

SECTION 230100
GENERAL PROVISIONS FOR HVAC

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. Provisions of this Section apply to all Division 23 Specification Sections.

1.2 SUMMARY

- A. Section includes basic requirements for heating, ventilation, and air-conditioning systems.
- B. Related Work:
 - 1. Division 03 – Concrete
 - a. Refer to Division 03 for rough grouting in and around work, patching concrete cut to accommodate work, and sumps for work.
 - b. Comply with the requirements of Division 03 for curbs, foundations, inertia bases, and equipment pads for equipment.
 - 2. Division 05 – Metals
 - a. Refer to Division 05 for framed openings for equipment.
 - b. Comply with the requirements of Division 05 for supports for work.
 - 3. Division 06 – Wood, Plastics, and Composites
 - a. Refer to Division 06 for framed openings for equipment.
 - 4. Division 07 – Thermal and Moisture Protection
 - a. Refer to Division 07 for installation of roof curbs and roof supports and for caulking and waterproofing of wall- and roof-mounted work.
 - b. Comply with the requirements of Division 07 for penetration firestopping and furnishing roof curbs and roof supports for equipment and piping.
 - 5. Division 08 – Openings
 - a. Refer to Division 08 for installation of access doors and frames and for louvers and vents.
 - b. Comply with the requirements of Division 08 for access doors and frames and for louvers and vents, unless otherwise included in the Contract Documents.
 - 6. Division 09 – Finishes
 - a. Refer to Division 09 for paint products and applications in finished spaces.

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

- b. Comply with the requirements of Division 09 for paint products and applications identified in the Contract Documents.
- 7. Division 10 – Specialties
 - a. Refer to Division 10 for fire protection cabinets and fire extinguishers.
- 8. Division 21 – Fire Suppression
 - a. Refer to Division 21 for all suppression work.
- 9. Division 22 – Plumbing
 - a. Refer to Division 22 for all plumbing work.
 - b. Comply with requirements of Division 22 for related equipment and components and for connections to systems.
- 10. Division 25 – Instrumentation and Control
 - a. Refer to Division 25 for instrumentation and control systems.
 - b. Comply with the requirements of Division 25 for installation of and integration with instrumentation and control components.
- 11. Division 26 – Electrical
 - a. Refer to Division 26 for all electrical work.
- 12. Division 27 – Communications
 - a. Refer to Division 27 for all communications work.
- 13. Division 28 – Electronic Safety and Security
 - a. Refer to Division 28 for all electronic safety and security work.
 - b. Coordinate with Division 28 for integration with security systems.
- 14. Division 29 – Fire Safety and Emergency Communications
 - a. Refer to Division 29 for all fire safety and emergency communications work.
 - b. Coordinate with Division 29 for integration with fire safety and emergency communications systems.
- 15. Division 31 – Earthwork
 - a. Refer to Division 31 for all site related work greater than five feet outside the building, unless noted otherwise in the Contract Documents.
 - b. Comply with the requirements of Division 31 for site clearing, earth moving, and dewatering within five feet outside the building and otherwise as indicated in the Contract Documents.
- 16. Division 33 – Utilities
 - a. Refer to Division 33 for all utility related work greater than five feet outside the building, unless noted otherwise in the Contract Documents.

- b. Comply with the requirements of Division 33 for utility work within five feet outside the building and otherwise as indicated in the Contract Documents.

1.3 DEFINITIONS

- A. Experienced: When used with an entity or individual, "experienced" unless otherwise further described means having successfully completed a minimum of five previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.
- B. Furnish: Supply and deliver to project site, ready for subsequent requirements.
- C. Install: Operations at project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar requirements.
- D. Provide: Furnish and install, complete and ready for intended use.
- E. Cutting: Removal of in-place construction necessary to permit installation or performance of subsequent work.
- F. Patching: Fitting and repair work required to restore construction to original conditions after installation of subsequent work.
- G. Concealed Work: Work hidden from view, including inside chases, furred spaces, or above ceilings.
- H. Exposed Work: Work open to view, including inside mechanical and equipment rooms.

1.4 QUALITY ASSURANCE

- A. General:
 1. It is the intent of the plans and specifications to obtain a complete, operable and satisfactory installation.
 2. All materials shall be new, be properly labeled and/or identified and be in full compliance with the contract documents.
 3. All work shall comply with applicable Codes and Standards.
 4. Manufacturer's model names and numbers used in these specifications are subject to change per manufacturer's action. Contractor shall therefore verify them with manufacturer's representative before ordering any product or equipment
- B. Furnish new and unused materials and equipment manufactured in the U.S.A. Where two or more units of the same type or class of equipment are required provide units of a single manufacturer.

1.5 CODES AND STANDARDS

- A. Perform work in accordance with the following codes and any applicable statutes, ordinances, codes, and regulations of governmental authorities having jurisdiction.
 1. ASHRAE

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

- a. Standard 15 Safety Standard for Refrigeration Systems - 2019
 - b. Standard 55 Thermal Environmental Conditions for Human Occupancy – 2017
 - c. Standard 62.1 Ventilation Standard for Acceptable Indoor air Quality - 2019
 - d. Standard 90.1 Energy Standard for Buildings Except Low Rise Residential Buildings - 2019
2. Occupational Safety and Health Regulations (OSHA).
3. National Fire Codes
- a. NFPA 1 Fire Code – 2021 (Florida Edition)
 - b. NFPA 30 Flammable and Combustible Liquids Code - 2021
 - c. NFPA 52 Vehicular Gaseous Fuel Systems Code – 2019
 - d. NFPA 54 National Fuel Gas Code – 2021
 - e. NFPA 70 National Electrical Code – 2020
 - f. NFPA 72 National Fire Alarm and Signaling Code - 2019
 - g. NFPA 90A Standard for the Installation of Air Conditioning and Ventilation Systems - 2021
 - h. NFPA 90B Standard for the Installation of Warm Air Heating and Air Conditioning Systems - 2021
 - i. NFPA 91 Standard for the Installation of Blower and Exhaust Systems - 2020
 - j. NFPA 101 Life Safety Code – 2021 (Florida Edition)
4. Florida Building Code, 2023 Edition
- a. Building Code
 - b. Energy Conservation Code
 - c. Mechanical Code
 - d. Plumbing Code
 - e. Fuel Gas Code
 - f. Accessibility Code
5. Florida Statutes
- a. Chapter 471 Engineering
 - b. Chapter 533.80 Building Construction Standards; Florida Building Code - Enforcement
6. Florida Administrative Code
- a. Chapter 9B-7 Florida Building Commission Handicapped Accessibility Standards
 - b. Chapter 61C-5 Florida Elevator Safety Code
 - c. Chapter 61G15-34 Responsibility Rules of Professional Engineers Concerning the Design of Mechanical Systems
 - d. Chapter 69A-3 Fire Prevention – General Provisions
 - e. Chapter 69A-60 The Florida Fire Prevention Code
- B. Resolve, in writing, any code violation discovered in contract documents with the Engineer prior to bidding. After award of the contract, make any correction or addition necessary for compliance with applicable codes at no additional cost to Owner.
- C. The Contractor shall include in the Work, without extra cost to the Owner, any labor, materials, services, apparatus, and drawings required to comply with all applicable laws, ordinances, rules, and regulations.

- D. Where there is conflict between the Contract Documents and the applicable Codes, the Codes shall govern, except where the requirements of the Contract Documents are more stringent.

1.6 REFERENCE SPECIFICATIONS AND STANDARDS

- A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, or AWWA Specifications; Federal Standards; or other standard specifications must comply with latest editions, revisions, amendments, or supplements in effect on date bids are received. Specifications and standards are minimum requirements for all equipment, material and work. In instances where capacities, size or other feature of equipment, devices or materials exceed these minimums, meet listed or shown capacities.
- B. Whenever a reference is made to a standard, installation and materials shall comply with the latest published edition of the standard at the time project is bid unless otherwise specified herein

1.7 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.

1.8 PERMITS FEES AND INSPECTIONS

- A. Obtain and pay for all permits, fees, tap fees, connection charges, demand charges, systems charges, impact fees, and inspections.
- B. Deliver all certificates of inspection issued by authorities having jurisdiction to the Engineer.

1.9 CONFLICTING REQUIREMENTS

- A. Conflicting Standards and Other Requirements: If compliance with two or more standards or requirements are specified and the standards or requirements establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to Engineer for direction before proceeding.
 - 1. If discrepancies or conflicts occur between drawings, or between drawings and specifications, notify the Engineer in writing prior to bid date; however, the most stringent requirement shall govern.
- B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to Engineer for a decision before proceeding.

1.10 REQUEST FOR INFORMATION (RFI)

- A. General: Immediately on discovery of the need for additional information, clarification, or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.
 - 1. Engineer will return without response those RFIs submitted to Engineer by other entities controlled by Contractor.
 - 2. Coordinate and submit RFIs in a prompt manner to avoid delays in Contractor's work or work of subcontractors.
- B. Prepare RFIs as PDF electronic files and electronically transmit to Engineer through email or web-based project software site, in accordance with Division 01 Specification Sections. All electronic files shall ONLY be transmitted to inbox@h2engineering.com and shall not be transmitted to any individual email addresses for H2Engineering personnel. Submittals shall be in searchable PDF format and not a scanned copy.
- C. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow seven days for Engineer's response for each RFI. RFIs received by Engineer after 1:00 p.m. Eastern Time will be considered as received the following working day.
 - 1. The following Contractor-generated RFIs will be returned without action:
 - a. Requests for approval of submittals.
 - b. Requests for approval of substitutions.
 - c. Requests for approval of Contractor's means and methods.
 - d. Requests for coordination information already indicated in the Contract Documents.
 - e. Requests for adjustments in the Contract Time or the Contract Sum.
 - f. Requests for interpretation of Engineer's actions on submittals.
 - g. Incomplete RFIs or inaccurately prepared RFIs.
 - 2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt by Engineer of additional information.

1.11 SUBMITTALS

- A. Submittals (including Product Data, Shop Drawings, and any other Action Submittal or Information Submittal) will only be reviewed if they are submitted in full accordance with the General and Supplementary Conditions, Division 01, and the following:
 - 1. Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.
 - 2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are approved by the Engineer.
 - 3. Submittals shall only contain relevant product data. Remove or strikeout irrelevant product data.
 - 4. Prepare submittals as PDF electronic files and electronically transmit to Engineer through email or web-based project software site, in accordance with Division 01 Specification Sections. All electronic files shall ONLY be transmitted to inbox@h2engineering.com and shall not be transmitted to any individual email addresses for H2Engineering personnel. Submittals shall be in searchable PDF format and not a scanned copy.
 - 5. Options: Identify options requiring selection by Engineer.

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

6. Deviations: Clearly identify deviations from requirements in the Contract Documents, including minor variations and limitations.
 7. Revisions: Include relevant additional information and revisions, other than those specifically requested by Engineer on previous submittals. Indicate by highlighting on each submittal or noting on attached submittal sheet.
 8. Contractor's Review:
 - a. Submittals shall have been reviewed and approved by the General Contractor / Construction Manager. Include approval stamp, 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.
 - b. Engineer will not review submittals received from Contractor that do not have Contractor's review and approval.
 9. Electrical Modifications:
 - a. The electrical design indicated on the plans supports the Basis of Design specifications for the HVAC systems at the time of design.
 - b. If HVAC equipment is submitted with different electrical requirements, it is the responsibility of the Contractor to resolve all required electrical design changes, including, but not limited to: wire and conduit size, type or size of disconnect or overload protection, breaker coordination, point(s) of connection, etc. Any corrections required shall be provided at no additional cost.
 - c. Submittal shall clearly show the electrical design revisions with a written statement that this change will be provided at no additional cost. Submittals made with no written reference to the electrical design revisions will be presumed to work with the electrical design.
- B. Processing Time: Time of review shall commence on Engineer's receipt of submittal. No extension of the Contract Time will be authorized because of the failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
1. Allow not less than 15 days for submittal review. Allow not less than 21 days for review of large or complex submittals. Submittals received by Engineer after 1:00 p.m. Eastern Time will be considered as received the following working day.
 2. If Contractor transmits more than five submittals over two consecutive business days, review time shall increase by no less than 7 days for submittal review.
 3. Allow additional time if coordination with subsequent submittals is required. Engineer will advise Contractor when a submittal being processed must be delayed for coordination.
 4. Engineer reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received. Time of review shall commence on receipt of all other related submittals.
- C. The Contractor shall not be relieved of responsibility for deviations from requirements of the contract documents by the Engineer's approval of shop drawings, product data, samples, or similar submittals unless the Contractor has specifically informed the Engineer in writing of such deviation at the time of submittal, and the Engineer has given written approval to the specific deviation. The Contractor shall not be relieved of responsibility for errors or omissions in shop drawings, product data, samples, or similar submittals by the Engineer's approval thereof.
- D. Submittal Review Fees:
1. Additional Reviews: Submittals on any particular phase of Work will receive only one review and one re-review (if required). If additional reviews are required beyond these two, the Contractor will be charged \$200.00 per hour for review time, in addition to any

expedited review charges. This fee shall be paid to the Engineer prior to Submittal release.

2. Expedited Reviews: If General Contractor / Construction Manager requests for an expedited review, whether by official request or unofficially by assigning a review time less than required above, the General Contractor / Construction Manager will be charged \$1,000.00 per Submittal, in addition to any charges for additional reviews. This fee shall be paid to the Engineer prior to Submittal release.

1.12 COORDINATION DRAWINGS (NOT REQUIRED)]

- A. Should the Contractor elect to provide Coordination Drawings when not expressly required by the Engineer, such Drawings shall be considered for informational purposes only. The Engineer will not conduct a review of these Drawings, and their submission or any implied approval shall not relieve the Contractor of the obligation to fully comply with the requirements set forth in the Construction Documents. The Contractor remains solely responsible for ensuring that all work meets the contract specifications and standards, regardless of the content or status of the Coordination Drawings.

1.13 SUBSTITUTIONS

- A. By submitting a bid, the Bidder represents that its bid is based on materials and equipment described in the Procurement and Contracting Documents, including Addenda. Bidders are encouraged to request approval of qualifying substitute materials and equipment when the Specifications Sections list materials and equipment by product or manufacturer name.
- B. Substitution Requests shall include, at a minimum:
 1. Statement indicating why specified material, equipment, or installation method cannot be provided, if applicable.
 2. Coordination of information, including a list of changes and revisions needed to other parts of the Work and to construction performed by Owner and separate contractors that will be necessary to accommodate proposed substitution.
 3. Detailed comparison of significant qualities of proposed substitutions with those of the Work specified. Include an annotated copy of applicable Specification Section. Significant qualities may include attributes, such as performance, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements indicated. Indicate deviations, if any, from the Work specified.
 4. Product Data, including drawings and descriptions of products and fabrication and installation procedures.
 5. Detailed comparison of Contractor's construction schedule using proposed substitutions with products specified for the Work, including effect on the overall Contract Time. If specified product or method of construction cannot be provided within the Contract Time, include letter from manufacturer, on manufacturer's letterhead, stating date of receipt of purchase order, lack of availability, or delays in delivery.
 6. Cost information, including a proposal of change, if any, in the Contract Sum.
 7. Contractor's certification that proposed substitution complies with requirements in the Contract Documents, except as indicated in substitution request, is compatible with related materials and is appropriate for applications indicated.
 8. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.

- C. Procurement Substitution Requests submitted prior to receipt of bids will be received and considered by Owner when the following conditions are satisfied, as determined by Engineer; otherwise, requests will be returned without action:
1. Requests for substitution of materials and equipment are received no later than 10 days prior to date of bid opening.
 2. Extensive revisions to the Contract Documents are not required.
 3. Proposed changes are in keeping with the general intent of the Contract Documents, including the level of quality of the Work represented by the requirements therein.
 4. The request is fully documented and properly submitted.
- D. Substitutions for Cause, as required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms will be received and considered by Engineer, only when the following conditions are satisfied; otherwise, requests will be returned without action, except to record noncompliance with these requirements:
1. Requested substitution is consistent with the Contract Documents and will produce indicated results.
 2. Substitution request is fully documented and properly submitted.
 3. Requested substitution has received necessary approvals of authorities having jurisdiction.
 4. Requested substitution is compatible with other portions of the Work.
 5. Requested substitution has been coordinated with other portions of the Work.
 6. Requested substitution provides specified warranty.
 7. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
- E. Substitutions for Convenience, not required in order to meet other Project requirements but may offer advantage to Contractor or Owner, will be received and considered by Owner, as determined by Engineer, only when the following conditions are satisfied; otherwise, requests will be returned without action, except to record noncompliance with these requirements:
1. Requested substitution is received within 60 days after the Notice of Award.
 2. Requested substitution offers Owner a substantial advantage in cost, time, energy conservation, or other considerations, after deducting additional responsibilities Owner must assume. Owner's additional responsibilities may include compensation to Engineer for redesign and evaluation services, increased cost of other construction by Owner, and similar considerations.
 3. Requested substitution does not require extensive revisions to the Contract Documents.
 4. Requested substitution is consistent with the Contract Documents and will produce indicated results.
 5. Substitution request is fully documented and properly submitted.
 6. Requested substitution has received necessary approvals of authorities having jurisdiction.
 7. Requested substitution is compatible with other portions of the Work.
 8. Requested substitution has been coordinated with other portions of the Work.
 9. Requested substitution provides specified warranty.
 10. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.
- F. If a requested substitution is approved but contains differences or omissions not specifically identified to the attention of the Engineer in the substitution request, the Owner reserves the right to require equal or similar features to be added to the substituted products or to have the substituted products replaced at the Contractor's expense.

1.14 PROJECT RECORD DOCUMENTS

- A. Recording: Maintain one copy of the Contract Documents and Shop Drawings 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.
- B. Preparation:
 - 1. Contract Drawings and Shop Drawings:
 - a. Mark revisions to show where the actual installation varies from that shown originally.
 - b. Mark record sets completely and accurately, including important information that was either shown schematically or omitted from original Drawings.
 - c. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
 - d. Record underground and under-slab piping installed, dimensioning exact location and elevation of piping.
 - 2. Mark Specifications to indicate the actual product installation where installation varies from that indicated in Specifications, addenda, and contract modifications.
 - 3. Mark Product Data to indicate the actual product installation where installation varies substantially from that indicated in Product Data submittal.
- C. Deliver: Prior to Final Completion, provide record documents to Owner as indicated below:
 - 1. Record Drawings: Submit PDF electronic files of scanned record prints and one set of prints.
 - 2. Record Specifications: Submit annotated PDF electronic files of Project's Specifications, including addenda and contract modifications.
 - 3. Record Product Data: Submit annotated PDF electronic files and directories of each submittal.
 - 4. Miscellaneous Record Submittals: Submit annotated PDF electronic files directories of each submittal.

1.15 OPERATION AND MAINTENANCE MANUALS

- A. Prepare and submit a comprehensive manual of emergency, operation, and maintenance data and materials in full accordance with the General and Supplementary Conditions, Division 01, and the following:
 - 1. Operations and Maintenance Manuals: Assemble a complete set of data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system, including:
 - a. Information required for daily operation and management, operating standards, and routine and special operating procedures.
 - b. Manufacturers' maintenance documentation, preventative maintenance procedures and frequency, repair procedures, wiring and systems diagrams, list of spare parts, and warranty information.
 - 2. Submit manuals as PDF electronic files and electronically transmit to Engineer through email or web-based project software site, in accordance with Division 01 Specification Sections. Submittals shall be in searchable PDF format and not a scanned copy.

1.16 DEMONSTRATION AND TRAINING

- A. Prepare and provide services of qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not a part of a system in accordance with the General and Supplementary Conditions, Division 01, individual Specification Sections, and the following:
 - 1. Demonstration and training shall occur upon completion of the Work and at a time designated by the Owner's representative.
 - 2. Provide a high-resolution, digital video recording of each training session to the Owner.

1.17 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. Inspect products on delivery to determine compliance with the Contract Documents and to determine that products are undamaged and properly protected.

1.18 WARRANTY

- A. Warranty work and equipment within specified warranty period. During the warranty period, provide labor and materials to make good any faults or imperfections that may arise due to defects or omissions in materials or workmanship without expense to the Owner.
 - 1. Warranty Period: One year from date of Substantial Completion.
- B. 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 Contract Documents.
- C. Owner reserves the right to make emergency repairs as required to keep equipment in operation without voiding Contractor's Guarantee Bond nor relieving the Contractor of responsibilities during the warranty period.

PART 2 - PRODUCTS (NONE)

PART 3 - EXECUTION

3.1 CONTRACT DOCUMENTS

- A. Examine all drawings and specifications carefully before submitting a bid. Architectural drawings take precedence over mechanical or electrical drawings with reference to building construction.
- B. For purposes of clearness and legibility, drawings are essentially diagrammatic and, although size and location of equipment are drawn to scale wherever possible, Contractor shall make use of all data in all of the contract documents and shall verify this information at the building

- C. The drawings indicate required size and points of termination of pipes, conduits, 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 responsibility of the 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 instructions or cost to the Owner.
- D. Furnish, install and/or connect with appropriate services all items shown on any drawing without additional compensation.
- E. Any and all questions about a subcontractor's scope of work responsibility shall be addressed to and answered by the General Contractor / Construction Manager.
- F. Questions About Construction Documents: Any and all questions shall be submitted through the proper channels IN WRITING and, in turn, shall be answered by the Engineer in writing. All telephone conversations shall be considered unofficial and, as such, shall not be considered official or binding responses to Contractor's questions.
- G. Drawings, specifications, or other documents issued by the Engineer in electronic format and/or electronic media are provided for convenience only and are not intended for use as Contract Documents.
 - 1. The electronic files are provided merely as a convenience to the Recipient.
 - 2. The electronic files do not replace or supplement the paper copies of any drawings, specifications, or other documents included in the Contract Documents for use on the project.
 - 3. The Engineer makes no representation, warranty, or guarantee that electronic files:
 - a. Are suitable for any other usage or purpose.
 - b. Have any particular durability.
 - c. Will not damage or impair the Recipient's computer or software.
 - d. Contain no errors or mechanical flaws or other discrepancies that may render them unsuitable for the purpose intended by the Recipient.
 - 4. Due to the unsecured nature of the electronic files and the inability of Engineer or the Recipient to establish controls over their use, the Engineer assumes no responsibility for any consequences arising out of the use of the data. It is the sole responsibility of the Recipient to check the validity of all information contained therein. The Recipient shall at all times refer to the signed and sealed drawings, specification or other documents for the project during all phases of the project. The Recipient shall assume all risks and liabilities resulting from the use of the electronic files.

3.2 SUPERVISION OF WORK

- A. Perform all work under the direct supervision of an experienced, qualified superintendent. The Engineer has the right to remove a superintendent who, in the Engineer's opinion, is not satisfactory.

3.3 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.
- 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.
 - 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.

3.4 PREPARATION

- A. Existing Utility Information: Furnish information to Owner that is necessary to adjust, move, or relocate existing utility structures, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.
- B. 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.
- C. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.
- D. 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 Engineer.
- E. Interruption of Service: Before any existing equipment or system is shut down for disconnecting or tie-ins, coordinate with Engineer and Owner regarding acceptable dates and times for this Work to be performed. Work shall be performed at the time best suited for the Owner, which typically is either on weekends, holidays, and/or after normal working hours. Services shall be restored the same day unless prior arrangements are made. All overtime or premium costs associated with this Work shall be included in the Contractor's bid.

3.5 INSTALLATION

- A. Install materials and equipment in a professional manner. The Engineer may direct replacement of items which, in the Engineer's opinion, do not present a professional appearance or do not allow adequate space for maintenance. Replace or reinstall items at the expense of the Contractor.

- B. 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.
 - 4. Maintain minimum headroom clearance of 96 inches (2440 mm) in occupied spaces and 90 inches (2300 mm) in unoccupied spaces.
- C. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.
- D. Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.
- E. 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.
- F. Sequence the Work and allow adequate clearances to accommodate movement of construction items on site and placement in permanent locations.
- G. Obstructions
 - 1. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.
 - 2. Before any cutting or trenching operations are begun, verify with Owner's representative, utility companies, municipalities, and other interested parties that all available information has been provided. Verify locations given.
 - 3. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.
 - 4. Assume total responsibility for and repair any damage to existing utilities or construction, whether or not such existing facilities are shown.
- H. Where "rated" walls, floor, roofs and ceilings are penetrated or cut to install equipment, materials, devices, etc. the Contractor shall provide and install all materials required to re-establish the rating of the wall, floor, roof, or ceiling to the satisfaction of the authority having jurisdiction.
- I. Structural Elements: Do not cut structural elements without written approval from Engineer. Notify Engineer of locations and details of cutting and await directions from Engineer before proceeding. If approved by Engineer:
 - 1. Shore, brace, and support structural elements during cutting and patching.
 - 2. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection.
- J. Space Requirements: Consider space limitations imposed by contiguous work in selection and location of equipment and material. Do not provide equipment or material which is not suitable in this respect.

- K. Tools and Equipment: Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions without cost to the Owner.
- L. Phasing: Provide all temporary valves, piping, ductwork, equipment, and devices as required. Maintain temporary services to areas as required. Remove all temporary material and equipment on completion of work unless Engineer concurs that such material and equipment would be beneficial to the Owner on a permanent basis.

3.6 OWNER-INSTALLED PRODUCTS

- A. Coordination: Coordinate construction and operations of the Work with work performed by Owner's construction personnel.

3.7 UTILITY SERVICES AND MECHANICAL SYSTEMS

- A. Existing Services/Systems to Remain: Maintain services/systems indicated to remain and protect them against damage.
- B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off utility services and mechanical/electrical systems serving areas to be selectively demolished.
 - 1. Owner will arrange to shut off indicated services/systems when requested by Contractor.
 - 2. Arrange to shut off utilities with utility companies.
 - 3. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
 - 4. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated on Drawings to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material and leave in place.
 - c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
 - f. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - g. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material and leave in place.

3.8 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.

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

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. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during installation or cutting and patching operations, by methods and with materials so as not to void existing warranties.
- C. Temporary Support: Provide temporary support of work to be cut.
- D. 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.
- E. Structural Elements: When cutting and patching structural elements, notify Engineer of locations and details of cutting and await directions from Engineer 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.
- F. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety.
- G. Other Construction Elements: Do not cut and patch other construction elements or components in a manner that could change their load-carrying capacity, that results in reducing their capacity to perform as intended, or that result in increased maintenance or decreased operational life or safety.
- H. Visual Elements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch exposed construction in a manner that would, in Engineer's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.
- I. 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.
 3. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
 4. Excavating and Backfilling: Comply with requirements in applicable Sections where required by cutting and patching operations.
 5. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.
 6. Proceed with patching after construction operations requiring cutting are complete.
- J. 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 or with in-place materials.

1. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.
 2. If identical materials are unavailable or cannot be used, use materials that, when installed, will provide a match acceptable to Engineer for the visual and functional performance of in-place materials.
- K. Cleaning: Clean areas and spaces where cutting and patching are performed. Remove paint, mortar, oils, putty, and similar materials from adjacent finished surfaces.

3.9 PAINTING

- A. Comply with requirements with General and Supplementary Conditions, Division 01, Division 09, and individual Specification Sections.
- B. Touch-up factory finishes on equipment provided under Division 23. Obtain matched color coatings from the manufacturer and apply as directed. If corrosion is found during inspection on the surface of any equipment, clean, prime, and paint, as required.
- C. Paint the following work where exposed to view:
1. Uninsulated Metal Piping (bare copper piping not required to be painted unless noted otherwise):
 - a. Condenser Water: Green
 - b. Other: To be determined by Engineer
 2. Uninsulated plastic piping
 3. Tanks that do not have factory-applied final finishes.
 4. Duct, equipment, and pipe insulation having a cotton or canvas insulation covering or other paintable jacket material, as outlined in individual Specification Sections.
- D. Paint the following work where exposed in occupied spaces:
1. Duct, equipment, and pipe insulation having a cotton or canvas insulation covering or other paintable jacket material, as outlined in individual Specification Sections.
 2. Other items as directed by Engineer.
- E. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

3.10 REPAIR OF WORK

- A. Complete repair and restoration operations before requesting inspection for determination of Substantial Completion.
- B. Repair or remove and replace defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specified condition.

1. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that already show evidence of repair or restoration.
 - a. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.
2. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.

3.11 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Furnish a letter from an authorized factory representative of the air conditioning unit manufacturer stating that the complete refrigeration installation including pipe sizing and routing and operating and safety controls has been checked and is operating properly.
- C. Tests
 1. Include all tests specified and/or required under laws, rules and regulations of all departments having jurisdiction. Tests shall also be performed as indicated herein and other sections of the specifications.
 2. After all systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation. Make adjustments as required to ensure proper functioning of all systems.
 3. All parts of the work and associated equipment shall be tested and adjusted to work properly and be left in perfect operating condition.
 4. Correct defects disclosed by these tests without any additional cost to the Owner. Repeat tests on repaired or replaced work.
 5. Maintain a log of all tests being conducted and have it available for review by the Engineer. Log to indicate date, type of tests, duration, and defects noted and when corrected.
 6. Special tests on individual systems are specified under individual Specification Sections.
- D. Retesting/Reinspecting: Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and reinspecting, for construction that replaced Work that failed to comply with the Contract Documents.

3.12 CLEANING

- A. Progress Cleaning: Clean Project site and work areas daily, including common areas. Enforce requirements strictly. Dispose of materials lawfully.
 1. Comply with requirements in NFPA 241 for removal of combustible waste materials and debris.
 2. Do not hold waste materials more than seven days during normal weather or three days if the temperature is expected to rise above 80 deg F (27 deg C).
 3. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately and dispose of legally, according to regulations.

- B. Final Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.
- 1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a designated portion of Project:
 - a. Remove tools, construction equipment, machinery, and surplus material from Project site.
 - b. Remove labels that are not permanent.
 - c. Wipe surfaces of equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.

END OF SECTION

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**SECTION 230513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

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 general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

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.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.

- C. Service Factor: 1.15.
- D. Power factor: 0.80.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Re-greasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- G. Temperature Rise: Match insulation rating.
- H. Insulation: Class F.
- I. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable-Frequency Controllers:
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
- B. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- C. Motors 1/20 HP and Smaller: Shaded-pole type.
- D. 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.

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings
PART 3 - EXECUTION (Not Applicable)

END OF SECTION

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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. Grout.
 - 4. Silicone sealants.
- B. Related Requirements:
 - 1. Division 07 for penetration Firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- B. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Jay R. Smith Mfg. Co; 1720-C or a comparable product by one of the following:

1. Zurn Industries, LLC.

- B. Description: Manufactured, cast-iron sleeve with integral cast flashing flange for use in water-proof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 GROUT

- A. Description: Non-shrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.4 SILICONE SEALANTS

- A. Silicone, S, NS, 25, NT: Single-component, non-sag, plus 25 percent and minus 25 percent movement capability, non-traffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, use NT.
 1. Sealant shall have a VOC content of 250 g/L or less.
- B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and non-traffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.
 1. Sealant shall have a VOC content of 250 g/L or less.
- C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.
 1. Sealant shall have a VOC content of 250 g/L or less.

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 2-inch (50-mm) 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.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. 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 (50 mm)** above finished floor level.
 - 3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.
- D. 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 (6.4-mm)** annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified Division 07.

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 (6.4-mm)** annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 07.
 - 3. Install section of cast-iron soil pipe to extend sleeve to **3 inches (76 mm)** above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.
- B. Fire-Resistance-Rated, Horizontal Assembly, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Division 07.

3.3 HOLE-FORMING SYSTEM INSTALLATION

- A. Install hole-forming systems in new walls and slabs as they are constructed.
- B. Provide quantity of disks to match finished wall thickness.
- C. Wrap seams between disks with tape to bridge gaps.

- D. After removal of disks, repair voids and grind smooth any ridges to provide a smooth opening.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

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 (DN 150)**: Steel pipe sleeves.
 - b. Piping **NPS 6 (DN 150)** and Larger: Steel pipe sleeves.
 - 2. Concrete Slabs Above Grade:
 - a. Piping Smaller Than **NPS 6 (DN 150)**: Steel pipe sleeves.
 - b. Piping **NPS 6 (DN 150)** and Larger: Steel pipe sleeves.
 - 3. Interior Partitions:
 - a. Piping Smaller Than **NPS 6 (DN 150)**: Steel pipe sleeves .
 - b. Piping **NPS 6 (DN 150)** and Larger: Galvanized-steel sheet sleeves.

END OF SECTION

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.

1.3 DEFINITIONS

- A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated and polished brass finish and set-screw fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished, chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

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.
 - b. Insulated Piping: One-piece stamped steel with polished, chrome-plated finish.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: One-piece cast brass with rough-brass finish.
 - f. Bare Piping in Equipment Rooms: One-piece cast brass with rough-brass finish.

3.2 FIELD QUALITY CONTROL

- A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION

**SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT**

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. Metal pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Fastener systems.
 - 5. Insulation couplings.
 - 6. Equipment supports.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
 - 1. Trapeze pipe hangers.
 - 2. Metal framing systems.
 - 3. Pipe stands.
 - 4. Insulation couplings.
 - 5. Equipment supports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pre-galvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

2.3 TRAPEZE PIPE HANGERS

- ### **A.**
- Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. [Cooper B-Line, Inc.](#)
 - b. [Flex-Strut Inc.](#)
 - c. [Unistrut Corporation](#); Tyco International, Ltd.
2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted carbon-steel channel with intumed lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

8. Metallic Coating: Electroplated zinc indoors and Hot-dip galvanized outdoors.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel channel with intumed lips.
4. Channel Width: Select for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Metallic Coating: Hot-dip galvanized.

2.5 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 INSULATION COUPLINGS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide [FNW; Ferguson Enterprises, Inc.](#); Figure 7897 (flexible elastomeric insulation) / Figure 7899 (mineral fiber insulation) or a comparable product by one of the following:
1. [Eaton.](#)
 2. [Unistrut; Part of Atkore International.](#)
- B. Description: Insulation coupling designed to support insulated pipes and for use with metal framing system mounted clamps and either flexible elastomeric or mineral fiber insulation.
- C. Material: Molded with high-strength thermoplastic.
- D. UL Classified 2043 for use in plenum and air handling systems.
- E. Temperature Rating: **-60 deg F to +225 deg F.**

2.7 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MATERIALS

- A. Aluminum: **ASTM B 221 (ASTM B 221M).**

- B. Carbon Steel: ASTM A 1011 / A 1011M.
- C. Structural Steel: ASTM A 36 / A 36M, carbon-steel plates, shapes, and bars; galvanized.
- D. Stainless Steel: ASTM A 240 / A 240M.
- E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.
- F. Grout: ASTM C 1107 / C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Non-staining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Division 07 for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36 / A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1 / D1.1M.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.
- D. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick 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.

2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- G. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- H. Install lateral bracing with pipe hangers and supports to prevent swaying.
- I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, **NPS 2-1/2 (DN 65)** and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- L. Insulated Piping:
 1. Install insulation couplings for pipes mounted to metal framing systems based on pipe size and insulation material. Arrange for grouping of parallel runs of piping and support together on metal framing system.
 - a. Flexible Elastomeric Insulation: For pipe **NPS 4 (DN 100)** and Smaller
 - b. Mineral Fiber Insulation: For pipe **NPS 4 (DN 100)** and Smaller
 2. Install MSS SP-58, Type 40, protective shields on piping not using insulation couplings. Shields shall span an arc of 180 degrees. Secure shield to pipe on both ends with stainless steel bands.
 3. Shield Dimensions for Pipe: Not less than the following:
 - a. **NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm)** long and **0.048 inch (1.22 mm)** thick.
 - b. **NPS 4 (DN 100): 12 inches (305 mm)** long and **0.06 inch (1.52 mm)** thick.
 - c. **NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm)** long and **0.06 inch (1.52 mm)** thick.
 - d. **NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm)** long and **0.075 inch (1.91 mm)** thick.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 / D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to **1-1/2 inches (40 mm)**.

3.6 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of **2.0 mils (0.05 mm)**.
- B. Touchup: Comply with requirements in Division 09 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 / A 780M.

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers, and metal framing systems and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes **NPS 1/2 to NPS 30 (DN 15 to DN 750)**.
 - 2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes **NPS 1/2 to NPS 24 (DN 15 to DN 600)** if little or no insulation is required.
 - 3. Pipe Saddle Supports (MSS Type 36): For support of pipes **NPS 4 to NPS 36 (DN 100 to DN 900)**, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 - 4. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes **NPS 2-1/2 to NPS 24 (DN 65 to DN 600)**, from single rod if horizontal movement caused by expansion and contraction might occur.
 - 5. Complete Pipe Rolls (MSS Type 44): For support of pipes **NPS 2 to NPS 42 (DN 50 to DN 1050)** if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers **NPS 3/4 to NPS 24 (DN 24 to DN 600)**.
- K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
- L. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- M. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 230548.13
VIBRATION CONTROLS FOR HVAC

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. Elastomeric isolation pads.
 - 2. Open-spring isolators.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 - 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.
- B. Shop Drawings:
 - 1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- C. Delegated-Design Submittal: For each vibration isolation device.
 - 1. Include design calculations for designing vibration isolation bases.
 - 2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind restraints and for designing vibration isolation bases.
 - a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - 3. Wind-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of wind restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods,

and spacings. Identify components, list their strengths, and indicate directions and values of forces. Indicate association with vibration isolation devices.

- c. Coordinate wind-restraint details with requirements in other Sections for equipment mounted outdoors.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
 1. **Basis-of-Design Product:** Subject to compliance with requirements, provide Mason Industries, Inc.; Mason Super W or comparable product by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Vibration Mountings & Controls, Inc.
 2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 3. Size: Factory or field cut to match requirements of supported equipment.
 4. Pad Material: Oil and water resistant with elastomeric properties.
 5. Surface Pattern: Waffle pattern.

2.2 OPEN-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators: .
 1. **Basis-of-Design Product:** Subject to compliance with requirements, provide Mason Industries, Inc.; Mason SLFH or comparable product by one of the following:
 - a. Kinetics Noise Control, Inc.
 - b. Vibration Mountings & Controls, Inc.
 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 rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to **500 psig (3447 kPa)**.
 7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- 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 VIBRATION CONTROL DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03.
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

3.3 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Division 03.

END OF SECTION

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SECTION 230553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

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. Equipment labels.
 - 2. Ceiling marker labels.
 - 3. Warning signs and labels.
 - 4. Pipe labels.
 - 5. Stencils.
 - 6. Valve tags.
 - 7. Warning tags.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- C. Valve numbering scheme.
- D. Valve Schedules: For each piping system to include in maintenance manuals.
- E. Control System Diagrams and Descriptions: For each control system to include in maintenance manuals.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/8 inch (3.2 mm)** thick, and having predrilled holes for attachment hardware.

2. Letter Color: White.
 3. Background Color: Black.
 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number.
- C. Equipment Label Schedule: For each item of equipment to be labeled, tabulate equipment label information. Equipment schedule shall be included in operation and maintenance data.

2.2 CEILING MARKER LABELS

- A. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
- B. Letter Color: Black.
- C. Background Color: Clear.
- D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- E. Minimum Letter Size: 1/2 inch (13 mm).
- F. Label Content: Include either the equipment tag identifier or a clear description of the concealed component, along with the system or service abbreviation. Label content shall match identifiers shown on Drawings or be descriptive enough for field recognition and maintenance access.
1. System of Service Abbreviations: "CHW, HHW, CW, STEAM, HVAC".
 2. Components: "VALVE, BALANCE VALVE, FIRE DAMPER, SMOKE DAMPER, CONTROL DAMPER".

2.3 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White.
- C. Background Color: Red.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

- F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- H. Label Content: Include caution and warning information plus emergency notification instructions.

2.4 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.5 STENCILS

- A. Stencils for Ducts:
 - 1. Lettering Size: Minimum letter height of 1-1/4 inches (32 mm) for viewing distances up to 15 feet (4-1/2 m) and proportionately larger lettering for greater viewing distances.
 - 2. Stencil Material: Fiberboard or metal.
 - 3. Stencil Paint: Exterior, gloss, acrylic enamel. Paint may be in pressurized spray-can form.

2.6 VALVE TAGS

- A. Description: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
 - 1. Tag Material: Brass, 0.032-inch (0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link chain or beaded chain or S-hook.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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 modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

- A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 - 1. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum.
 - 2. Fasteners: Brass grommet and wire.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 CEILING MARKER LABEL INSTALLATION

- A. Apply labels for each concealed major item of mechanical equipment or component requiring service or maintenance.
- B. Align labels neatly, parallel to ceiling edges or panel orientation.
- C. Apply after ceiling installation and verification of concealed item locations.
- D. Do not install labels on surfaces subject to frequent replacement or repainting without coordination.
- E. Locate ceiling marker labels where accessible and visible.
- F. Application Locations:
 - 1. Suspended Acoustical Tile Ceilings (ACT):

- a. Apply label to the face of the ceiling grid tee directly adjacent to or centered over the concealed item.
 - b. If grid location is not feasible, affix to accessible tile surface, avoiding any tile likely to be replaced or removed.
2. Gypsum Board or Hard-Lid Ceilings with Access Panels:
 - a. Apply label directly to the surface of the access panel.
 - b. Label shall be centered, upright, and clearly legible from floor level.
3. Exposed Ceilings or Open Structures:
 - a. Apply label to the nearest permanent building surface or equipment mounting plate visible from below.
 - b. If no surface is available, affix to suspended tag or placard mounted below the item.
4. Multiple Components at Single Access Location:
 - a. Use a single label listing all concealed components above the ceiling at that location, aligned vertically or in column format.
 - b. Use consistent labeling format and spacing.

3.5 PIPE LABEL INSTALLATION

- A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 1. Near each 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 and on both sides of through walls, floors, ceilings, and inaccessible 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 (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions. Install marker tape with arrows around the entire circumference of the pipe at the beginning and end of the pipe-label content.
- C. Pipe Label Color Schedule:
 1. Refrigerant Piping: Black letters on a safety-orange background.

3.6 DUCT LABEL INSTALLATION

- A. Stenciled Duct Label: Stenciled labels showing service and flow direction.

- B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

3.7 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, 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 according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape: 1-1/2 inches (38 mm), round
 - 2. Valve-Tag Colors:
 - a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
 - b. Flammable Fluids: Black letters on a safety-yellow background.
 - c. Combustible Fluids: White letters on a safety-brown background.
 - d. Potable and Other Water: White letters on a safety-green background.
 - e. Compressed Air: White letters on a safety-blue background.
 - f. Defined by User: White letters on a safety-purple background, black letters on a safety-white background, white letters on a safety-gray background, and white letters on a safety-black background

3.8 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

SECTION 230566
ANTIMICROBIAL ULTRAVIOLET LAMP SYSTEMS FOR HVAC

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. Antimicrobial UV-C lamp systems for packaged air-handling units.
 - 2. Controls.

1.3 DEFINITIONS

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- B. UV-C: Ultraviolet-C short-wave spectrum.
- C. UV-C Lamp System: Unit including UV lamp, power supply, housing, and supports.
- D. UVGI: Ultraviolet germicidal irradiation.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Product description with complete technical data, performance data, and product specification sheets.
 - 2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating power, distribution range, control signal over range, default control signal with loss of power, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Installation instructions, including factors affecting performance.
- B. Shop Drawings: For each UV-C lamp system.
 - 1. Include plans, elevations, sections, mounting, and attachment details.
 - 2. Include details of UV-C lamp system assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Elevations and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Structural members of equipment to which lamp systems will be attached.
 - 2. Air-handling unit penetrations.
 - 3. Access points for service of lamps and power supplies.
 - 4. Power and communications connections.
- B. Contractor's Construction Schedule.
- C. Application for Payment and schedule of values.
- D. Qualification Data: For testing laboratory providing data for UV lamps and fixtures.
- E. Product Certificates: For each type of UV lamp, fixture, and system.
- F. Product Test Reports: For each type of UV lamp and fixture, for tests performed by a qualified testing agency.
- G. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lamp systems to include in operation and maintenance manuals.
 - 1. Provide a list of all lamp and fixture types used on Project.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. UV-C Lamps: 10 for every 100 of each type and rating installed. Furnish no fewer than one of each type.

1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period, System: Five years from date of Substantial Completion.
 - 2. Warranty Period, Lamp: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- 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 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE Compliance:
 - 1. Test UV-C lamp systems according to ASHRAE 185.1, "Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms."
 - 2. Test UV-C lamp systems according to ASHRAE 185.2, "Method of Testing Ultraviolet Lamps for Use in HVAC&R Units or Air Ducts on Irradiated Surfaces."

2.2 MANUFACTURERS

- A. Source Limitations: Obtain from single source from single manufacturer.

2.3 ANTIMICROBIAL UV-C LAMP SYSTEMS FOR PACKAGED AIR-HANDLING UNITS

- A. Description: Factory-assembled UV-C lamp system with NEMA 4X power supply housing, four each, **1/2- or 3/4-inch (12.7- or 19-mm)** electrical knock-outs, power supply with integrated lamp plug, lamp compression nut, and UV lamp.
- B. Power Supply: UL listed, single phase, 120 or 240 V ac, 50 or 60 Hz, with a programmed rapid start.
 - 1. Power Factor: High power factor, Class P, Sound Rated A, Type 1 Outdoor, and with inherent thermal protection and without polychlorinated biphenyl.
 - 2. Output: Automatically sense and maximize lamp output, energy efficiency, and reliability for lamp lengths from **17 to 61 inches (432 to 1549 mm)**.
 - 3. Operating Temperature: From **34 to 194 deg F (1 to 90 deg C)**.
 - 4. Safety: Integral interlock switch on power supply.
 - 5. Power Consumption: Maximum **15 W/sq. ft. (161.5 W/sq. m)**.
 - 6. Electrical Connection: Factory powered thru packaged air handling unit (PAC). PAC has single point power
- C. UV-C Lamps: Encapsulated lamps with lamp wattage and model number visibly printed on all lamps, less than 8 Mg of mercury in each lamp. Lamps do not produce ozone.
 - 1. Quantity and Type: T5, hot cathode, single-ended, four pin.
 - 2. Output: UV-C energy, primarily at 253.7-nm wavelength with a 360-degree energy distribution.
 - 3. Base: Long-mount base lamp. Lamp filament extends into the airstream beyond plenum walls and insulation.
 - 4. Operating Temperature: From **34 to 158 deg F (1 to 70 deg C)**, 100-percent relative humidity, at any velocity.
 - 5. Lamp Protection: Hermetically sealed with a thin layer of UV-C-transmissible fluorinated ethylene propylene to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.
 - 6. Lamp Life: Minimum of 9000 hours with greater than 85 percent of initial output at end of lamp life.
- D. Power Supply Housing: High-performance, white polycarbonate for external thermal rejection, equipped with lamp support for lamp lengths up to **61 inches (1549 mm)** and a weathertight cover with an integrated seal. Housing contains all components in one integral assembly for safety and serviceability without tools.

1. Interlock: Disrupt lever on the cover actuates the interlock switch to disconnect or restore power when removed or installed. Padlock eyelets lock the housing cover to guard against unwanted entry.
 2. Surface Installation Mounting: Four mounting holes and gasket to seal housing to the mounting surface.
- E. Lamp Holder and Lamp Clamp: Four-pin type accommodates a single-ended lamp.
1. Lamp Holder Construction: UV-resistant materials and designed to connect the lamp to the plug.
 2. Lamp Clamp Construction: UV-resistant materials to ensure a watertight connection. A seal between the single-ended UV lamp and the lamp plug prevents electrical shock, connection shorts, and lamp or power supply failure, from lamp pin oxidation or arcing.

2.4 CONTROLS

- A. Interface with DDC System for HVAC: Factory-installed hardware and software (where applicable) to enable the DDC system for HVAC to monitor, control, and display status and alarms.
- B. Lamp and Power Supply Monitoring: Factory-assembled and tested, consisting of a housing, PC board, and wire block. Construction is designed to withstand installation inside air-handling unit airstream.
1. Housing: Industrial-grade plastic equipped with a direct-reading high-output green LED, two mounting holes, and an external wiring block for wiring to a remote sensing or input device. PC board converts inductive field to a regulated electromotive force of 1 to 5 V dc, maximum.
 2. Wiring Block: One positive and one negative terminal for No. 18 AWG and smaller wire.
 3. Remote Monitor(s): Installed outside the plenum in a suitable NEMA enclosure to directly or remotely monitor the lamp and power supply combination, with option for a single signal to the DDC system.
- C. Operating Control: Monitor lamp and power supply combination and provide a single on/off signal to the DDC system. UV-C lamp system operates continuously. Interlock UV-C lamp system operation with air-handling unit and component access doors. When an access door is opened, UV-C lamp system is de-energized.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for UV-C lamp system to verify actual locations of UV lamps and electrical connections before UV-C lamp system installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install UV-C lamp systems according to manufacturer's installation manual and drawings unless otherwise indicated.
- B. Install UV lamps in each UV-C lamp system.
- C. Install UV-C lamp systems in locations that are accessible and that will permit servicing and maintenance.
- D. Provide sufficient length of wiring loom to facilitate lamp connection to a remotely located power supply and/or power supply housing, such that lamp and loom can be mounted anywhere in the system.
- E. Seal air-handling unit penetrations to maintain integrity of air-handling unit casings.
- F. Irradiation: Quantity of UV lamps are to be installed to provide an equal distribution of available UV-C energy. When installed, UV-C energy produced shall be of the lowest possible reflected and shadowed losses, distributed in a 360-degree pattern within the cavity or plenum space.
- G. Intensity: UV-C lamp system modeling shall be included in the submittal and must contain necessary calculations to demonstrate a minimum of 6 W/sq. ft. (64.6 W/sq. m) of coil surface area to achieve a minimum of 100 microwatts/sq. cm equally distributed on the target surface as recommended by ASHRAE.
- H. Housing Installation: Power supply housing can be installed inside or outside air-handling units or plenums.
- I. UV Lamp Installation: Mount UV lamp to irradiate surfaces, as well as the available line of sight airstream, through proper lamp placement, and incident angle reflection.
- J. Safety: Comply with requirements in UL 1995, "Standard of Safety for Heating and Cooling Equipment." Provide mechanical interlock switch on access panels and doors to UV lamp systems, or within view of UV lamp systems, to ensure that UV-C lamp systems will be de-energized when these accesses are opened. Warning signs and labels are specified in Section 230553 "Identification for HVAC Piping and Equipment."
- K. Signage: Comply with requirements in UL 1995 "Heating and Cooling Equipment." Mark access panels and doors to UV-C lamp systems with warning signs stating, "WARNING: UV LIGHT SOURCE" and "DISCONNECT POWER BEFORE SERVICING." Warning signs and labels are specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.3 INSTALLATION OF ANTIMICROBIAL UV-C LAMP SYSTEMS FOR LARGE AIR-HANDLING UNITS

- A. Size and rate supports for UV-C lamp system weight.
- B. Maintain UV lamp position after cleaning and relamping.
- C. Provide support for UV-C lamp system without causing deflection of air-handling unit casing.
- D. Provide vertical supports on interior air-handling unit surfaces for UV-C lamp system.
- E. UV-C lamp system mounting devices shall be capable of supporting a horizontal force of 100 percent of system weight, and a vertical force of 400 percent of system weight.

- F. Equipment supports are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.4 ELECTRIC CONNECTIONS

- A. Provide electrical power and service disconnects to products requiring electrical connections.
- B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- C. Comply with requirements for service disconnects in Section 262816 "Enclosed Switches and Circuit Breakers."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 IDENTIFICATION

- A. Identify UV-C lamp systems with equipment labels. Comply with requirements for equipment labels specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Perform the following tests and inspections:
 - 1. Operational Test: After installing UV-C lamp systems, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Safety Interlock: Confirm proper operation of safety interlock power switches on access panels and doors.
- D. UV-C lamp systems and components will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.8 STARTUP SERVICE

- A. Perform startup service.

3.9 ADJUSTING

- A. After installation, adjust UV-C lamp systems and supports to maximize exposure to surfaces, before energizing system.

3.10 CLEANING

- A. Wipe lamps clean using manufacturers' recommended cleaning methods and materials.

3.11 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain UV-C lamp systems.

END OF SECTION

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SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

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. Balancing Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - c. Multizone systems.
 - d.
 - 2. Testing, Adjusting, and Balancing Equipment:
 - a. Motors.
 - b. Condensing units.
 - c. Heat-transfer coils.
 - 3. Testing, adjusting, and balancing existing systems and equipment.
 - 4. Sound tests.
 - 5. Vibration tests.
 - 6. Duct leakage tests.
 - 7. Control system verification.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.
- H. Special Inspector: An entity engaged to inspect smoke control systems.

1.4 PREINSTALLATION MEETINGS

- A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

- a. The Contract Documents examination report.
- b. The TAB plan.
- c. Needs for coordination and cooperation of trades and subcontractors.
- d. Proposed procedures for documentation and communication flow.

1.5 ACTION SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Report Format Submittals: Within 60 days of Contractor's Notice to Proceed, submit the following as specified in "Preparation" Article.
1. TAB strategies and step-by-step procedures.
 2. System readiness checklists.
- C. Certified TAB reports: Submit a minimum of 14 days prior to scheduled Substantial Completion.

1.6 INFORMATIONAL SUBMITTALS

- A. Contract Documents Examination Report: Within 60 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- B. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- C. Instrument calibration reports, to include the following:
1. Instrument type and make.
 2. Serial number.
 3. Application.
 4. Dates of use.
 5. Dates of calibration.

1.7 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Certified by AABC or NEBB.
1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB. A TAB Field Supervisor shall be on the project site at all times during TAB work and shall have a minimum three years' of TAB experience with air, water, sound, and vibration testing.
 - a. NEBB: Certified Professional (TAB-CP) or Certified Technician (TAB-CT).
 - b. AABC: Certified Test and Balance Engineer (TBE) or Certified Technician.

2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB as a TAB technician.
 - a. NEBB: Certified Technician (TAB-CT).
 - b. AABC: Certified Technician.
- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."
- E. Warranty: Comply with the program requirements of either:
 1. AABC National Performance Guaranty.
 2. NEBB Conformance Certification.

1.8 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. 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.

1.9 TAB CONTRACTOR'S RESPONSIBILITIES

- A. Attend testing, adjusting, and balancing review and coordination meeting.
- B. Participate in verification of the TAB report by the CxA or Engineer for verification and diagnostic purposes.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

- A. Subject to compliance with requirements, engage one of the following:
 1. FTS Test and Balance
 - a. Location: Tallahassee, Florida
 - b. Contact: Heath Allbaugh, CP
 - c. Phone Number: (850) 519-7845

2. HVAC Testing Services, Inc.
 - a. Location: Thomasville, Georgia
 - b. Contact: Greg Lang, CP / Pete Lang
 - c. Phone Number: (229) 227-0255
3. Indoor Air Professionals, Inc.
 - a. Location: Fort Myers, Florida
 - b. Contact: Joseph Molloy, III, CP
 - c. Phone Number: (239) 707-9732
4. Dynamic Analysis, Inc.
 - a. Location: Pensacola, Florida
 - b. Contact: Brian Barr, CP
 - c. Phone Number: (850) 492-8325
5. W.W. Gay Mechanical
 - a. Location: Jacksonville, Florida
 - b. Contact: Don Eshelman, CP
 - c. Phone Number: (904) 394-7298

3.2 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.

- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- 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 operating safety interlocks and controls on HVAC equipment.
- P. 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.

3.3 PREPARATION

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Project specific forms with specific identification for all equipment and systems. Project specific forms shall include design data for all equipment and systems to be tested and descriptions of any other necessary supporting data required in the final report that will be included (i.e. fan/pump curves, layout drawings, balancing valve charts, etc).
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed.
 - j. Suitable access to balancing devices and equipment is provided.

3.4 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 Total System Balance", ASHRAE 111, or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems", and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
 - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 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 outdoor-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. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.6 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 total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 4. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 - 5. 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 occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
 - 6. Determine and make appropriate modifications for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
 - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 - 2. Measure inlets and outlets airflow.
 - 3. Adjust each inlet and outlet for specified airflow.
 - 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
 - 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
 - 2. Re-measure and confirm that total airflow is within design.

3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. Adjust upstream manual balancing damper so that, at maximum air-handler system output (flow and pressure), the terminal unit control damper is capable of modulating between minimum and maximum design airflows without exceeding design limits, and at minimum air-handling system output the control damper can achieve design maximum airflow with the damper nearly wide open (approximately 75–95% open). Record final damper position.
 - d. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - e. Adjust controls so that terminal is calling for minimum airflow.
 - f. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - g. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
 - h. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity (where the total flow rate of all outlets is more than the indicated flow of the fans), adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.

- 1) Determine diversity factor.
 - 2) Simulate system diversity by setting a required number of air terminals to minimum airflows, as approved by the design engineer.
 - 3) Set air terminals that were at minimum airflow to maximum airflow. Set a sufficient number of air terminals that were previously at maximum airflow to minimum airflow to maintain diversity, and balance terminals that were just set to maximum.
- c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
- d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
- e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
- f. Obtain approval from Engineer before adjustment of fan speed higher or lower than indicated speed. Determine and make appropriate modifications for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
- g. 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 mode to determine the maximum required brake horsepower.
6. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor. Coordinate maximum and minimum static pressure setpoints with Controls Contractor for static pressure setpoint reset. Record damper positions for associated terminal units at maximum and minimum static pressure setpoints.
9. Simulate maximum filter loading. The intent is for the variable frequency drive to operate between 55-60 Hz at maximum filter loading. Remeasure the static pressure at the most critical terminal unit and adjust the static pressure controller to ensure that adequate static pressure is maintained at the most critical unit. Report the minimum static pressure value and speed of variable frequency drives.
10. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, rpms, volts, amps, and static profile.

- d. Mark final settings.
- e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
- f. Verify tracking between supply and return fans.

3.8 PROCEDURES FOR MULTIZONE SYSTEMS

- A. Position the unit's automatic zone dampers for maximum flow through the cooling coil.
- B. The procedures for multizone systems will utilize the zone balancing dampers to achieve the indicated airflow within the zone.
- C. After balancing, place the unit's automatic zone dampers for maximum heating flow. Retest zone airflows and record any variances.
- D. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air and relief-air dampers for proper position that simulates minimum outdoor air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 4. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 - 5. 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 occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
 - 6. Determine and make appropriate modifications for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
- E. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
 2. Adjust submain and branch duct volume dampers for specified airflow.
 3. Re-measure each submain and branch duct after all have been adjusted.
- F. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 2. Measure inlets and outlets airflow.
 3. Adjust each inlet and outlet for specified airflow.
 4. Re-measure each inlet and outlet after they have been adjusted.
- G. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 2. Re-measure and confirm that total airflow is within design.
 3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
 4. Mark all final settings.
 5. Test system in economizer mode. Verify proper operation and adjust if necessary.
 6. Measure and record all operating data.
 7. Record final fan-performance data.

3.9 PROCEDURES FOR MOTORS

- A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Phase and hertz.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter size and thermal-protection-element rating.
 8. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.10 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.

3.11 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each refrigerant coil:
1. Dry-bulb temperature of entering and leaving air.
 2. Wet-bulb temperature of entering and leaving air.

3. Airflow.
4. Air pressure drop.

3.12 DUCT LEAKAGE TESTS

- A. Witness the duct pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- C. Report deficiencies observed.

3.13 CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 1. Verify temperature control system is operating within the design limitations.
 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 3. Verify that controllers are calibrated and function as intended.
 4. Verify that controller set points are as indicated.
 5. Verify the operation of lockout or interlock systems.
 6. Verify the operation of valve and damper actuators.
 7. Verify that controlled devices are properly installed and connected to correct controller.
 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.
- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.14 TOLERANCES

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 2. Air Outlets and Inlets: Plus or minus 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.15 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found

in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.16 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
 - 3. Certify validity and accuracy of field data.
 - 4. Include warranty certificate meeting the requirements of one of the following programs:
 - a. AABC – National Performance Guaranty
 - b. NEBB – Conformance Certification
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Pump curves, marked with operating conditions.
 - 2. Fan curves, marked with operating conditions.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 - 1. Title page.
 - 2. Name and address of the TAB specialist.
 - 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 supervisor 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's name, type, size, and fittings.
 - 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 - 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, 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. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. 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.
 8. Quantities and sizes of doors in smoke control systems.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
 1. Unit Data:
 - 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 (mm), and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 2. Motor Data:
 - a. Motor 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 (mm), and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Filter static-pressure differential in inches wg (Pa).
 - f. Preheat-coil static-pressure differential in inches wg (Pa).
 - g. Cooling-coil static-pressure differential in inches wg (Pa).
 - h. Heating-coil static-pressure differential in inches wg (Pa).
 - i. Outdoor airflow in cfm (L/s).
 - j. Return airflow in cfm (L/s).

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

- k. Outdoor-air damper position.
- l. Return-air damper position.
- m. Vortex damper position.

F. 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 (mm) o.c.**
- f. Make and model number.
- g. Face area in **sq. ft. (sq. m).**
- h. Tube size in **NPS (DN).**
- i. Tube and fin materials.
- j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in **cfm (L/s).**
- b. Average face velocity in **fpm (m/s).**
- c. Air pressure drop in **inches wg (Pa).**
- d. Outdoor-air, wet- and dry-bulb temperatures in **deg F (deg C).**
- e. Return-air, wet- and dry-bulb temperatures in **deg F (deg C).**
- f. Entering-air, wet- and dry-bulb temperatures in **deg F (deg C).**
- g. Leaving-air, wet- and dry-bulb temperatures in **deg F (deg C).**
- h. Refrigerant expansion valve and refrigerant types.
- i. Refrigerant suction pressure in **psig (kPa).**
- j. Refrigerant suction temperature in **deg F (deg C).**

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

- a. System identification.
- b. Location.
- c. Make and type.
- d. Model number and unit size.
- e. Manufacturer's serial number.
- f. Fuel type in input data.
- g. Output capacity in **Btu/h (kW).**
- h. Ignition type.
- i. Burner-control types.
- j. Motor horsepower and rpm.
- k. Motor volts, phase, and hertz.
- l. Motor full-load amperage and service factor.
- m. Sheave make, size in **inches (mm),** and bore.
- n. Center-to-center dimensions of sheave and amount of adjustments in **inches (mm).**

2. Test Data (Indicated and Actual Values):

- a. Total airflow rate in **cfm (L/s).**

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

- b. Entering-air temperature in **deg F** (**deg C**).
 - c. Leaving-air temperature in **deg F** (**deg C**).
 - d. Air temperature differential in **deg F** (**deg C**).
 - e. Entering-air static pressure in **inches wg** (**Pa**).
 - f. Leaving-air static pressure in **inches wg** (**Pa**).
 - g. Air static-pressure differential in **inches wg** (**Pa**).
 - h. Low-fire fuel input in **Btu/h** (**kW**).
 - i. High-fire fuel input in **Btu/h** (**kW**).
 - j. Manifold pressure in **psig** (**kPa**).
 - k. High-temperature-limit setting in **deg F** (**deg C**).
 - l. Operating set point in **Btu/h** (**kW**).
 - m. Motor voltage at each connection.
 - n. Motor amperage for each phase.
 - o. Heating value of fuel in **Btu/h** (**kW**).
- H. Fan Test Reports: For supply, return, and exhaust 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** (**mm**), and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in **inches** (**mm**).
 - 2. Motor Data:
 - a. Motor 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** (**mm**), and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in **inches** (**mm**).
 - g. Number, make, and size of belts.
 - h. Belt tension in lbs.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in **cfm** (**L/s**).
 - b. Total system static pressure in **inches wg** (**Pa**).
 - c. Fan rpm.
 - d. Discharge static pressure in **inches wg** (**Pa**).
 - e. Suction static pressure in **inches wg** (**Pa**).
- I. Round, Flat-Oval, 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.

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

- c. Traverse air temperature in **deg F** (**deg C**).
- d. Duct static pressure in **inches wg** (**Pa**).
- e. Duct size in **inches** (**mm**).
- f. Duct area in **sq. ft.** (**sq. m**).
- g. Indicated airflow rate in **cfm** (**L/s**).
- h. Indicated velocity in **fpm** (**m/s**).
- i. Actual airflow rate in **cfm** (**L/s**).
- j. Actual average velocity in **fpm** (**m/s**).
- k. Barometric pressure in **psig** (**Pa**).

J. Air-Terminal-Device Reports:

1. Unit Data:

- a. System and air-handling unit identification.
- b. Location and zone.
- c. Apparatus used for test.
- d. Area served.
- e. Make.
- f. Number from system diagram.
- g. Type and model number.
- h. Size.
- i. Effective area in **sq. ft.** (**sq. m**).

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in **cfm** (**L/s**).
- b. Air velocity in **fpm** (**m/s**).
- c. Preliminary airflow rate as needed in **cfm** (**L/s**).
- d. Preliminary velocity as needed in **fpm** (**m/s**).
- e. Final airflow rate in **cfm** (**L/s**).
- f. Final velocity in **fpm** (**m/s**).
- g. Space temperature in **deg F** (**deg C**).

K. Instrument Calibration Reports:

1. Report Data:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

3.17 VERIFICATION OF TAB REPORT

- A. At Engineer's option, Engineer shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- B. If 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."

- C. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- D. If TAB work fails, proceed as follows:
 - 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 - 2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
 - 3. If the second verification also fails, design professional may contact AABC Headquarters regarding the AABC National Performance Guaranty or NEBB Headquarters regarding the NEBB Conformance Certification.
- E. Prepare test and inspection reports.

3.18 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB 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 TAB during near-peak summer and winter conditions.

END OF SECTION

SECTION 230713.11
INSULATION FOR INDOOR GENERAL HVAC DUCTS

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 insulating the following duct services:
 - 1. Indoor, concealed supply, return, and outdoor air.
 - 2. Indoor, exposed supply, return, and outdoor air.
 - 3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 4. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
- B. Related Sections:
 - 1. Section 233113.11 "Metal Ducts for General HVAC" for duct liners.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Shop Drawings:
 - 1. Detail application for each type of insulation and hanger.
 - 2. Detail insulation application for each type of insulation.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," and "Indoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. **Products:** Subject to compliance with requirements, provide one of the following:
 - a. CertainTeed Corp.; SoftTouch Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Friendly Feel Duct Wrap.
 - d. Owens Corning; SOFTR All-Service Duct Wrap.

- G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. **Products:** Subject to compliance with requirements, provide one of the following:
 - a. CertainTeed Corp.; Commercial Board.
 - b. Johns Manville; 800 Series Spin-Glas.
 - c. Knauf Insulation; Insulation Board.
 - d. Owens Corning; Fiberglas 700 Series.
- H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied [ASJ] [and] FSK jacket complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is **2.5 lb/cu. ft. (40 kg/cu. m)** or more. Thermal conductivity (k-value) at **100 deg F (55 deg C)** is **0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K)** or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. **Products:** Subject to compliance with requirements, provide one of the following:
 - a. CertainTeed Corp.; CrimpWrap.
 - b. Johns Manville; MicroFlex.
 - c. Knauf Insulation; Pipe and Tank Insulation.
 - d. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. **Products:** Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. Fiberglass adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. **Products:** Subject to compliance with requirements, provide one of the following:

- a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50. Mon-Eco Industries, Inc.; 22-25.
2. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.3 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
 1. VOC Content: 50 g/L or less.
 2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - b. Vimasco Corporation; 749.
 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 3. Service Temperature Range: **Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).**
 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products; CP-10.
 - b. Eagle Bridges - Marathon Industries; 550.
 - c. Foster Brand; H. B. Fuller Construction Products; 46-50.
 - d. Mon-Eco Industries, Inc; 55-50.
 2. Vimasco Corporation; WC-1/WC-5. Water-Vapor Permeance: ASTM E96, greater than **1.0 perm (0.66 metric perms)** at manufacturer's recommended dry film thickness.
 3. Service Temperature Range: **Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).**
 4. Color: White.

2.4 SEALANTS

A. FSK Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.Eagle Bridges - Marathon Industries; 405.
 - b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - c. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: **Minus 40 to plus 250 deg F** (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

B. ASJ Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: **Minus 40 to plus 250 deg F** (Minus 40 to plus 121 deg C).
5. Color: White.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.5 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric: Approximately **6 oz./sq. yd. (203 g/sq. m)** with a thread count of **5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm)** for covering ducts.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:

- a. Childers Brand; H. B. Fuller Construction Products; Chil-Glas Number 5.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 2. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ Width: **3 inches (75 mm)**.
 3. Thickness: **11.5 mils (0.29 mm)**.
 4. Adhesion: **90 ounces force/inch (1.0 N/mm)** in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: **40 lbf/inch (7.2 N/mm)** in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
 2. Width: **3 inches (75 mm)**.
 3. Thickness: **6.5 mils (0.16 mm)**.
 4. Adhesion: **90 ounces force/inch (1.0 N/mm)** in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: **40 lbf/inch (7.2 N/mm)** in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.9 SECUREMENTS

- A. Bands:
 1. Aluminum: **ASTM B209 (ASTM B209M)**, Alloy 3003, 3005, 3105, or 5005; Temper H-14, **0.020 inch (0.51 mm)** thick, **1/2 inch (13 mm)** wide with wing seal.
 2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Products: Subject to compliance with requirements, provide one of the following:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - 4) Nelson Stud Welding; Speed Clips.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with **3-inch- (75-mm-)** wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced **4 inches (100 mm)** o.c.
 - 3. Overlap jacket longitudinal seams at least **1-1/2 inches (38 mm)**. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at **4 inches (100 mm)** o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least **4 inches (100 mm)** beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least **2 inches (50 mm)** below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least **2 inches (50 mm)**.
 - 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least **2 inches (50 mm)**.
 - 1. Comply with requirements in Division 07.
- E. Insulation Installation at Floor Penetrations:
 - 1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least **2 inches (50 mm)**.
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07.

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with insulation pins.

1. Install metal, adhesively attached, perforated-base insulation hangers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions **18 inches (450 mm)** and smaller, place pins along longitudinal centerline of duct. Space **3 inches (75 mm)** maximum from insulation end joints, and **16 inches (400 mm)** o.c.
 - b. On duct sides with dimensions larger than **18 inches (450 mm)**, place pins **16 inches (400 mm)** o.c. each way, and **3 inches (75 mm)** maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. 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.
 2. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing **2 inches (50 mm)** from one edge and one end of insulation segment. Secure laps to adjacent insulation section with **1/2-inch (13-mm)** outward-clinching staples, **1 inch (25 mm)** o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, field-applied fabric-reinforcing mesh, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below **50 deg F (10 deg C)** at **18-foot (5.5-m)** intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than **3 inches (75 mm)**.
 3. Overlap unfaced blankets a minimum of **2 inches (50 mm)** on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of **18 inches (450 mm)** o.c.
 4. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 5. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with **6-inch- (150-mm-)** wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced **6 inches (150 mm)** o.c.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
 2. Install metal, adhesively attached, perforated-base insulation hangers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions **18 inches (450 mm)** and smaller, place pins along longitudinal centerline of duct. Space **3 inches (75 mm)** maximum from insulation end joints, and **16 inches (400 mm)** o.c.
 - b. On duct sides with dimensions larger than **18 inches (450 mm)**, space pins **16 inches (400 mm)** o.c. each way, and **3 inches (75 mm)** maximum from insulation

- joints. Install additional pins to hold insulation tightly against surface at cross bracing.
- c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. 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.
3. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing **2 inches (50 mm)** from one edge and one end of insulation segment. Secure laps to adjacent insulation section with **1/2-inch (13-mm)** outward-clinching staples, **1 inch (25 mm)** o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, field-applied fabric-reinforcing mesh, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
- a. Repair punctures, tears, and penetrations with mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below **50 deg F (10 deg C)** at **18-foot (5.5-m)** intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than **3 inches (75 mm)**.
4. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
5. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with **6-inch- (150-mm-)** wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced **6 inches (150 mm)** o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
1. Draw jacket smooth and tight to surface with **2-inch (50-mm)** overlap at seams and joints.
 2. Embed glass cloth between two **0.062-inch- (1.6-mm-)** thick coats of lagging adhesive.
 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
1. Install lap or joint strips with same material as jacket.
 2. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

3.7 FINISHES

- A. Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below .

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

3.8 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 1. Indoor, concealed supply, return, and outdoor air.
 2. Indoor, exposed supply, return, and outdoor air.
 3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 4. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
- B. Items Not Insulated:
 1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 2. Factory-insulated flexible ducts.
 3. Factory-insulated plenums and casings.
 4. Flexible connectors.
 5. Vibration-control devices.
 6. Factory-insulated access panels and doors.

3.9 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Supply air duct and plenum insulation shall be the following:
 1. Concealed, round and flat-oval ducts:
 - a. Mineral-Fiber Blanket, 2-3/16 inches (56 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
 2. Concealed, rectangular ducts:
 - a. Mineral-Fiber Blanket: 2-3/16 inches (56 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
 3. Concealed, plenums:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 4. Exposed, round and flat-oval ducts:
 - a. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
 5. Exposed, rectangular ducts:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and nominal density.

6. Exposed, plenums:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- B. Return air duct and plenum insulation shall be the following:
 1. Concealed, round and flat-oval ducts:
 - a. Mineral-Fiber Blanket, 2-3/16 inches (56 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
 2. Concealed, rectangular ducts:
 - a. Mineral-Fiber Blanket: 2-3/16 inches (56 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
 3. Concealed, plenums:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 4. Exposed, round and flat-oval ducts:
 - a. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
 5. Exposed, rectangular ducts:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and nominal density.
 6. Exposed, plenums:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- C. Outdoor air duct and plenum insulation shall be the following:
 1. Concealed, round and flat-oval ducts:
 - a. Mineral-Fiber Blanket, 2-3/16 inches (56 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
 2. Concealed, rectangular ducts:
 - a. Mineral-Fiber Blanket: 2-3/16 inches (56 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
 3. Concealed, plenums:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 4. Exposed, round and flat-oval ducts:
 - a. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.

5. Exposed, rectangular ducts:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and nominal density.
 6. Exposed, plenums:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
- D. Exhaust air duct and plenum insulation shall be the following:
1. Concealed, round and flat-oval ducts between isolation damper and penetration of building exterior:
 - a. Mineral-Fiber Blanket, 2-3/16 inches (56 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
 2. Concealed, rectangular ducts between isolation damper and penetration of building exterior:
 - a. Mineral-Fiber Blanket: 2-3/16 inches (56 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
 3. Concealed, plenums:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
 4. Exposed, round and flat-oval ducts between isolation damper and penetration of building exterior:
 - a. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
 5. Exposed, rectangular ducts between isolation damper and penetration of building exterior:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and nominal density.
 6. Exposed, plenums:
 - a. Mineral-Fiber Board: 2 inches (50 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

END OF SECTION

SECTION 230719.11
INSULATION FOR CONDENSATE DRAIN 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 insulating the following HVAC piping systems:
 - 1. Condensate drain piping, indoors and outdoors.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.
- E. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials.
 - 1. **Products:** Subject to compliance with requirements, provide one of the following:
 - a. [Aeroflex USA, Inc.; Aerocel.](#)
 - b. [Armacell LLC; AP Armaflex.](#)
 - c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. [Aeroflex USA, Inc.](#); Aero seal.
 - b. [Armacell LLC](#); Armaflex 520 Adhesive.
 - c. [Foster Brand](#), Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. [K-Flex USA](#); R-373 Contact Adhesive.

2.3 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 1. VOC Content: 50 g/L or less.
 - 2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below-ambient services.
 - 1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. [Foster Brand](#), Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80 / 30-90.
 - b. [Vimasco Corporation](#); 749.
 - 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 - 3. Service Temperature Range: **Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C)**.
 - 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
 - 5. Color: White.
- C. Vapor-Retarder Mastic: Solvent based; suitable for outdoor use on below-ambient services.
 - 1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. [Childers Brand](#), Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
 - b. Marathon Industries; 570.
 - c. [Foster Brand](#), Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95 / 60-96.
 - 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 - 3. Service Temperature Range: **Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C)**.
 - 4. Color: White.

2.4 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas Number 10.

2.5 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.
- B. Metal Jacket:
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
 - b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
 - c. RPR Products, Inc.; Insul-Mate.
 - 2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 2.5-mil- (0.063-mm-) thick polysurlyn.
 - d. Moisture Barrier for Outdoor Applications: .
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.6 SECUREMENTS

- A. Bands:
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
 - 2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal.
- B. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
 - 3. 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.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Below Ambient Systems.
 - 1. Provide continuous vapor barrier; seal joints, longitudinal seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic and joint sealant.

2. Where mastic is indicated provide vapor-barrier mastic as required for indoor or outdoor application.
 3. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least **4 inches (100 mm)** beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- B. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Division 07.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 3. Install insulation to flanges as specified for flange insulation application.
 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with **2-inch (50-mm)** overlap at seams and joints.
 2. Embed glass cloth between two **0.062-inch- (1.6-mm-)** thick coats of mastic.
 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
 4. Finish to achieve smooth, uniform finish.
- B. Where metal jackets are indicated, install with **2-inch (50-mm)** overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weather-proof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands **12 inches (300 mm)** o.c. and at end joints.
- C. Do not install metal jacket over field-applied glass-cloth jacket unless indicated in schedule.
- D. Where PVC piping is installed in a plenum, install plenum fire resistant wrap over PVC piping. Install plenum fire resistant wrap over any PVC piping insulated with flexible elastomeric insulated, if installed in a plenum.

3.7 FINISHES

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Color per schedule below.
- B. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.
1. White.
- C. Do not field paint aluminum jackets.

3.8 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.9 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain Water below **60 Deg F (16 Deg C)**:
1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: **3/4 inch (19 mm)** thick.

3.10 OUTDOOR PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain Water below **60 Deg F (16 Deg C)**:
1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: **3/4 inch (19 mm)** thick.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. Piping, Concealed:
 - 1. None.
- C. Piping, Exposed:
 - 1. Aluminum, Corrugated: 0.016 inch (0.41 mm) thick.
- D. Fittings, valves, strainers, flanges, unions, and other specialties, Concealed:
 - 1. None.
- E. Fittings, valves, strainers, flanges, unions, and other specialties, Exposed:
 - 1. Glass cloth jacket.

3.12 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. Piping, Concealed:
 - 1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.
- C. Piping, Exposed:
 - 1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.
- D. Fittings, unions, and other specialties, Concealed:
 - 1. None.
- E. Fittings, unions, and other specialties, Exposed:
 - 1. Glass cloth jacket, install metal jacket over finished glass-cloth jacket.

END OF SECTION

SECTION 230719.16
INSULATION FOR REFRIGERANT 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 insulating the following HVAC piping systems:
 - 1. Refrigerant suction and hot-gas piping, indoors and outdoors.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 3. Detail 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 Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.
- E. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Aeroflex USA, Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aero seal.
 - b. Armacell LLC; Armaflex 520 Adhesive.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. K-Flex USA; R-373 Contact Adhesive.

2.3 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
 1. VOC Content: 50 g/L or less.
 2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below-ambient services.
 1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80 / 30-90.
 - b. Vimasco Corporation; 749.
 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 3. Service Temperature Range: **Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C)**.
 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
 5. Color: White.
- C. Vapor-Retarder Mastic: Solvent based; suitable for outdoor use on below-ambient services.
 1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
 - b. Marathon Industries; 570.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95 / 60-96.
 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 3. Service Temperature Range: **Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C)**.
 4. Color: White.

2.4 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. Metal Jacket:

1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. **Childers Brand**, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
 - b. **ITW Insulation Systems**; Aluminum and Stainless Steel Jacketing.
 - c. **RPR Products, Inc.**; Insul-Mate.
2. Aluminum Jacket: Comply with **ASTM B209 (ASTM B209M)**, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: **2.5-mil- (0.063-mm-)** thick polysurlyn.
 - d. Moisture Barrier for Outdoor Applications: .
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.5 SECUREMENTS

A. Bands:

1. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. **ITW Insulation Systems**; Gerrard Strapping and Seals.
 - b. **RPR Products, Inc.**; Insul-Mate Strapping, Seals, and Springs.
2. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304; **0.015 inch (0.38 mm)** thick, **1/2 inch (13 mm)** wide with wing seal.

B. Wire: **0.062-inch (1.6-mm)** soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
 3. 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.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Below Ambient Systems.
 - 1. Provide continuous vapor barrier; seal joints, longitudinal seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic and joint sealant.
 - 2. Where mastic is indicated provide vapor-barrier mastic as required for indoor or outdoor application.
 - 3. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least **2 inches (50 mm)**.
 - 4. Seal jacket to wall flashing with flashing sealant.
- B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements in Division 07 for firestopping and fire-resistive joint sealers.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 - 1. Install pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 - 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of mastic.
 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
 4. Finish to achieve smooth, uniform finish.
- B. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weather-proof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.7 FINISHES

- A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.
 1. Semi-glass Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof. Color per schedule below.
 - a. Finish Coat Material: Interior, semi-gloss, latex-emulsion size.
 2. Paint exposed piping without field applied metal jacket.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Color per schedule below.
- C. Color: Final color as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.
 1. White.
- D. Do not field paint aluminum jackets.

3.8 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.9 INDOOR PIPING INSULATION SCHEDULE

- A. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.

3.10 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.

B. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.

3.11 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Concealed:

1. None.

C. Piping, Exposed:

1. Aluminum, Corrugated: 0.016 inch (0.41 mm) thick.

3.12 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.

D. Piping, Exposed:

1. Aluminum, Corrugated: 0.024 inch (0.61 mm) thick.

END OF SECTION

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**SECTION 232113.11
CONDENSATE DRAIN PIPING**

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Copper tube and fittings.
 2. Piping joining materials.
 3. Dielectric fittings.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
1. Pipe and tube.
 2. Fittings.
 3. Joining materials.
 4. Transition fittings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation are to be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
1. Condensate-Drain Piping: 150 deg F (66 deg C).

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: ASTM B88, Type L (ASTM B88M, Type B).
- B. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4 (DN 100).
- C. Wrought-Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than NPS 4 (DN 100).
- D. Copper-Tube, Pressure-Seal-Joint Fittings - Copper or Bronze:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mueller Streamline Co.; a company of Mueller Industries.
 - b. Victaulic Company.
 - c. Viega LLC.

2. Source Limitations: Obtain copper-tube pressure-seal-joint fittings from single manufacturer.
3. Housing: Copper or bronze.
4. O-Rings and Pipe Stops: EPDM.
5. Tools: Manufacturer's special tools.
6. Minimum **200 psig (1370 kPa)** working pressure rating at **250 deg F (121 deg C)**.

2.3 PIPING JOINING MATERIALS

- A. Solder Filler Metals: ASTM B32, lead-free alloys.
- B. Flux: ASTM B813, water flushable.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Condensate-Drain Piping Installed Aboveground to Be Any of the Following:
 1. **Type L (Type B)**, drawn-temper copper tubing, wrought-copper fittings, and soldered or pressure-seal joints.

3.2 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to lay-out are approved on coordination drawings.
- B. Install piping in concealed locations 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 specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.

- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- M. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- N. Install valves according to Section 230523.11 "General Duty Valves for Hydronic Piping."
- O. Install unions in piping, **NPS 2 (DN 50)** and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- P. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 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. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
- D. Pressure-Seal Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- B. Install hangers for copper tubing, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- C. Support horizontal piping within **12 inches (300 mm)** of each fitting and coupling.
- D. Support vertical runs of copper tubing to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

3.6 FIELD QUALITY CONTROL

- A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:
 - 1. Leave joints uninsulated and exposed for examination during test.
 - 2. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
- 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. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure is not to 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 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9.
 - 3. 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.
 - 4. Prepare written report of testing.

END OF SECTION

**SECTION 232300
REFRIGERANT 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. Copper tube and fittings.
 - 2. Valves and specialties.
 - 3. Refrigerants.

1.3 ACTION SUBMITTALS

- A. Delegated-Design Submittal: For refrigerant piping size and layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
- B. Shop Drawings:
 - 1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
 - 2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
 - 3. Show interface and spatial relationships between piping and equipment.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

- A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-32:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
 - 2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
 - 3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).
- B. Line Test Pressure for Refrigerant R-410a:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
 - 2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
 - 3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).
- C. Line Test Pressure for Refrigerant R-454b:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
 - 2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
 - 3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

2.2 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type K or L (ASTM B 88M, Type A or B) or ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Copper Pressure-Seal Fittings for Refrigerant Piping:
 - 1. Standard: UL 207; certified by UL for field installation. Certification as a UL-recognized component alone is unacceptable.
 - 2. Housing: Copper.
 - 3. O-Rings: HNBR or compatible with specific refrigerant.
 - 4. Tools: Manufacturer's approved special tools.
 - 5. Minimum Rated Pressure: 700 psig (48 bar).

2.3 VALVES AND SPECIALTIES

- A. Service Valves:
 - 1. Body: Forged brass with brass cap including key end to remove core.

2. Core: Removable ball-type check valve with stainless-steel spring.
 3. Seat: Polytetrafluoroethylene.
 4. End Connections: Copper spring.
 5. Working Pressure Rating: 500 psig (3450 kPa).
- B. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 2. Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Seat: Polytetrafluoroethylene.
 4. End Connections: Threaded.
 5. Working Pressure Rating: 400 psig (2760 kPa).
 6. Maximum Operating Temperature: 240 deg F (116 deg C).
- C. Thermostatic Expansion Valves: Comply with AHRI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Packing and Gaskets: Non-asbestos.
 4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 5. Suction Temperature: 40 deg F (4.4 deg C).
 6. Superheat: Adjustable.
 7. Reverse-flow option (for heat-pump applications).
 8. End Connections: Socket, flare, or threaded union.
 9. Working Pressure Rating: 700 psig (4820 kPa).
- D. Moisture/Liquid Indicators:
1. Body: Forged brass.
 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 3. Indicator: Color coded to show moisture content in parts per million (ppm).
 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 5. End Connections: Socket or flare.
 6. Working Pressure Rating: 500 psig (3450 kPa).
 7. Maximum Operating Temperature: 240 deg F (116 deg C).
- E. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: Activated alumina or charcoal.
 4. Designed for reverse flow (for heat-pump applications).
 5. End Connections: Socket.
 6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
 7. Working Pressure Rating: 500 psig (3450 kPa).
 8. Maximum Operating Temperature: 240 deg F (116 deg C).

2.4 REFRIGERANTS

- A. R-410A, ASHRAE 34: Pentafluoroethane/Difluoromethane.

- B. R-454B, ASHRAE 34: R-32 (68.9%) / R-1234yf (31.1%).

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS SCHEDULES

- A. Refrigerant: As indicated on Drawings and applicable Division 23 sections for the specified equipment.
- B. Suction, Hot-Gas, and Liquid Tubing Applications, **NPS 4 (DN 100)** and Smaller: Copper, Type **ACR** or Type **L (B)**, drawn-temper tubing and wrought-copper fittings with soldered joints.
- C. Safety-Relief-Valve Discharge Piping: Copper, Type **ACR** or Type **L (B)**, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- B. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- C. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- D. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- E. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- F. Install filter dryers in liquid line between compressor and thermostatic expansion valve.
- G. Install receivers sized to accommodate pump-down charge.
- H. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

- A. 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 Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.

- 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 adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. Install refrigerant piping in protective conduit where installed belowground.
- L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- M. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Liquid lines may be installed level.
- N. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- O. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- P. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."
- Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE 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. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

3.5 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- B. Install the following pipe attachments:
 - 1. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Support horizontal piping within **12 inches (300 mm)** of each fitting.
- E. Support vertical runs of copper tubing to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Comply with ASME B31.5, Chapter VI.
 - 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
- B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Install core in filter dryers after leak test but before evacuation.
 - 2. Evacuate entire refrigerant system with a vacuum pump to **500 micrometers (67 Pa)**. If vacuum holds for 12 hours, system is ready for charging.
 - 3. Break vacuum with refrigerant gas, allowing pressure to build up to **2 psig (14 kPa)**.

4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 1. Open shutoff valves in condenser water circuit.
 2. Verify that compressor oil level is correct.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves except bypass valves that are used for other purposes.
 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- D. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

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SECTION 233113.11
METAL DUCTS FOR GENERAL HVAC

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 duct services for supply, return, outdoor air, and general exhaust (ASHRAE 62.1, Class 1 and 2):
 - 1. Single-wall rectangular ducts and fittings.
 - 2. Double-wall rectangular ducts and fittings.
 - 3. Single-wall round and flat-oval ducts and fittings.
 - 4. Double-wall round and flat-oval ducts and fittings.
 - 5. Sheet metal materials.
 - 6. Duct liner.
 - 7. Sealants and gaskets.
 - 8. Hangers and supports.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Liners and adhesives.
 - 2. Sealants and gaskets.
- B. Delegated-Design Submittal:
 - 1. Sheet metal thicknesses.
 - 2. Joint and seam construction and sealing.
 - 3. Reinforcement details and spacing.
 - 4. Materials, fabrication, assembly, and spacing of hangers and supports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

- B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".
- C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, comply with requirements per "Ductwork Exposed to Weather" Article.
- B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. For ducts with longest side less than 36 inches (914 mm), select joint types in accordance with Figure 2-1.
 - 2. For ducts with longest side 36 inches (914 mm) or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide McGill AirFlow LLC; Rectangular-k27 or a comparable product by one of the following:

1. [SEMCO, LLC.](#)
 2. [Sheet Metal Connectors, Inc.](#)
- B. Rectangular Ducts: Fabricate ducts with indicated dimensions for clear internal dimensions of the inner duct.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 2. For ducts exposed to weather, comply with requirements per "Ductwork Exposed to Weather" Article .
- D. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. For ducts with longest side less than **36 inches (914 mm)**, select joint types in accordance with Figure 2-1.
 2. For ducts with longest side **36 inches (914 mm)** or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
- E. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.
- F. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C534/C534M, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
1. Maximum Thermal Conductivity: **0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)** at **75 deg F (24 deg C)** mean temperature.
- G. Inner Duct: Minimum **24-gauge (0.7-mm)** perforated galvanized sheet steel having **3/32-inch-(2.4-mm-)** diameter perforations, with overall open area of 23 percent.

2.4 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 2. For ducts exposed to weather, comply with requirements per "Ductwork Exposed to Weather" Article.
 3. [Basis-of-Design Product](#): Subject to compliance with requirements, provide [SEMCO, LLC](#); SEMCO Single-Wall Round Duct & Fittings or a comparable product by one of the following:

- a. [Crown Products Company, Inc.](#)
 - b. [McGill AirFlow LLC.](#)
 - c. [Sheet Metal Connectors, Inc.](#)
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Transverse Joints in Ducts Larger Than **60 (1524) Inches (mm)** in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Fabricate round ducts larger than **90 inches (2286 mm)** in diameter with butt-welded longitudinal seams.
 2. Fabricate flat-oval ducts larger than **72 inches (1830 mm)** in width (major dimension) with butt-welded longitudinal seams.
- E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.5 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

- A. [Basis-of-Design Product](#): Subject to compliance with requirements, provide [SEMCO, LLC](#): SEMCO Double-Wall Round Duct & Fittings or comparable product by one of the following:
1. [Lindab Inc.](#)
 2. [McGill AirFlow LLC.](#)
 3. [Sheet Metal Connectors, Inc](#)
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
1. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
 - a. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - b. For ducts exposed to weather, comply with requirements per "Ductwork Exposed to Weather" Article.
 2. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse

Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- a. Transverse Joints in Ducts Larger Than 60 (1524) Inches (mm) in Diameter: Flanged.
3. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 - b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
4. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Inner Duct: Minimum 24-gauge (0.7-mm) perforated galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent.
- D. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C534/C534M, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
 1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.

2.6 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 1. Galvanized Coating Designation: G90 (Z275).
 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.
- D. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

- E. Tie Rods: Galvanized steel, 1/4-inch- (6-mm-) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch- (10-mm-) minimum diameter for lengths longer than 36 inches (900 mm).

2.7 DUCT LINER

- A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 - 1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 - 2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - a. Adhesive shall have a VOC content of 80 g/L or less.
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Insulation Pins and Washers:
 - 1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 - 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
 - 1. 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.
 - 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 - 3. Butt transverse joints without gaps, and coat joint with adhesive.
 - 4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
 - 5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
 - 6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s) or greater.
 - 7. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
 - 8. 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:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.

- c. Upstream edges of transverse joints in ducts where air velocities are higher than **2500 fpm (12.7 m/s)** or where indicated.
9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
 - a. Sheet Metal Inner Duct Perforations: **3/32-inch (2.4-mm)** diameter, with an overall open area of 23 percent.
10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.8 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
 1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: **10 inch wg (2500 Pa)**, positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- C. Solvent-Based Joint and Seam Sealant:
 1. Application Method: Brush on.
 2. Base: Synthetic rubber resin.
 3. Solvent: Toluene and heptane.
 4. Solids Content: Minimum 60 percent.
 5. Shore A Hardness: Minimum 60.
 6. Water resistant.
 7. Mold and mildew resistant.
 8. Sealant shall have a VOC content of 420 g/L or less.
 9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 10. Maximum Static-Pressure Class: **10-inch wg (2500 Pa)**, positive or negative.
 11. Service: Indoor or outdoor.
 12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
 6. Sealant shall have a VOC content of 420 g/L or less.
 7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.9 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
- E. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- G. Trapeze and Riser Supports:
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. In-

stall duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of **1 inch (25 mm)**, plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least **1-1/2 inches (38 mm)**.
- J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.
- K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.
- M. Elbows: Use long-radius elbows wherever they fit.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - 2. Fabricate 90-degree round elbows with a minimum of three segments for **12 inches (300 mm)** and smaller and a minimum of five segments for **14 inches (350 mm)** and larger.
- N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCTWORK EXPOSED TO WEATHER

- A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.
- B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.
- C. Double Wall:
 - 1. Ductwork shall comply with requirements in "Double-Wall Rectangular Ducts and Fittings" or "Double-Wall Round and Flat-Oval Ducts and Fittings" Article.
 - 2. Ductwork outer wall shall be either Type 304 or Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation, as follow:
 - a. Corrosive Environments: Type 316
 - b. All Others: Type 304
 - 3. Provide interstitial insulation.

3.4 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.

- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," **Table 5-1 (Table 5-1M)**, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within **24 inches (610 mm)** of each elbow and within **48 inches (1220 mm)** of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of **16 feet (5 m)**.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. The allowable duct leakage for each test section shall be based on a percentage of the total design airflow for that section. An additional allowance shall be included for leakage associated with manual balancing dampers.
 - 2. The total allowable leakage shall be calculated as follows:
 - a. Allowable Leakage (CFM) = (X% × Total Design Airflow) + (5 CFM × Number of Manual Balancing Dampers)
 - b. Where:
 - 1) X% represents the allowable percentage of design airflow.
 - 2) Total Design Airflow is the sum of design airflows for all outlets served by the test section
 - 3. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 4. Test the following systems:

- a. Ducts with a Pressure Class of **3-Inch wg (750 Pa) or Greater**: Test representative duct sections, selected by Engineer from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
 5. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 6. Testing of each duct section is to be performed with access doors, coils, filters, dampers, branch connections, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
 7. Test for leaks before applying external insulation.
 8. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 9. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
- a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.
1. Submit complete leakage test reports for review, including design airflow, test pressure, number of dampers, measured leakage, and pass/fail result.

3.9 STARTUP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
 - 2.
- B. Supply Ducts:
1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive **2-inch wg**.
 - b. Minimum SMACNA Seal Class: A
 - c. Maximum Allowable Leakage: (2% of Total Design Airflow) + (5 cfm per Manual Balancing Damper).

2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive **3-inch wg (750 Pa)**.
 - b. Minimum SMACNA Seal Class: A
 - c. Maximum Allowable Leakage: (1% of Total Design Airflow) + (5 cfm per Manual Balancing Damper).
 3. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive **2-inch wg (500 Pa)**.
 - b. Minimum SMACNA Seal Class: A
 - c. Maximum Allowable Leakage: (1% of Total Design Airflow) + (5 cfm per Manual Balancing Damper).
- C. Return Ducts:
1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive or negative **2-inch wg (500 Pa)**.
 - b. Minimum SMACNA Seal Class: A
 - c. Maximum Allowable Leakage: (2% of Total Design Airflow) + (5 cfm per Manual Balancing Damper).
 2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative **2-inch wg (500 Pa)**.
 - b. Minimum SMACNA Seal Class: A
 - c. Maximum Allowable Leakage: (1% of Total Design Airflow) + (5 cfm per Manual Balancing Damper).
 3. Ducts Connected to Equipment Not Listed above:
 - a. Pressure Class: Positive or negative **2-inch wg (500 Pa)**.
 - b. Minimum SMACNA Seal Class: A
 - c. Maximum Allowable Leakage: (1% of Total Design Airflow) + (5 cfm per Manual Balancing Damper).
- D. Intermediate Reinforcement:
1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
 2. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
- E. Liner:
1. Return-Air Ducts: Flexible elastomeric, **1 inch(es) (25 mm)** thick.
 2. Exhaust-Air Ducts: Flexible elastomeric, **1 inch(es) (25 mm)** thick.
 3. Transfer Ducts: Flexible elastomeric, **1 inch(es) (25 mm)** thick.
- F. Double-Wall Duct Interstitial Insulation:
1. Supply-Air Ducts: **2 inch(es) (51 mm)** thick.
 2. Return-Air Ducts: **2 inch(es) (51 mm)** thick.

G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - 1) Mitered elbows are not permitted in Noise Critical Spaces.
2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Welded.

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: 45-degree entry.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm (5 m/s) or Lower: Conical tap.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
 - c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION

**SECTION 233300
AIR DUCT ACCESSORIES**

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. Backdraft and pressure relief dampers.
 - 2. Manual volume dampers.
 - 3. Control dampers.
 - 4. Flange connectors.
 - 5. Duct silencers.
 - 6. Turning vanes.
 - 7. Duct-mounted access doors.
 - 8. Duct access panel assemblies.
 - 9. Flexible connectors.
 - 10. Duct accessory hardware.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 90A and NFPA 90B.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company; CBD4 or a comparable product by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Nailor Industries Inc.
- B. Description: Gravity balanced with adjustable counterweights.
- C. Performance:
 - 1. Maximum Air Velocity: 2000 fpm (10 m/s).
 - 2. Maximum System Pressure: 3 inches wg (0.8 kPa).
 - 3. AMCA Certification: Test and rate in accordance with AMCA 511.
- D. Construction:
 - 1. Frame:
 - a. Hat shaped.
 - b. 0.093-inch- (2.4-mm-) thick extruded aluminum, with welded or mechanically attached corners.
 - 2. Blades:
 - a. Multiple single-piece blades.
 - b. End pivoted, maximum 6-inch (150-mm) width, 0.050-inch- (1.2-mm-) thick aluminum sheet with sealed edges.
 - 3. Blade Action: Parallel.
- E. Blade Seals: Extruded vinyl, mechanically locked.
- F. Blade Axles:
 - 1. Material: Nonmetallic.
 - 2. Diameter: 0.50 inch (13 mm) .
- G. Tie Bars and Brackets: Aluminum.
- H. Return Spring: Adjustable tension.
- I. Bearings: Steel ball.
- J. Accessories:

1. Adjustment device to permit setting for varying differential static pressure between **0.01-inch wg (0.003 kPa)** and **0.05-inch wg (0.013 kPa)**.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. 90-degree stops.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company; MD35 (rectangular) and MDRS25 (round) or a comparable product by one of the following:
 - a. Greenheck Fan Corporation.
 - b. Nailor Industries Inc.
2. Performance:
 - a. Leakage Rating Class III: Leakage not exceeding **40 cfm/sq. ft. (203 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
3. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
4. Frames:
 - a. Hat-shaped, **16-gauge- (1.6-mm-)** thick, galvanized sheet steel.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
 - a. Multiple or single blade.
 - b. Opposed-blade design (rectangular).
 - c. Stiffen damper blades for stability.
 - d. Galvanized steel; **16 gauge (1.6 mm)** thick.
6. Blade Axles: Galvanized steel.
7. Bearings:
 - a. Molded synthetic.
 - b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
8. Tie Bars and Brackets: Galvanized steel.
9. Locking device to hold damper blades in a fixed position without vibration.

2.4 CONTROL DAMPERS

- ### A. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin Company; CD60 or a comparable product by one of the following:

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

1. [Greenheck Fan Corporation](#).
2. [Nailor Industries Inc.](#)

B. General Requirements:

1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.

C. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA 511.
2. Leakage:
 - a. Class IA: Leakage shall not exceed **3 cfm/sq. ft. (15.2 L/s per sq. m)** against **1-inch wg (250-Pa)** differential static pressure.
3. Pressure Drop: **0.05 inch wg (12.5 Pa)** at **1500 fpm (7.6 m/s)** across a **24-by-24-inch (600-by-600-mm)** damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to **3000 fpm (15 m/s)**.
5. Temperature: **Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C)**.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

D. Construction:

1. Linkage out of airstream.
2. Suitable for horizontal or vertical airflow applications.
3. Frames:
 - a. Hat, U, or angle shaped.
 - b. **16-gauge- (1.6-mm-)** thick, galvanized sheet steel.
 - c. Mitered and welded corners.
 - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
 - a. Multiple blade with maximum blade width of **6 inches (150 mm)**.
 - b. Opposed-blade design.
 - c. Galvanized steel.
 - d. **14-gauge- (1.9-mm-)** thick air foil dual skin.
5. Blade Edging Seals:
 - a. Replaceable Closed-cell neoprene.
 - b. Inflatable seal blade edging, or replaceable rubber seals.
6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: **1/2-inch (13-mm)** diameter; galvanized steel.
8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
9. Bearings:

- a. Oil-impregnated stainless steel sleeve.
 - b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.
- E. Damper Operators: Comply with requirements in Section 250923.12 "Control Damper Accessories."

2.5 FLANGE CONNECTORS

- A. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.
- B. Material: Galvanized steel.
- C. Gauge and Shape: Match connecting ductwork.

2.6 DUCT SILENCERS

- A. **Basis-of-Design Product:** Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. [Industrial Noise Control, Inc.](#)
 - 2. [McGill AirFlow LLC.](#)
 - 3. [Price Noise Control.](#)
 - 4. [Vibro-Acoustics.](#)
- B. General Requirements:
 - 1. Factory fabricated.
 - 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
 - 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - 4. Bearing AMCA's Certified Ratings Seal for prefabricated silencer sound and air performance.
- C. Shape:
 - 1. Rectangular straight with splitters or baffles.
 - 2. Round straight with center bodies or pods.
 - 3. Rectangular elbow with splitters or baffles.
 - 4. Round elbow with center bodies or pods.
 - 5. Rectangular transitional with splitters or baffles.
- D. Rectangular Silencer Outer Casing: ASTM A653/A653M, **G90 (Z275)**, galvanized sheet steel, **0.034 inch (0.85 mm)** thick.
- E. Round Silencer Outer Casing: ASTM A653/A653M, **G90 (Z275)**, galvanized sheet steel.
 - 1. Sheet Metal Thickness for Units up to **24 Inches (600 mm)** in Diameter: **22 gauge (0.85 mm)** thick.

2. Sheet Metal Thickness for Units 26 through 40 Inches (660 through 1000 mm) in Diameter: 20 gauge (1.02 mm) thick.
 3. Sheet Metal Thickness for Units 42 through 52 Inches (1060 through 1300 mm) in Diameter: 18 gauge (1.3 mm) thick.
 4. Sheet Metal Thickness for Units 54 through 60 Inches (1370 through 1500 mm) in Diameter: 16 gauge (1.62 mm) thick.
- F. Inner Casing and Baffles: ASTM A653/A653M, G90 (Z275) galvanized sheet metal, 22 gauge ((0.85 mm)) thick, and with 1/8-inch- (3-mm-) diameter perforations.
- G. Special Construction:
1. Suitable for outdoor use.
 2. High transmission loss to achieve STC 45.
- H. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- I. Principal Sound-Absorbing Mechanism:
1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
 2. Dissipative type with fill material.
 - a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression.
 - b. Erosion Barrier: Polymer bag enclosing fill, heat-sealed before assembly.
 3. Lining: None.
- J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
1. Joints: Flanged connections.
 2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 3. Reinforcement: Cross or trapeze angles for rigid suspension.
- K. Accessories:
1. Factory-installed end caps to prevent contamination during shipping.
- L. Source Quality Control:
- M. Capacities and Characteristics:
1. Configuration: Straight or 90-degree elbow, as indicated on Plans..
 2. Shape: Rectangular or Round, as indicated on Plans.
 3. Maximum Pressure Drop: 0.25-inch wg (0.06 kPa) .

2.7 TURNING VANES

- A. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- C. Vane Construction:
 1. Single wall for ducts up to **48 inches (1200 mm)** wide and double wall for larger dimensions.

2.8 DUCT-MOUNTED ACCESS DOORS

- A. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."
 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. **24-gauge- (0.70-mm-)** thick galvanized steel or **24-gauge- (0.70-mm-)** thick stainless steel door panel.
 - d. Hinges and Latches: **1-by-1-inch (25-by-25-mm)** butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - a. **24-gauge- (0.70-mm-)** thick galvanized steel or **0.032-inch- (0.81-mm-)** thick aluminum frame.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than **12 Inches (300 mm)** Square: No hinges and two sash locks.
 - b. Access Doors up to **18 Inches (460 mm)** Square: Two hinges and two sash locks.
 - c. Access Doors up to **24 by 48 Inches (600 by 1200 mm)**: Three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than **24 by 48 Inches (600 by 1200 mm)**: Four hinges and two compression latches with outside and inside handles.

2.9 DUCT ACCESS PANEL ASSEMBLIES

- A. Access panels used in cooking applications:
 1. Labeled compliant to NFPA 96 for grease duct access doors.
 2. Labeled in accordance with UL 1978 by an NRTL.
- B. Panel and Frame: Minimum thickness **16-gauge (1.6-mm)** stainless steel.

- C. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.
- D. Gasket: Comply with NFPA 96, grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).
- E. Minimum Pressure Rating: 10 inches wg (2500 Pa) positive or negative.

2.10 FLEXIBLE CONNECTORS

- A. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Materials: Flame-retardant or noncombustible fabrics.
- D. Coatings and Adhesives: Comply with UL 181, Class 1.
- E. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.
- F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
 - 2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and [360 lbf/inch (63 N/mm)] in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
- G. 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. (810 g/sq. m).
 - 2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

2.11 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

2.12 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - 1. Galvanized Coating Designation: G90 (Z275).
 - 2. Exposed-Surface Finish: Mill phosphatized.

- B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2D finish for concealed ducts and No. 2B finish for exposed ducts.
- C. Aluminum Sheets: Comply with **ASTM B209** (**ASTM B209M**), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with **ASTM B221** (**ASTM B221M**), Alloy 6063, Temper T6.
- 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** (**6-mm**) minimum diameter for lengths **36 inches** (**900 mm**) or less; **3/8-inch** (**10-mm**) minimum diameter for lengths longer than **36 inches** (**900 mm**).

PART 3 - EXECUTION

3.1 COORDINATION OF WORK WITH OTHER TRADES

- A. Control Dampers:
 - 1. Damper furnished and installed by Division 23.
 - 2. Damper actuator furnished and installed by Division 25.

3.2 INSTALLATION

- A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.
- E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- F. Set dampers to fully open position before testing, adjusting, and balancing.
- G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

- H. Connect ducts to duct silencers rigidly.
- I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream and downstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 6. At each change in direction and at maximum 50-ft. (15-m) spacing.
 - 7. Upstream from turning vanes.
 - 8. Upstream or downstream from duct silencers.
 - 9. Control devices requiring inspection.
 - 10. Elsewhere as indicated.
 - 11. Downstream of air terminal units with reheat coils.
- J. Install access doors with swing against duct static pressure.
- K. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
 - 2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
 - 3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
 - 4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
 - 5. Body Access: 25 by 14 inches (635 by 355 mm).
 - 6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
- L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- M. Install flexible connectors to connect ducts to equipment.
- N. For fans developing static pressures of 5 inches wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- O. Install duct test holes where required for testing and balancing purposes.

3.3 FLEXIBLE CONNECTOR SCHEDULE

- A. Indoor equipment, non-corrosive environment with airstream not in excess of 200 deg F (93 deg C): Indoor system, flexible connector fabric.
- B. Outdoor equipment, non-corrosive environment with airstream not in excess of 200 deg F (93 deg C): Outdoor system, flexible connector fabric.

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.

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UU&PI LBR Relocation Project
Administration and Support Buildings

2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
3. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.

END OF SECTION

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**SECTION 233346
FLEXIBLE DUCTS**

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. Insulated flexible ducts.
 - 2. Flexible duct elbow supports.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."
- D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 INSULATED FLEXIBLE DUCTS

- A. Products: Subject to compliance with requirements, provide one of the following:
 - 1. Flexmaster U.S.A., Inc.; 1M.
 - 2. JP Lamborn Co.; AMR.
 - 3. Thermaflex; a Flex-Tek Group company; M-KE.
 - 4. Atco; UPC 036.
- B. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film or polyethylene fabric supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
4. Insulation R-Value: R6.

2.3 FLEXIBLE DUCT CONNECTORS

- A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

2.4 FLEXIBLE DUCT ELBOW SUPPORTS

- A. Products: Subject to compliance with requirements, provide one of the following:
1. Flexmaster U.S.A., Inc; FlexRight.
 2. Malco; FDS1.
 3. Titus; FlexRight.
 4. Thermaflex; a Flex-Tek Group company; FlexFlow.
- B. 90-degree Elbow: UL 2043, universal-mount, one-piece, fully adjustable, radius-forming brace to support 4-inch (102-mm) through 16-inch (406-mm) diameter flexible air ducts; copolymer polypropylene.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.
- C. Connect terminal units to supply ducts with maximum 24-inch (600-mm) lengths of flexible duct. Do not use flexible ducts to change directions.
- D. Connect diffusers to ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.
- E. Connect flexible ducts to metal ducts with draw bands.
- F. Installation:
1. Install ducts fully extended.
 2. Do not bend ducts across sharp corners.
 3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
 4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
 5. Install flexible ducts in a direct line, without sags, twists, or turns.
 6. Install flexible duct elbow supports in accordance with manufacturer's instructions.

7. Install flexible duct elbow supports over outer jacket of flexible ducts to form smooth, 90-degree bends to eliminate flexible duct kinks and airflow restrictions. Secure flexible duct to flexible duct elbow support with nylon cable ties.
 8. Install flexible duct elbow supports at 90-degree bends at the following locations:
 - a. Diffusers, registers, and grilles.
 - b. Duct take-offs and taps.
 - c. Air devices with round inlets and outlets.
 - d. Flexible ducts being used as elbows.
- G. Supporting Flexible Ducts:
1. Suspend flexible ducts with bands 1-1/2 inches (38 mm) wide or wider and spaced a maximum of 48 inches (1200 mm) apart. Maximum centerline sag between supports shall not exceed 1/2 inch (13 mm) per 12 inches (300 mm).
 2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
 3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
 4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches (1800 mm) o.c.

END OF SECTION

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SECTION 233416.11
SQUARE IN-LINE CENTRIFUGAL FANS

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. Square in-line centrifugal fans.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
 - 2. Rated capacities, operating characteristics, and furnished specialties and accessories.
 - 3. Certified fan performance curves with system operating conditions indicated.
 - 4. Certified fan sound-power ratings.
 - 5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 6. Material thickness and finishes, including color charts.
 - 7. Dampers, including housings, linkages, and operators.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For centrifugal fans to include in normal operation, emergency operation, and maintenance manuals with replacement parts listing.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Belts: One set(s) for each belt-driven unit.

2.1 SQUARE IN-LINE CENTRIFUGAL FANS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Carnes Company.
 2. Greenheck Fan Corporation.
 3. Loren Cook Company.
 4. PennBarry.
- B. Description: Square in-line centrifugal fans.
- C. Housing:
1. Housing Material: Reinforced galvanized steel.
 2. Housing Coating: None.
 3. Housing Construction: Side panels shall be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- D. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- E. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosures around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- F. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.
- G. Motor Enclosure: Totally enclosed, fan cooled.
- H. Accessories:
1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
 2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 3. Companion Flanges: For inlet and outlet duct connections.
 4. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
 6. Side Discharge: Flange connector and attachment hardware to provide right-angle discharge on side of unit.
 7. Insulated Housing: Fiberglass duct liner for the interior of unit to provide a reduction in noise.

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

- B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.3 SOURCE QUALITY CONTROL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. AMCA Compliance: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.
- C. Fan Sound Ratings: Comply with AMCA 311 and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.
- D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.
- E. Operating Limits: Classify fans according to AMCA 99.

PART 3 - EXECUTION

3.1 INSTALLATION OF CENTRIFUGAL HVAC FANS

- A. Install centrifugal fans level and plumb.
- B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.
- D. Equipment Mounting:
 - 1. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
 - 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Install units with clearances for service and maintenance.
- F. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK AND PIPING CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

- B. Install ducts adjacent to fans to allow service and maintenance.
- C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Division 26.
- B. Ground equipment according to Division 26.
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Division 26.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Division 26.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that there is adequate maintenance and access space.
 - 4. Verify that cleaning and adjusting are complete.
 - 5. 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.
 - 6. Adjust belt tension.
 - 7. Adjust damper linkages for proper damper operation.
 - 8. Verify lubrication for bearings and other moving parts.
 - 9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 10. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
 - 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION

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SECTION 233423.15
SIDEWALL PROPELLER FANS

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. Sidewall propeller fans.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
 - 2. Rated capacities, operating characteristics, and furnished specialties and accessories.
 - 3. Certified fan performance curves with system operating conditions indicated.
 - 4. Certified fan sound-power ratings.
 - 5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 6. Material thickness and finishes, including color charts.
 - 7. Dampers, including housings, linkages, and operators.
 - 8. Fan speed controllers.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Belts: One set(s) for each belt-driven unit.

2.1 SIDEWALL PROPELLER FANS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Carnes Company.
 2. Greenheck Fan Corporation.
 3. Loren Cook Company.
 4. PennBarry.
- B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.
- C. Fan Wheel: Replaceable, cast-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
- D. Fan Drive: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- E. Fan Drive:
1. Belt drive.
 2. Resiliently mounted to housing.
 3. Statically and dynamically balanced.
 4. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 5. Extend grease fitting to accessible location outside of unit.
 6. Service Factor Based on Fan Motor Size: 1.4.
 7. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 8. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L(5) of 200,000 hours.
 9. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
 10. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 11. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 12. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
- F. Accessories:
1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
 2. Dampers: Counterbalanced, parallel-blade, backdraft dampers factory set to close when fan stops.
 3. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
 4. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
 5. Wall Sleeve: Galvanized steel to match fan and accessory size.

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, 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.

2.3 SOURCE QUALITY CONTROL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. AMCA Certification: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.
- C. Fan Sound Ratings: Comply with AMCA 311, and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.
- D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.
- E. Operating Limits: Classify according to AMCA 99.
- F. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.1 INSTALLATION OF HVAC POWER VENTILATORS

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:
 - 1. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
 - 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install units with clearances for service and maintenance.
- D. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 250523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that there is adequate maintenance and access space.
 - 4. Verify that cleaning and adjusting are complete.
 - 5. 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.
 - 6. Adjust belt tension.
 - 7. Adjust damper linkages for proper damper operation.
 - 8. Verify lubrication for bearings and other moving parts.
 - 9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 10. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 11. Shut unit down and reconnect automatic temperature-control operators.
 - 12. Remove and replace malfunctioning units and retest as specified above.

- C. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

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SECTION 233439
HIGH-VOLUME, LOW-SPEED FANS

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 high-volume, low-speed fans.

1.3 DEFINITIONS

- A. HVLS - High volume, low speed.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, furnished specialties, and accessories for each fan.
 - 2. Certified fan performance curves with system operating conditions indicated.
 - 3. Certified fan sound-power ratings.
 - 4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 5. Material thickness and finishes, including color charts.
 - 6. Fan speed controllers.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Show dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For each HVLS fan.
 - 1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation required to select mounting components and seismic restraints.

1.5 CLOSEOUT SUBMITTALS

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

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean and dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 - 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 - 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
- E. Replace installed products damaged during construction.

1.7 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of fans that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period:
 - a. For Motor, Including Controls: Seven year(s) from date of Substantial Completion.
 - b. For Parts, Including Blades and Hub: Five year(s) from date of Substantial Completion.
 - c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- 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. UL Compliance: Listed and labeled to UL 507.
- C. CSA Compliance: Listed and labeled to CSA C22.2, No. 113.
- D. Comply with NFPA 13 requirements for HVLS fans.
- E. AMCA Compliance:
 - 1. Test HVLS fans according to AMCA 230.
 - 2. Certify HVLS fan performance according to AMCA 211.
- F. Performance Data: Comply with ANSI 230 test procedure standard, based on five rating points: 20-, 40-, 60-, 80-, and 100-percent of maximum speed. Comply with AMCA 211 for publication of performance data.

2.2 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. Big Ass Fans.
 2. Greenheck Fan Corporation.
 3. Kelley; An Entrematic brand.
- B. Source Limitations: Obtain HVLS fans from single source from single manufacturer.

2.3 HIGH-VOLUME, LOW-SPEED FANS

- A. Description: Factory-assembled and -tested horizontal, non-ducted fan unit, consisting of large-diameter blade set, direct-drive electric motor, with speed-reducing gearbox.
1. Provide fan designed to circulate large air volume, vertically, at low velocity.
 2. Maximum Operating Temperature: 122 (50) deg F (deg C).
 3. Frame:
 - a. Material: Galvanized steel.
 - 1) Finish: Powdercoat.
 4. Diameter: As indicated on Plans.
 5. Blades: Airfoil type.
 - a. Material: Aluminum.
 - 1) Blade Finish: Anodized.
 6. Motor: Squirrel cage, integral to fan frame totally enclosed fan cooled.
 7. Wiring and Controls Enclosure:
 - a. NEMA 250, Class 4X.
 - b. Material: Galvanized steel.
 - 1) Enclosure Finish: Powdercoat.
 - c. Grounded.
 8. Controls: Provide wall-mounted keypad.
 - a. Provide variable speed motor controller.
 - b. Provide fan start/stop, speed, and direction control.
 9. Maximum Sound Power Level: 55 dBA.
 10. Standard Mounting Bracket: Steel beam/steel angle.
 11. Mounting Bracket: See structural plans..
 12. Accessories:
 - a. Mounting extension tube.
 - b. Guy wires.

3.1 EXAMINATION

- A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting HVLS fan performance, maintenance, and operations.
 - 1. Fan locations indicated on Drawings are approximate. Determine exact locations before roughing-in for mounting, control, and electrical connections.
- B. Examine roughing-in for mounting location, anchor-bolt sizes, and locations, to verify actual locations for mounting connections before installation of fan.
- C. Examine areas for suitable conditions where fan will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HIGH-VOLUME LOW-SPEED FANS

- A. Install fan according to manufacturer's published instructions.
- B. Comply with NECA 1 and NFPA 70.
- C. Equipment Mounting:
 - 1. Anchor fan to building structure with manufacturer's recommended mounting bracket for installed condition.
 - 2. Consult a licensed professional structural engineer for mounting methods and approval for mounting to the structure. Structure must be able to withstand the torque and forces generated by the fan.
 - 3. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
 - 4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- D. Install unit to permit access for maintenance.
- E. Install parts and accessories shipped loose.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Division 26.
- B. Ground equipment according to Division 26.
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Division 26.
 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.
- E. Install power wiring to field-mounted electrical devices, furnished by fan manufacturer, but not factory mounted.

3.4 CONTROL CONNECTIONS

- A. Connect control wiring to field-mounted control devices.
- B. Connect control wiring according to Division 26.
- C. Connect control interlock wiring between HVLS fan and other equipment to provide a complete and functioning system.
- D. Connect control wiring between fan unit control interface and control system to provide remote control and monitoring.
- E. Install control devices furnished by manufacturer, but not factory mounted.
- F. Install control wiring to field-mounted control devices, furnished by fan manufacturer, but not factory mounted.
- G. Protect installed units from damage caused by other work.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Fan or components will be considered defective if fan or components do not pass tests and inspections.
- C. Prepare and submit test and inspection reports.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Verify that fan is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers and switches.
 3. Verify proper motor rotation direction and free fan rotation.
 4. Check bearing and gearbox lubrication.

5. Verify proper fan rotation. Set rotation selector to blow vertically downward during heating season, and vertically upward during cooling season.

3.7 CLEANING

- A. Clean equipment externally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions. Following manufacturer's cleaning procedures, and clean with manufacturer-recommended cleaning products.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain HVLS fans.
- B. Video training sessions, and provide electronic copy of video to Owner.

END OF SECTION

**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. Shutoff, single-duct air terminal units.
 - 2. Casing liner.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of air terminal unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For air terminal units.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

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

- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier Corporation; a unit of United Technologies Corp.
 - 2. ENVIRO-TEC; by Johnson Controls, Inc.
 - 3. METALAIRE, Inc.
 - 4. Price Industries.
 - 5. Titus.
 - 6. Trane.
- B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: **0.034-inch- (0.85-mm-)** thick galvanized steel, single wall.
 - 1. Casing Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
 - 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 parts requiring service, adjustment, or maintenance, including upstream of hydronic and electric-resistance heating coils; with airtight gasket.
 - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at **3-inch wg (750-Pa)** inlet static pressure.
- E. Velocity Sensors: Multi-point, multi-axis flow ring or cross sensor in air inlet. Single point or flow bar sensors are not acceptable. Sensor shall be capable of maintaining airflow to within plus or minus **5 percent** of rated unit airflow setpoint with 1.5 duct diameters straight duct upstream from the unit.
- F. Attenuator Section: **0.034-inch (0.85-mm)** steel sheet.
 - 1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for flexible elastomeric duct liner.
 - 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- G. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Stage(s): As scheduled on Drawings.
 2. SCR controlled.
 3. Access door interlocked disconnect switch.
 4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
 5. Nickel chrome 80/20 heating elements.
 6. Airflow switch for proof of airflow.
 7. Fan interlock contacts.
 8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
 9. Magnetic contactor for each step of control (for three-phase coils).
- H. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
 2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
 3. Disconnect Switch: Factory-mounted, fuse type.
 4. Damper actuator, differential pressure transmitter, transformer, and microprocessor-based application specific controller shall be provided by the Division 25 contractor to the air terminal unit manufacturer for factory installation prior to shipment to the project.
- I. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
- J. Control devices shall be compatible with temperature controls system specified in Division 25.

2.3 CASING LINER

- A. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
1. Minimum Thickness: 1/2 inch (13 mm).
 2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - a. Adhesive shall have a VOC content of 80 g/L or less.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests: Test assembled air terminal units according to AHRI 880.
1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- 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 (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.
- 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.

3.2 TERMINAL UNIT 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.

3.3 CONNECTIONS

- A. Comply with requirements in Section 233113.11 "Metal Ducts for General HVAC", 233113.13 "Metal Ducts for Laboratory Exhaust", and Section 233116 "Nonmetal Ducts" for connecting ducts to air terminal units.

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 Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

- A. Perform the following 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.
- B. Air terminal unit will be considered defective if it does not pass tests and inspections.
- C. 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

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SECTION 233713.13
AIR DIFFUSERS

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. Square ceiling diffusers.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 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. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 SQUARE CEILING DIFFUSERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries; SPD or a comparable product by one of the following:
 - 1. Carnes Company.
 - 2. METALAIRE, Inc.
 - 3. Nailor Industries Inc.
 - 4. Titus.
 - 5. Tuttle & Bailey.
- B. Devices shall be specifically designed for variable-air-volume flows.
- C. Material: Aluminum.
- D. Finish: Baked enamel, white.
- E. Face Size: 24 by 24 inches (600 by 600 mm).
- F. Face Style: Plaque.
- G. Pattern: Adjustable.

- H. Insulation: Factory applied, foil faced, R-6 insulation formed to fit contour of diffuser back, continuously glued and sealed around perimeter of outer cone to form vapor seal.
- I. Accessories:
 - 1. Dampers: Radial opposed blade, where indicated on Plans.
 - 2. Plaster (trim) ring: For installations in hard ceiling applications.
 - 3. Sectorizing baffles: Where indicated on Plans.

2.2 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers 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 are 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 diffusers 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 practical. 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 diffusers 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 diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

**SECTION 233713.23
REGISTERS AND GRILLES**

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. Adjustable blade face registers and grilles.
 - 2. Fixed face registers and grilles.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 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. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 REGISTERS

- A. Adjustable Blade Face Register:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries; 620 or a comparable product by one of the following:
 - a. Carnes Company.
 - b. METALAIRe, Inc.
 - c. Nailor Industries Inc.
 - d. Titus.
 - e. Tuttle & Bailey.
 - 2. Material: Aluminum.
 - 3. Finish: Baked enamel, white.
 - 4. Face Blade Arrangement: Vertical spaced **3/4 inch (19 mm)** apart.
 - 5. Rear-Blade Arrangement: Horizontal spaced **3/4 inch (19 mm)** apart.
 - 6. Frame: **1 inch (25 mm)** wide.
 - 7. Mounting: Countersunk screw.
 - 8. Damper Type: Adjustable, aluminum, opposed blade.

2.2 GRILLES

A. Fixed Face Grille:

1. Basis-of-Design Product: Subject to compliance with requirements, provide Price Industries; 630 (no filter) and 630FF (with filter) or a comparable product by one of the following:
 - a. Carnes Company.
 - b. METALAIRE, Inc.
 - c. Nailor Industries Inc.
 - d. Titus.
 - e. Tuttle & Bailey.
2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Horizontal; spaced 3/4 inch (19 mm) apart.
5. Frame: 1 inch (25 mm) wide.
6. Mounting: Countersunk screw or Lay in, as required by ceiling type.

2.3 SOURCE QUALITY CONTROL

- ### A. Verification of Performance: Rate 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 registers and grilles are 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 registers and grilles level and plumb.
- B. Outlets and Inlets Locations: 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 practical. 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 registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

- A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

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**SECTION 233716
FABRIC AIR-DISTRIBUTION 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.

1.2 SUMMARY

- A. Section includes continuous, tubular, fabric air-dispersion diffusers and suspension systems.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
- B. Shop Drawings: For fabric air-distribution devices.
 - 1. Include plans, elevations, sections, and suspension and attachment details.
 - 2. Indicate size and placement of fabric air dispersion diffusers and installation instructions.
 - 3. Include manufacturer's performance data for each fabric air distribution system including airflow rate, design static pressure, inlet velocity, and isothermal throw.
- C. Diffuser Schedule: Use same designations indicated on Drawings. Indicate room location, quantity, model number, size, and accessories furnished.

1.4 INFORMATIONAL SUBMITTALS

- A. 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. Method of attaching hangers to building structure.
 - 3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

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. [DuctSox Corp.](#)
2. [FabricAir Inc.](#)
3. [KE Fibertec NA, Inc.](#)

2.2 PERFORMANCE REQUIREMENTS

- A. Fabric air dispersion diffuser materials shall be listed and labeled as complying with UL 2518 and NFPA 90A.
- B. Air permeability of fabric will comply with ASTM D737.
- C. Design Pressure Requirements: From **0.25 inches wg (65 Pa)** to **3.0 inches wg (774 Pa)**, with **0.5 inches wg (129 Pa)** as the standard.
- D. Design Temperature Requirements: From **0 degrees F (-17.8 degrees C)** to **180 degrees F (82 degrees C)**.

2.3 QUALITY ASSURANCE

- A. All product sections must be labeled with the logo and classification marking of Underwriter's Laboratories.
- B. Manufacturer shall have documented design support information including fabric air dispersion system sizing, vent location, total length, and suspension configuration. Parameters for design shall include but not be limited to maximum air temperature, velocity, pressure drop, and fabric permeability shall be provided and documented.
- C. System overall design (diameter, length, airflow, operating static pressure and dispersion) shall be designed or approved by the manufacturer.

2.4 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fabric air dispersion diffusers that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: 10 years from date of Substantial Completion.
- B. Design and Performance Warranty: Provide manufacturer's standard design and performance warranty stating fabric air dispersion system will perform in accordance with design parameters stipulated in submittals.

2.5 FABRIC AIR DISPERSION DIFFUSERS

- A. Description:
 1. Fabric: Woven flame retardant polyester, factory treated with anti-microbial agent.
 2. Permeability: **2 cfm per square foot** at **0.5 inches wg (129 Pa)**.
 3. Shape: Round
 4. Application: For positive pressure air distribution only.

5. Fabrication: Constructed in modular lengths, with zippered ends and with proper radial securing clips along the length of the system. Zippers shall connect sections together and shall provide closure completely around the circumference to prevent leakage.
6. Color: As selected by Architect from manufacturer's standard color options.

B. Duct Connection Types:

1. Inlet Connection to Metal Duct: Fabric draw band with anchor patches as supplied by manufacturer. Include zipper on inlet connection for easy installation and maintenance.
2. Connection to Fabric Duct Sections: Zipper as supplied by manufacturer.
3. Connection to End Caps: Zipper as supplied by manufacturer for easy adjustment of air-flow.
4. Connection to Suspension System: Include connectors to accommodate specified suspension system

C. Air-Outlet Dispersion Configuration:

1. Permeable Fabric: Air dispersion accomplished by permeable fabric only.
2. Linear Vents: Air dispersion accomplished by linear vent and permeable fabric.
 - a. Linear vents shall be sized in 1 CFM per linear foot increments, starting at 1 CFM through 90 CFM per linear foot.
 - b. Linear vent shall consist of an array of open orifices rather than a mesh style vent to reduce maintenance requirements of mesh style vents.
 - c. Linear vents shall be designed to minimize the collection of dirt and dust on fabric surface.
 - d. Size of vent openings and location of linear vents to be specified and approved by manufacturer.

D. Accessories:

1. Adjustable flow devices to balance turbulence, airflow and distribution as needed, including the ability to adjust the airflow resistance.
2. Snap hooks.
3. Cleanout zipper.
4. Condensate drain.
5. End cap.
6. Draw cords.
7. Elbows.

2.6 SUSPENSION SYSTEM

A. Internal Hoop System:

1. System shall consist of an internal 360-degree hoop system, spaced no more than 5 foot apart on center.
2. System shall be installed with a one row suspension system located no more than 2 inches above 12 o'clock location.
3. System attachment to cable or track shall be spaced no more than 12 inches apart on center.
4. Available for diameters from 8 inches to 60 inches.

B. One Row Cable System:

1. One row cable system installed no more than 2 inches above 12 o'clock location.
 2. Attachments between fabric air system and cable shall be spaced no more than 24 inches apart on center.
 3. Available for systems less than 32 inches diameter.
 4. Cable suspension hardware to include cable, eye bolts, thimbles, cable clamps, and turn-buckle(s) as required.
- C. Tension Cable: Stainless steel
- D. System to include Adjustable Flow Devices to balance turbulence, airflow and distribution as needed. Flow restriction device shall include ability to adjust the airflow resistance from 0.06 – 0.60 in w.g. static pressure.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

- A. Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet 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 practical. Where architectural features or other items conflict with installation, notify Engineer for a determination of final location.

3.2 EXAMINATION

- A. Examine areas for compliance with requirements for installation tolerances and for appropriate alignment, tension, obstructions, and other conditions affecting proper installation of fabric air distribution system.
1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 HANGER AND SUSPENSION SYSTEM INSTALLATION

- A. Overhead suspension system:
1. Install overhead suspension system in accordance with the requirements of the manufacturer. Installation instructions shall be provided by the manufacturer with product.
 2. Coordinate layout with suspended ceiling, lighting layouts, and all other trades that may interfere with the installation of fabric air-distribution systems.

3.4 CONNECTIONS

- A. Connect fabric diffuser to supply air plenum using a round sheet metal tap collar (per manufacturer's recommendations). Fabric diffuser shall be connected to sheet metal collar using fabric inlet collar.
- B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Apply edge guard to edge of sheet metal ductwork prior to installation of fabric air dispersion system.

- C. Fabric air distribution system shall not pass through non-fire-rated interior partitions. Sheet metal duct or sleeve and appropriate mechanical devices should be used to penetrate wall assembly
 - 1. Where fabric air dispersion systems pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers. Provide sheet metal extensions from housing of fire damper to connect fabric air dispersion system on either side of fire damper.

3.5 CLEANING AND PROTECTION

- A. Clean air handling unit and ductwork prior to the fabric air-distribution system unit-by-unit as it is installed. Clean external surfaces of foreign substance which may cause corrosive deterioration of facing.
- B. Ensure that all construction debris, including dust, is removed from the air handling unit and other ductwork before connecting the fabric air-distribution system.
- C. Temporary Closure: At ends of ducts which are not connected to equipment or distribution devices at time of ductwork installation, cover with polyethylene film or other covering which will keep the system clean until installation is completed.
- D. If the fabric air-distribution system becomes soiled during the installation, it should be removed and cleaned following the manufacturers cleaning instructions.

3.6 FIELD QUALITY CONTROL

- A. Test, adjust, and balance air handling equipment, main supply air ductwork and branch supply air ductwork. Replace any damaged or malfunctioning HVAC system components upstream of inlet to fabric air dispersion system.

END OF SECTION

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**SECTION 233919
FIXED LOUVERS**

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fixed extruded-aluminum louvers.

1.2 DEFINITIONS

- A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.
- B. Horizontal Louver: Louver with horizontal blades (i.e., the axis of the blades are horizontal).
- C. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.
- D. Wind-Driven-Rain-Resistant Louver: Louver that provides specified wind-driven-rain performance, as determined by testing in accordance with AMCA 550.
- E. Windborne-Debris-Impact-Resistant Louver: Louver that provides specified windborne-debris-impact resistance, as determined by testing in accordance with AMCA 540.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
- B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.
 - 1. Show weep paths, gaskets, flashings, sealants, and other means of preventing water intrusion.
 - 2. Show mullion profiles and locations.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: Based on evaluation of comprehensive tests performed in accordance with AMCA 550 and AMCA 540 by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

1.6 FIELD CONDITIONS

- A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.7 WARRANTY

- A. Special Finish Warranty, Factory-Applied Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of baked enamel, powder coat, or organic finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain fixed louvers from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

2.2 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Louvers withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver-blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures are considered to act normal to the face of the building.
1. Wind Loads:
 - a. Determine loads based on pressures as indicated on Drawings.
- B. Windborne-Debris-Impact Resistance: Louvers located within 30 feet (9.1 m) of grade pass enhanced protection, when tested in accordance with AMCA 540.
- C. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width in accordance with AMCA 550 and AMCA 540.

- D. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

2.3 FIXED EXTRUDED-ALUMINUM LOUVERS

- A. Horizontal Front Blades with Vertical Rear Blades, Wind-Driven-Rain-Resistant, Windborne-Debris-Impact-Resistant Louver, Extruded Aluminum:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Ruskin; HZ700MD or a comparable product by one of the following:
 - a. Greenheck Fan Corporation; EHV-550D.
 - b. Pottorff; EDV-545
 2. Louver Depth: 5.375 inches (136 mm).
 3. Frame Nominal Thickness: 0.080 inch (2.03 mm).
 4. Blades:
 - a. Front Blade: Horizontal, drainable blade style not less than 0.080 inch (2.03 mm).
 - b. Rear Blade: Vertical, wind-driven-rain-resistant style not less than 0.050 inch (1 mm).
 5. Louver Performance Ratings:
 - a. Free Area: Not less than 8.0 sq.ft (0.74 sq. m) for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - b. Air Performance: Not more than 0.20-inch wg (40-Pa) static pressure drop at 700-fpm (3.6-m/s) free-area exhaust velocity.
 - c. Wind-Driven Rain Performance: Not less than 99 percent effectiveness when subjected to a rainfall rate of 8 inches (200 mm) per hour and a wind speed of 50 mph (22.4 m/s) at a core-area intake velocity of 803 fpm (4.0 m/s).
 6. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
 7. AMCA Rating: AMCA 540, AMCA 550.

2.4 LOUVER SCREENS

- A. General: Provide screen at each exterior louver.
1. Screen Location for Fixed Louvers: Interior face.
 2. Screening Type: Bird screening.
- B. Secure screen frames to louver frames with machine screws with heads finished to match louver, spaced a maximum of 6 inches (150 mm) from each corner and at 12 inches (300 mm) o.c.
- C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
1. Metal: Same type and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.
 2. Finish: Same finish as louver frames to which louver screens are attached.
 3. Type: Non-rewirable, U-shaped frames.
- D. Louver Screening for Aluminum Louvers:

1. Bird Screening, Aluminum: 1/2-inch- (13-mm-) square mesh, 0.063-inch (1.60-mm) wire.

2.5 MATERIALS

- A. Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063-T5, T-52, or T6.
- B. Aluminum Sheet: ASTM B209 (ASTM B209M), Alloy 3003 or 5005, with temper as required for forming, or as otherwise recommended by metal producer for required finish.
- C. Fasteners: Use types and sizes to suit unit installation conditions.
 1. Use Phillips flat-head screws for exposed fasteners unless otherwise indicated.
 2. For fastening aluminum, use aluminum or 300 series stainless steel fasteners.
 3. For fastening galvanized steel, use hot-dip-galvanized-steel or 300 series stainless steel fasteners.
 4. For color-finished louvers, use fasteners with heads that match color of louvers.
- D. Postinstalled Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, fabricated from stainless steel components, with allowable load or strength design capacities calculated in accordance with ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing in accordance with ASTM E488/E488M conducted by a qualified testing agency.
- E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

2.6 FABRICATION

- A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
- B. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.
 1. Continuous Vertical Assemblies: Fabricate units without interrupting blade-spacing pattern unless horizontal mullions are indicated.
- C. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.
- D. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
 1. Frame Type: Exterior flange unless otherwise indicated.
- E. Include supports, anchorages, and accessories required for complete assembly.
- F. Provide vertical mullions of type and at spacings indicated, but not more than is recommended by manufacturer, or 72 inches (1830 mm) o.c., whichever is less.

1. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.
- G. Provide extended sills for recessed louvers.
- H. Join frame members to each other and to fixed louver blades with fillet welds, threaded fasteners, or both, as standard with louver manufacturer unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.7 ALUMINUM FINISHES

- A. Finish louvers after assembly.
- B. Superior-Performance Organic Finish, Three-Coat PVDF: Fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat.
1. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 2. Color and Gloss: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

- A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Form closely fitted joints with exposed connections accurately located and secured.
- D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

- E. Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.
- F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Division 07 for sealants applied during louver installation.

3.4 ADJUSTING AND CLEANING

- A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.
- B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
- C. Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
 - 1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION

**SECTION 234100
PARTICULATE AIR FILTRATION**

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. Pleated panel filters.
 - 2. Filter gauges.

1.3 DEFINITIONS

- A. HIPS: High-impact polystyrene.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated air-flow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean, dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 - 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 - 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
 - 3. Replace installed products damaged during construction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. ASHRAE Compliance:
 - 1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
 - 2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
- B. Comply with NFPA 90A and NFPA 90B.
- C. Comply with UL 900.
- 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.

2.2 PLEATED PANEL FILTERS - STANDARD

- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil; AP-Thirteen or comparable product by one of the following:
 - a. AAF / Flanders.
 - b. Airguard.
 - c. Purafil, Inc.
- B. Source Limitations: Obtain from single source from single manufacturer.
- C. Capacities and Characteristics:
 - 1. Depth: **1 inch (25 mm)**, **2 inches (50 mm)**, or **4 inches (100 mm)** nominal, as indicated in Equipment Schedules.

2. Maximum or Rated Face Velocity: 625 fpm (3.2 m/s).
3. Initial Resistance: 0.25-inch wg (62 Pa) at 350 fpm (1.8 m/s).
4. Recommended Final Resistance: 1.0 inches wg (249 Pa).
5. Minimum Efficiency Reporting Value: MERV 13, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.

- D. Media: Interlaced glass or synthetic fibers coated with nonflammable adhesive.
1. Separators shall be bonded to the media to maintain pleat configuration.
 2. Welded-wire grid shall be on downstream side to maintain pleat.
 3. Media shall be bonded to frame to prevent air bypass.
 4. Support members on upstream and downstream sides to maintain pleat spacing.
- E. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.

2.3 PLEATED PANEL FILTERS – MOISTURE RESISTANT

- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil; Opti-Pac Durable or comparable product by one of the following:
 - a. AAF / Flanders; PrecisionCell III.
- B. Source Limitations: Obtain from single source from single manufacturer.
- C. Capacities and Characteristics:
1. Depth: 2 inches (50 mm) or 4 inches (100 mm) nominal, as indicated in Equipment Schedules.
 2. Maximum or Rated Face Velocity: 625 fpm (3.2 m/s).
 3. Initial Resistance: 0.25-inch wg (62 Pa) at 350 fpm (1.8 m/s).
 4. Recommended Final Resistance: 1.5 inches wg (373 Pa).
 5. Minimum Efficiency Reporting Value: MERV 13, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
- D. Media: Synthetic polypropylene fibers coated with nonflammable adhesive.
1. Separators shall be bonded to the media to maintain pleat configuration.
 2. Media shall be bonded to frame to prevent air bypass.
- E. Filter-Media Frame: Plastic frame bonded to the entire periphery of media.

2.4 FILTER GAUGES

- A. Diaphragm-type gauge with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Dwyer Instruments, Inc; Series 2000 or comparable product by one of the following:

- a. Airguard.
- B. Source Limitations: Obtain from single source from single manufacturer.
 1. Diameter: 4-1/2 inches (115 mm).
 2. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
- C. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF FILTERS

- A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. Install filter gauge for each filter bank.
- D. 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.
- E. Coordinate filter installations with duct and air-handling-unit installations.

3.3 INSTALLATION OF FILTER GAUGES

- A. Install filter gauge for each filter bank.
- B. Install filter-gauge, static-pressure tips upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

3.4 FILTER SCHEDULE

- A. Indoor equipment with outside airflow less than 100 percent of supply airflow:
 1. Pleated panel filters - standard.
- B. Indoor equipment with outside airflow equal to 100 percent of supply airflow:

1. Pleated panel filters – moisture resistant.

C. Outdoor equipment:

1. Pleated panel filters – moisture resistant.

3.5 CLEANING

- A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

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SECTION 23 74 33.11
PACKAGED, HIGH-PERCENTAGE OUTDOOR-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Section includes factory-assembled, packaged units, including multiple components, capable of heating and cooling 100 percent outdoor air.

1.2 DEFINITIONS:

- A. ECM: Electronically commutated motor.
- B. IS COP: Integrated Seasonal Coefficient of Performance.
- C. ISMRE: Integrated Seasonal Moisture Removal Efficiency.
- D. MRC: Moisture Removal Capacity.

1.3 ACTION SUBMITTALS

A. Product Data: For each high-percentage outdoor-air unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. 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.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include heat exchangers with performance characteristics.
9. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each high-percentage outdoor-air unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Startup service reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For high-percentage outdoor-air units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fan Belts: One set(s) for each belt-driven fan.
 - 2. Filters: One set(s) for each unit.
 - 3. Gaskets: One set(s) for each access door.

1.7 WARRANTY

- A. Warranty: Manufacturer's standard form in which manufacturer agrees to provide labor, materials, refrigerant, and oil to replace/repair inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, and failure to perform. Provide warranty signed by the manufacturer's representative.
 - 1. Warranty shall cover unit operation under normal conditions and use, where installed, operated, and maintained in accordance with manufacturer's instructions.
 - 2. Extended warranties include, but are not limited to, the following:
 - a. Complete outdoor air unit including refrigerant and oil charge.
 - b. Parts and labor.
 - c. Loss of refrigerant charge for any reason.
 - 3. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an "NRTL" (nationally recognized testing laboratory), and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

- D. ASHRAE 15 and ASHRAE 34 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. UL Compliance:
 - 1. Electric Coils: Comply with requirements in UL 1995.
- G. Wind-Restraint Performance:
 - 1. See Section 230548.13 "Vibration Controls for HVAC" for requirements.

2.2 HIGH-PERCENTAGE OUTDOOR-AIR 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. Addison.
 - 2. Trane.
- B. Source Limitations: Obtain high-percentage outdoor-air units from single manufacturer.
- C. Unit Casing:
 - 1. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
 - 2. Configuration: Horizontal unit with bottom discharge for concrete-base installation.
 - 3. Double-Wall Configuration:
 - a. Outside Casing Wall: Galvanized steel , minimum **18 gauge (1.3 mm)** thick with corrosion-resistant coating , with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
 - b. Inside Casing Wall:
 - 1) Inside Casing, Burner Section: Galvanized steel , solid, minimum **14-gauge-(0.759-mm-)** thick steel.
 - 2) Inside Casing, All Other Sections: Galvanized steel , solid .
 - 3) Antimicrobial Coating: Applied during the manufacturing process..
 - c. Floor Plate: Reinforced metal surface; reinforced to limit deflection when walked on by service personnel. Insulation is provided below metal walking surface.
 - d. Roof: Standing seam or membrane; sloped to drain water.
 - e. Casing Insulation:
 - 1) Materials: Polyurethane foam insulation.
 - 2) Casing Panel R-Value: Minimum R-13 .
 - 3) Insulation Thickness: **2 inches (50 mm)** .
 - 4) Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
 - 4. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

5. Panels and Doors:

a. Panels:

- 1) Fabrication: Formed and reinforced double-wall and insulated panels of same materials and thicknesses as casing.
- 2) Fasteners: Two or more camlock-type fasteners for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
- 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
- 4) Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.

b. Doors:

- 1) Fabrication: Formed and reinforced double-wall and insulated panels of same materials and thicknesses as casing.
- 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
- 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
- 4) Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.

c. Locations and Applications:

- 1) Fan Section: Doors.
- 2) Access Section: Doors.
- 3) Gas-Fired Burner Section: Doors.
- 4) Damper Section: Doors.
- 5) Filter Section: Doors large enough to allow periodic removal and installation of filters.
- 6) Relief Section: Doors.

6. Condensate Drain Pans:

a. Location: Each refrigerant coil.

b. Construction:

- 1) Single-wall, stainless steel sheet.

c. Size: Large enough to collect condensate from cooling coils, including coil piping connections, coil headers, and return bends.

d. Drain Connection:

- 1) Located on one end of pan, at lowest point of pan.
- 2) Terminated with threaded nipple.
- 3) Minimum Connection Size: **NPS 1 (DN 25)** .

e. Slope: Minimum **0.125-inch/ft. (10-mm/m)** slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.

f. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1 .

- g. Width: Entire width of water-producing device.
- h. Depth: A minimum of **2 inches (50 mm)** deep.
- i. Provide units having stacked coils with intermediate drain pan to collect condensate from top coil.

D. Fans, Drives, And Motors:

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
2. Supply-Air Fans and Relief-Air Fans: Centrifugal; galvanized or painted steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings:
 - 1) Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours in accordance with ABMA 9.
 - c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - 1) Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - d. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
 - e. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with set-screws.
 - f. Mounting: For internal vibration isolation. Factory mount fans with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of **1 inch (25 mm)**.
 - g. Shaft Lubrication Lines: Extended to a location outside the casing.
 - h. Flexible Connector: Factory fabricated with a fabric strip minimum **3-1/2 inches (89 mm)** wide, attached to two strips of minimum **2-3/4-inch- (70-mm-)** wide by **0.028-inch- (0.7-mm-)** thick, galvanized-steel sheet.
 - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
3. Drive, Direct: Factory-mounted direct drive.
4. Drive, Belt: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with 1.25 service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - b. Belts: Oil resistant, nonsparking and nonstatic; in matched sets for multiple-belt drives.
 - c. Belt Guards: Comply with requirements specified by OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards"; **0.146 inch (2.7**

mm) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame; prime coated.

5. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated electronically commutated motors.
6. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
7. Variable-Frequency Motor Controller: Serving all fans combined in fan array.
 - a. Manufactured Units: Pulse-width modulated; constant torque and variable torque for inverter-duty motors.
 - b. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range ; maximum voltage equals input voltage.
 - c. Unit Operating Requirements:
 - 1) Internal Adjustability:
 - a) Minimum Speed: 5 to 25 percent of maximum rpm.
 - b) Maximum Speed: 80 to 100 percent of maximum rpm.
 - c) Acceleration: 0.1 to 999.9 seconds.
 - d) Deceleration: 0.1 to 999.9 seconds.
 - e) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - 2) Self-Protection and Reliability Features:
 - a) Surge suppression.
 - b) Loss of input signal protection.
 - c) Under- and overvoltage trips.
 - d) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - e) Critical frequency rejection.
 - f) Loss-of-phase protection.
 - g) Reverse-phase protection.
 - h) Motor-overtemperature fault.
 - 3) Bidirectional autospeed search.
 - 4) Torque boost.
 - 5) Motor temperature compensation at slow speeds.
 - a) Panel-mounted operator station.
 - b) Historical logging information and displays.
 - c) Digital indicating devices.
 - 6) Control Signal Interface: Electric.
 - 7) Proportional Integral Directive (PID) control interface.
 - 8) DDC system for HVAC Protocols for Network Communications: ASHRAE 135.
 - d. Line Conditioning:
 - 1) Input line conditioning.
 - 2) Output filtering.

3) EMI/RFI filtering.

e. Bypass Systems:

- 1) Bypass Mode: Manual operation only .
- 2) Bypass Controller, Three-Contactor Style: With bypass and input and output isolating contactors.
- 3) Bypass Contactor Configuration: Full-voltage (across the line) type.

E. Coils:

1. General Requirements for Coils:

- a. Comply with AHRI 410.
- b. Fabricate coils section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
- c. Coils are not to act as structural component of unit.

2. Supply-Air Refrigerant Coils:

- a. Tubes: Copper .
- b. Fins:
 - 1) Material: Aluminum .
 - 2) Fin Spacing: Maximum 14 fins per inch (mm).
- c. Fin and Tube Joints: Mechanical bond.
- d. Headers: Seamless-copper headers with brazed connections .
- e. Frames: Galvanized steel .
- f. Coatings: Corrosion-resistant coating.
- g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum 300 psig (2070 kPa).

3. Hot-Gas Reheat Refrigerant Coils:

- a. Tubes: Copper .
- b. Fins:
 - 1) Material: Aluminum .
 - 2) Fin Spacing: Maximum 14 fins per inch (mm).
- c. Fin and Tube Joints: Mechanical bond.
- d. Headers: Seamless-copper headers with brazed connections .
- e. Frames: Galvanized steel .
- f. Coatings: Corrosion-resistant coating and anti-microbial coating.
- g. Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - 1) Working Pressure: Minimum 300 psig (2070 kPa).
- h. Suction-discharge bypass valve.

4. Condenser Refrigerant Coils:

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

- a. Tube Material: Copper .
- b. Fin Material: Aluminum .
- c. Fin and Tube Joint: Mechanical bond.
- d. Coating: Corrosion-resistant.

F. Refrigeration Circuit Components:

- 1. Compressors: Hermetic, variable-capacity, digital scroll compressors, mounted on integral vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.
- 2. Refrigerant: R-32 or R-454B.
- 3. Refrigeration Specialties:
 - a. Expansion valve with replaceable thermostatic element.
 - b. Refrigerant filter/dryer.
 - c. Manual-reset high-pressure safety switch.
 - d. Automatic-reset low-pressure safety switch.
 - e. Minimum off-time relay.
 - f. Automatic-reset compressor motor thermal overload.
 - g. Thermostat for coil freeze-up protection during low-ambient-temperature operation or loss of air.
 - h. Brass service valves installed in discharge and liquid lines.
 - i. Low-ambient kit high-pressure sensor.
 - j. Single compressor with evaporator and condenser coil within the refrigerant section to provide initial pre-cooling and to reheat for humidity control.
 - k. Modulating hot-gas reheat solenoid valve with a replaceable magnetic coil.
 - l. Heat-pipe heat exchanger, wrapped around the evaporator coil to pre-cool the air entering the evaporator coil and reheat the air leaving the evaporator coil to control humidity.
- 4. Hot-gas bypass refrigerant control for capacity control with continuous dehumidification for single-speed compressor.
- 5. Liquid line sight glass.
- 6. Condenser fan head pressure control.

G. Air Filtration:

- 1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- 2. Mounting Frames:
 - a. Panel filters arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or from access plenum.
 - b. Cartridge filters arranged for flat orientation, removable from access plenum.
 - c. Galvanized or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

H. Indirect-Fired Gas Furnace Heating:

- 1. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.
- 2. CSA Approval: Designed and certified by and bearing label of CSA.
- 3. Burners:
 - a. Heat-Exchanger Material: Stainless steel.
 - b. Fuel: Natural gas.

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

- c. Ignition: Electronically controlled electric spark with flame sensor.
 - d. Gas Control Valve: Electronic modulating.
 - e. Gas Train: Single-body, regulated, redundant, 24 V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.
- 4. Venting, Gravity: Gravity vented.
- 5. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.
- 6. Heat-Exchanger Drain Pan: Stainless steel.
- 7. Safety Controls:
 - a. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global .
- I. Dampers:
 - 1. Outdoor, Return and Relief Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed **4 cfm/sq. ft. (20 L/s per sq. m)** at **1 inch wg (250 Pa)** and **8 cfm/sq. ft. (40 L/s per sq. m)** at **4 inches wg (1.0 MPa)**.
 - 2. Electronic Damper Operators:
 - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - b. Electronic damper position indicator shall have visual scale indicating percentage of travel and 2 to 10 V dc feedback signal.
 - c. Operator Motors:
 - 1) 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."
 - 2) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
 - e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
 - f. Size dampers for running torque calculated as follows:
 - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
 - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
 - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft. (49.6 kg-cm/sq. m)** of damper.
 - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.

- 5) Dampers with 2 to 3 Inches wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - 6) Dampers with 3 to 4 Inches wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
 - g. Coupling: V-bolt and V-shaped, toothed cradle.
 - h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
 - j. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
 - k. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2 to 10 V dc position feedback signal.
 - l. Temperature Rating: **Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)** .
- J. Electrical Power Connections:
- 1. Single-Point Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a single-point field power connection to unit except for service lights and convenience outlets, which are to be powered separately.
 - 2. Enclosure: NEMA 250, Type 3R, mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key.
 - 3. Wiring: Numbered and color-coded to match wiring diagram.
 - 4. Wiring Location: Install factory wiring outside an enclosure in a raceway.
 - 5. Power Interface: Field power interface to be NEMA KS 1, heavy-duty, nonfused disconnect switch.
 - 6. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:
 - a. NEMA KS 1, heavy-duty, nonfusible switch. Minimum SCCR according to UL 508 shall be as required by electrical power distribution system, but not less than 65,000 A.
 - b. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
 - 7. Factory-Mounted, Overcurrent-Protection Service: For each motor.
 - 8. Transformer: Factory mounted with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
 - 9. Controls: Factory wire unit-mounted controls where indicated.
 - a. Convenience Outlets: One 20 A duplex GFCI receptacle per location with junction box located on outside casing wall.
 - 1) Locations: Fan section .
 - 10. Control Relays: Auxiliary and adjustable time-delay relays.
- K. Controls:
- a. Per division 25.
- L. Roof Curbs:
- 1. Roof curbs with vibration isolators and wind restraints are specified in Section 230548.13 "Vibration Controls for HVAC."

2. Materials: Galvanized steel with corrosion-resistant coating, watertight gaskets, and factory-installed wood nailer; complying with National Roofing Contractors Association manuals for the specific type of roofing applicable to the Project.
 - a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1) Materials: ASTM C1071, Type I or II.
 - 2) Thickness: **1-1/2 inches** (38 mm) .
 - b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C916, Type I.
 - 2) 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 cabinet.
 - 3) Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service air velocity.
3. Curb Dimensions: Height of **24 inches** (610 mm) minimum or as indicated on plans, whichever is greater.
4. Wind Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration Controls for HVAC" for wind-load requirements.

M. Intake And Relief Openings:

1. Type: Manufacturer's standard hood or louver, including moisture eliminator, at all unit intake and relief openings.
2. Materials: Match material and finish of casing exterior.
3. Bird Screen: Comply with requirements in ASHRAE 62.1.
4. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.3 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: **ASTM B209** (ASTM B209M).

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

- F. Corrosion-Resistant and Anti-Microbial Coating: Coat casing, coils, and fan guards with a corrosion-resistant and anti-microbial coating capable of withstanding a 11,000-hour salt-spray test in accordance with ASTM B117.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Adsil; Microguard.
 - b. Blygold; PoluAl XT-MB.
 - 2. Application: Factory-applied Spray.

2.4 SOURCE QUALITY CONTROL

- A. AHRI 920: Manufacturer to certify that performance ratings are in accordance with AHRI 920 if AHRI 920 certification program is not in place. Provide AHRI 920 certification if AHRI 920 certification program is in place.
- B. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label unit fan sound ratings in accordance with AHRI 260 or AMCA 311.
- C. Fan Aerodynamic Performance Rating: Test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency.
 - 1. Fan Aerodynamic Performance Rating: Test and rate fan performance in accordance with AMCA 210.
 - 2. AMCA Fan Aerodynamic Certification Rating: Test, rate, and label, in accordance with AMCA 211.
- D. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- E. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- F. Damper Leakage and Air Performance:
 - 1. Damper Rating: Test and rate dampers for leakage and air performance in accordance with AMCA 510.
 - 2. AMCA Damper Certification: Test, rate, and label in accordance with AMCA 511.
- G. Refrigerant Coils: Factory tested to minimum 450 psig (3105 kPa) internal pressure and to minimum 300 psig (2070 kPa) internal pressure while under water, in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

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

- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HIGH-PERCENTAGE OUTDOOR-AIR UNITS

- A. Roof Curb: Install on roof structure or concrete base, level and secure. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07. Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
- B. Unit Support: Install unit level on structural curbs . Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of curbs with actual equipment provided.
 - 1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- 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-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- F. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.
- G. Comply with requirements for gas-fired furnace installation in NFPA 54.
- H. Install separate devices furnished by manufacturer and not factory installed.
- I. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to units, allow space for service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Gas Piping: Comply with requirements in Section 221123 "Facility Natural-Gas Piping." Provide AGA-approved flexible connectors.

1. Connect gas piping to furnace, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
2. Install AGA-approved flexible connectors.

E. Duct Connections:

1. Comply with requirements in Section 233113.11 "Metal Ducts for General HVAC."
2. Drawings indicate the general arrangement of ducts.
3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Division 26.
- B. Ground equipment in accordance with Division 26.
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Division 26.
 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Division 25 and Division 26.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Inspect units for visible damage to furnace combustion chamber.
 3. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure flue-gas temperature at furnace discharge.
 - d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

City of Tallahassee
UU&PI LBR Relocation Project
Administration and Support Buildings

4. Verify operation of remote panel, including pilot-light operation and failure modes. Inspect the following:
 - a. High-limit heat exchanger.
 - b. Alarms.
 5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
 6. Start refrigeration system when outdoor-air temperature is within normal operating limits. and measure and record the following:
 - a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
 - b. Cooling coil entering-air, dry- and wet-bulb temperatures.
 - c. Condenser coil entering-air dry-bulb temperature.
 - d. Condenser coil leaving-air dry-bulb temperature.
 7. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.
 8. Inspect casing insulation for integrity, moisture content, and adhesion.
 9. Verify that clearances have been provided for servicing.
 10. Verify that controls are connected and operable.
 11. Verify that filters are installed.
 12. Clean coils and inspect for construction debris.
 13. Clean furnace flue and inspect for construction debris.
 14. Inspect operation of power vents.
 15. Purge gas line.
 16. Inspect and adjust vibration isolators and seismic restraints.
 17. Verify bearing lubrication.
 18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 19. Adjust fan belts to proper alignment and tension.
 20. Start unit.
 21. Inspect and record performance of interlocks and protective devices, including response to smoke detectors by fan controls and fire alarm.
 22. Operate unit for run-in period.
 23. Calibrate controls.
 24. Adjust and inspect high-temperature limits.
 25. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
 26. Verify operational sequence of controls.
 27. Measure and record the following airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Relief-air flow.
 - c. Outdoor-air flow.
- B. After startup, change filters, verify bearing lubrication, and adjust belt tension.
- C. Remove and replace components that do not properly operate, and repeat startup procedures as specified above.
- D. Document all internal configurations and settings upon completion of startup and include with startup report.

- E. Prepare written report of the results of startup services.

3.7 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months from 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.

3.8 CLEANING

- A. After completing system installation; testing, adjusting, and balancing high-percentage outdoor-air unit and air-distribution systems; and completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, casings, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Charge refrigerant coils with refrigerant and test for leaks.
 - 2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

SECTION 238126.11
AIR-COOLED, SPLIT-SYSTEM AIR-CONDITIONERS (5 TONS AND SMALLER)

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 small capacity, air-cooled, split-system air-conditioning and heat-pump units (5 tons and smaller) consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: One set(s) for each air-handling unit.

1.6 QUALITY ASSURANCE

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

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.7 COORDINATION

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

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts: One year(s) from date of Substantial Completion.
 - c. For Labor: One year(s) from date of Substantial Completion.

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. [Daikin Industries, Ltd.](#)
 2. [Lennox Industries, Inc.; Lennox International.](#)
 3. [Mitsubishi Electric & Electronics USA, Inc.](#)
 4. [Trane.](#)

2.2 INDOOR UNITS (5 TONS (18 kW) OR LESS)

- A. Wall-Mounted, Evaporator-Fan Components:
 1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
 2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
 3. Fan: Direct drive, centrifugal.
 4. Fan Motors:

- a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - c. Enclosure Type: Totally enclosed, fan cooled.
 - d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 - e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - f. Mount unit-mounted disconnect switches on interior of unit.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
6. Condensate Drain Pans:
 - a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - 1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
 - 2) Depth: A minimum of **1 inch (25 mm)** deep.
 - b. Single-wall, galvanized-steel sheet.
 - c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - 1) Minimum Connection Size: **NPS 3/4 (DN 19)**.
 - d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
7. Air Filtration Section:
 - a. General Requirements for Air Filtration Section:
 - 1) Comply with NFPA 90A.
 - 2) Comply with Section 234100 "Particulate Air Filtration" for filters.
 - 3) Filter-Holding Frames: Arranged for flat. Filters shall be removable from one side.
 - b. Extended-Surface, Disposable Panel Filters:
 - 1) Factory-fabricated, dry, extended-surface type.
 - 2) Thickness: **1 inch (25 mm)**.
 - 3) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.3 OUTDOOR UNITS (**5 TONS (18 kW)** OR LESS)

- A. Air-Cooled, Compressor-Condenser Components:
 1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Scroll.
 - b. Single-stage or two-stage compressor motor (as indicated on Drawings) with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - c. Refrigerant: R-32, R-454B, or R-410A.
 - d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).

2.4 ACCESSORIES

- A. Control equipment are specified in Division 25.
- B. Thermostat/Humidistat: Low voltage with subbase to control compressor and evaporator fan. 7-day programmable combination thermostat/humidistat.
 1. Compressor time delay.
 2. 24-hour time control of system stop and start.
 3. Liquid-crystal display indicating temperature, humidity, set-point temperature, set-point humidity, time setting, operating mode, and fan speed.
 4. Fan-speed selection including auto setting.
- C. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
- D. Automatic-reset timer to prevent rapid cycling of compressor.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Equipment Mounting:
 1. Install ground-mounted, compressor-condenser components on 4-inch (100-mm) cast-in-place concrete equipment base(s) that is 4 inches (100 mm) larger, on each side, than unit. Comply with requirements for equipment bases and foundations specified in Division 03.
 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.
- C. Duct Connections: Duct installation requirements are specified in Section 233113.11 "Metal Ducts for General HVAC." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

3.4 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

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