) notification circuits since there is not a need for auxiliary power circuits.

f. The detection utilized inside the dormitory rooms will activate the sounder bases notification device within the respected room and the adjacent room only if the room shares Jack and Jill bathrooms. The rooms who share a Jack and Jill bathroom will have a visual notification device inside the shared bathroom for notification. Rooms without a shared bathroom will not have any additional notification inside the bathroom. Smokes inside the room will not dispatch the local fire department but will alert the Campus Policy via the FireWorks workstations and communication from the central monitoring station.

g. Includes reusing the existing smoke detectors, adding new smoke detectors, and providing new notification devices throughout the facility in common areas.

h. Includes furnishing duct detector and intelligent relays in new HVAC unit.

i. Includes furnishing and installing a programmable switch card in the main control panel to initiate controls of the (9) different audio speaker zones, (1) bypass of alarm notification signals, (1) bypass controls of the (9) different audio speaker zones, (1) bypass of alarm notification signals, (1) bypass of air handling shutdown functions, and (1) bypass of elevator control functions.

j. Includes furnishing and installing an audio source unit with a corded microphone in the main control panel located in the vestibule hallway. The audio source unit is capable of storing 2 minutes of prerecorded audio messages and also live voice controls utilizing the microphone input.

k. Includes audio amplifiers for the main control panel calculated on each speaker utilizing a tap of 1 watt each.

l. Includes furnishing and programming the necessary equipment to communicate to the FireWorks workstations located at Flynn and Alumni Hall.

m. Includes furnishing and installing the voice over internet protocol so that emergency communications may be initiated from the Flynn Hall, Campus Police Station into the dormitory facility.

n. Includes programming for the fire alarm system to function in accordance with applicable local codes.

o. Includes secondary power supplies for fire alarm control panel to provide 24 hours standby and 15 minutes in alarm for voice evacuation signals.

p. Includes abandoning the polarity reversal system interface into the Schmidt Hall control panel.

q. Includes programming the FireWorks workstations to initiate communication through the dialers located in Flynn and Schmidt Hall.

r. Assumptions:

1) Xavier University will supply (3) network drops to the fire alarm control panel for the integration of the Husman Hall fire alarm system into the campus's mass notification system and emergency communication system.

2) Xavier University's network team will provide (3) static IP addresses for any devices that need to configured to communicate to the existing network gateway.

3) Electrical installation including the mounting of fire alarm devices and panels will be completed by others who possess a current fire alarm license with the State of Ohio.

4) Raceways, conductors, back boxes, and other installation infrastructure will be furnish and installed by others.

5) Elevator contractor will make any necessary connection from the fire alarm relays into the elevator control equipment.

6) Elevator Contractor will install traveling cable to each speaker installed in elevator cars.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. NICET: National Institute for Certification in Engineering Technologies.

1.4 SYSTEM DESCRIPTION

A. Noncoded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.

2. Shop Drawings shall be prepared by persons with the following qualifications:

a. Trained and certified by manufacturer in fire-alarm system design.

b. NICET-certified fire-alarm technician, Level IV minimum.

c. Licensed or certified by authorities having jurisdiction.

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

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.

2. Include voltage drop calculations for notification appliance circuits.

3. Include battery-size calculations.

4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.

5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.

6. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

D. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.

2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.

E. Qualification Data: For qualified Installer.

F. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Field quality-control reports.

H. Operation and Maintenance Data: For fire-alarm systems 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. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.

3. Record copy of site-specific software.

4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

   a. Frequency of testing of installed components.

   b. Frequency of inspection of installed components.

   c. Requirements and recommendations related to results of maintenance.

   d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.

6. Abbreviated operating instructions for mounting at fire-alarm control unit.

7. Copy of NFPA 25.

I. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.

2. Program Software Backup: On magnetic media or compact disk, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level IV technician.

C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

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. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of fire-alarm service.

2. Do not proceed with interruption of fire-alarm service without Owner's written permission.

1.8 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service.

B. Equipment Removal: After acceptance of new fire-alarm system, remove certain items of existing disconnected fire-alarm equipment and wiring.

1.9 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. 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 operating system. 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.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.

2. Smoke Detectors and Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 1 unit of each type.

3. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than 1 unit of each type.

4. Keys and Tools: One extra set for access to locked and tamperproofed components.

5. Audible and Visual Notification Appliances: Two of each type installed.

6. Fuses: Two of each type installed in the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Edwards Systems Technology (EST3).

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors (in common areas only).
4. Duct smoke detectors.
5. Automatic sprinkler system water flow.
6. Fire-extinguishing system operation.
7. Fire standpipe system.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Activate voice/alarm communication system.
5. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
7. Recall elevators to primary or alternate recall floors.
8. Activate emergency lighting control.
9. Activate emergency shutoffs for gas and fuel supplies.
10. Record events in the system memory.
11. Record events by the system printer.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.

2. Elevator shunt-trip supervision.

3. Smoke detectors (in student rooms only).

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.

2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.

3. Loss of primary power at fire-alarm control unit.

4. Ground or a single break in fire-alarm control unit internal circuits.

5. Abnormal ac voltage at fire-alarm control unit.

6. Break in standby battery circuitry.

7. Failure of battery charging.

8. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Trouble and Supervisory Signal Actions: Annunciate at fire-alarm control unit and remote annunciators.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.

a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.

b. Include a real-time clock for time annotation of events on the event recorder and printer.

2. Addressable initiation devices that communicate device identity and status.

a. Smoke sensors shall additionally communicate sensitivity setting.

b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.

3. Addressable control circuits for operation of mechanical equipment.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 8 line(s) of 21 characters.

2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

C. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class B.

D. Elevator Recall:

1. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start elevator recall.

a. Elevator lobby detectors except the lobby detector on the designated floor.

b. Smoke detector in elevator machine room.

2. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.

E. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

F. Voice/Alarm Signaling Service: Central emergency communication system with microphone, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.

1. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711 and be listed by an NRTL.

a. Allow the application of and evacuation signal to indicated number of zones and, at same time, allow voice paging to the other zones selectively or in any combination.

b. Programmable tone and message sequence selection.

c. Standard digitally recorded messages for "Evacuation" and "All Clear."

d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification appliance circuits of fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.

3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

G. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event,

including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

H. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

I. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium, Sealed, valve-regulated, recombinant lead acid.

J. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.

2. Station Reset: Key- or wrench-operated switch.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.

2. Detectors shall be two-wire type.

3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.

5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.

6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.

7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.

    b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).

    c. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.

    b. Device type.

    c. Present average value.

    d. Present sensitivity selected.

    e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.

    b. Device type.

    c. Present average value.

    d. Present sensitivity selected.

    e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.

4. Each sensor shall have multiple levels of detection sensitivity.

5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

6. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.6 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable.

2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.

B. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

C. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

1. Rated Light Output:

a. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.

3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.

4. Flashing shall be in a temporal pattern, synchronized with other units.

5. Strobe Leads: Factory connected to screw terminals.

6. Mounting Faceplate: Factory finished, white.

D. Voice/Tone Notification Appliances:

1. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.

2. Low-Range Units: Rated ¼ to 2 W, 70V RMS.

3. Mounting: semi recessed or surface mounted and bidirectional.

4. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.8 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.9 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of the building.

2. Connect new equipment to existing monitoring equipment at the supervising station.

3. Expand, modify, and supplement existing control equipment as necessary to extend existing control functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

C. Smoke- or Heat-Detector Spacing:

1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.

2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.

3. Smooth ceiling spacing shall not exceed 30 feet (9 m).

4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.

5. HVAC: Locate detectors not closer than 3 feet (1 m) from air-supply diffuser or return-air opening.

6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.

D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

E. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

F. Wall Mounted Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling.

G. Wall Mounted Visible Alarm-Indicating Devices: Install not less than 80" above floor and at least 24 inches below the ceiling.

H. Device Location-Indicating Lights: Locate in public space near the device they monitor.

I. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.

3.2 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to elevator recall system and components.

2. Supervisory connections at valve supervisory switches.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.4 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.5 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.

b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.

4. Test audible appliances for the private operating mode according to manufacturer's written instructions.

5. Test visible appliances for the public operating mode according to manufacturer's written instructions.

6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 269999

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