

PROJECT MANUAL
FOR



recenter

A DBA OF THE MEN'S CENTER, INC.
3809 Main St. Houston, Texas 77002

BRAVE / ARCHITECTURE; Project No.: 13143

ISSUE FOR BID

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DOCUMENT 00 00 01

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PART 1 - GENERAL

1.01 SECTION INCLUDES:

- A. Basic Mechanical Requirements specifically applicable to Division 23 Sections, in addition to Division 01 - General Requirements.

1.02 RELATED REQUIREMENTS

- A. Section 01-10-00 - Summary: Contract descriptions, description of alterations work, work by others, future work, occupancy conditions, use of site and premises, work sequence.
- B. Section 01-20-00 - Price and Payment Procedures: Applications for payment, Schedule of Values, modifications procedures, closeout procedures.
- C. Section 01-30-00 - Administrative Requirements: Submittal procedures, project meetings, progress schedules and documentation, reports, coordination.
- D. Section 01-40-00 - Quality Requirements: Procedures for testing, inspection, mock-ups, reports, certificates; use of reference standards.
- E. Section 01-57-13 - Temporary Erosion and Sedimentation Control.
- F. Section 01-57-21 - Indoor Air Quality Controls: Procedures and testing; smoking room testing; LEED requirements.
- G. Section 01-60-00 - Product Requirements: Fundamental product requirements, substitutions and product options, delivery, storage, and handling.
- H. Section 01-70-00 - Execution Requirements: Examination, preparation, and general installation procedures; preinstallation meetings; cutting and patching; cleaning and protection; starting of systems; demonstration and instruction; closeout procedures except payment procedures; requirements for alterations work.
- I. See Section 01-74-19 - Construction Waste Management and Disposal.
- J. Section 01-78-00 - Closeout Submittals: Project record documents, operation and maintenance (O&M) data, warranties and bonds.
- K. Section 01-79-00 - Demonstration and Training: Detailed requirements.
- L. Section 01-91-13 - General Commissioning Requirements.

1.03 SUBMITTALS

- A. See Section 01-30-00 - Administrative Requirements, for submittal procedures.

1.04 WARRANTY

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- A. See Section 01-78-00 - Closeout Submittals, for additional warranty requirements.
- B. Warranties shall commence from the date of substantial completion of the project.
- C. Warranties shall be for 1 year unless specifically called for differently within the specific specification section.
- D. Warranty shall be unconditional and include material, labor and response within 24 hours of notification.

1.05 GENERAL:

- A. The Contractor shall execute all work hereinafter specified or indicated on accompanying Drawings. Contractor shall provide all equipment necessary and usually furnished in connection with such work and systems whether or not mentioned specifically herein or on the Drawings.
- B. The Contractor shall be responsible for fitting his material and apparatus into the building and shall carefully lay out his work at the site to conform to the structural conditions, to avoid all obstructions, to conform to the details of the installation and thereby to provide an integrated satisfactory operating installation.
- C. The Mechanical, Electrical, and associated Drawings are necessarily diagrammatic by their nature, and are not intended to show every connection in detail or every pipe or conduit in its exact location. These details are subject to the requirements of standards referenced elsewhere in these specifications, and structural and architectural conditions. The Contractor shall carefully investigate structural and finish conditions and shall coordinate the separate trades in order to avoid interference between the various phases of work. Work shall be organized and laid out so that it will be concealed in furred chases and suspended ceilings, etc., in finished portions of the building, unless specifically noted to be exposed. All exposed work shall be installed parallel or perpendicular to the lines of the building unless otherwise noted.
- D. When the mechanical and electrical Drawings do not give exact details as to the elevation of pipe, conduit and ducts, the Contractor shall physically arrange the systems to fit in the space available at the elevations intended with proper grades for the functioning of the system involved. Piping, exposed conduit and the duct systems are generally intended to be installed true and square to the building construction, and located as high as possible against the structure in a neat and workmanlike manner. The Drawings do not show all required offsets, control lines, pilot lines and other location details. Work shall be concealed in all finished areas.

1.06 DEFINITIONS:

- A. (Note: These definitions are included here to clarify the direction and intention of this specification. The list given here is not by any means complete. For further clarification as required, contractor shall contact the designated Owner's representative.)
- B. CONCEALED / EXPOSED: areas are those areas which cannot be seen by the building occupants. Exposed areas are all areas which are exposed to view by the building occupants, including under counters, inside cabinets and closets, plus all mechanical rooms.

- C. General Requirements: The provisions of requirements of other Division 01 Sections apply to entire work of contract and, where so indicated, to other elements which are included in project. Basic contract definitions are included in the General Conditions.
- D. Indicated: The term "indicated" is a cross reference to graphic representations, notes or schedules on drawings, to other paragraphs or schedules in the Specifications, and to similar means of recording requirements on contract documents. Where terms such as "shown", "noted", "scheduled", and "specified" are used in lieu of "indicated", it is for the purpose of helping reader locate the cross reference, and no limitation of location is intended except as specifically noted.
- E. Directed, requested, etc.: Where not otherwise explained, terms such as "directed", "requested", "authorized", "selected", "approved", "required", "accepted", and "permitted" mean directed by Architect/Engineer, "requested by Architect/Engineer" and similar phrases. However, no such implied meaning will be interpreted to extend Architect's/Engineer's responsibility into Contractor's area of construction supervision and job safety.
- F. And/Or: Where "and/or" is used in these Specifications or on the Drawings, it shall mean "that situations exist where either one or both conditions occur or are required and shall not be interpreted to permit an option on the part of the Contractor.
- G. Approve: Where used in conjunction with Architect's/Engineer's response to submittals, requests, applications, inquiries, reports and claims by Contractor, the meaning of term "approved" will be held to limitations to Architect's/Engineer's responsibilities and duties as specified in General and Supplementary Conditions. In no case will "approval" by Architect/Engineer be interpreted as a release of Contractor from responsibilities to fulfill requirements of contract documents or to extend Architect's/Engineer's responsibility into Contractor's area of construction supervision and job safety.
- H. As required: Where "as required" is used in these Specifications or on the drawings, it shall mean "that situations exist that are not necessarily described in detail or indicated that may cause the contractor certain complications in performing the work described or indicated. These complications entail the normal coordination activities expected of the Contractor where multiple trades are involved and new or existing construction causes deviations to otherwise simplistic approaches to the work to be performed. The term shall not be interpreted to permit an option on the part of the Contractor to achieve the end result."
- I. Furnish:
 - 1. The term "furnish" is used to mean "supply and deliver to project site, ready for unloading, unpacking, assemble, installation, and similar operations."
 - 2. Where "furnish" applies to work for which the installation is not otherwise specified, "furnish" in such case shall mean "furnish and install."
 - 3. Install: The term "install" is used to describe operations at project site including "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning and similar operation."
 - 4. Provide: The term "provide" means "to furnish and install, complete and ready for intended use."

1.07 PERMITS, UTILITY CONNECTIONS AND INSPECTIONS:

- A. General: Refer to Division 01 for construction phasing and time increments.
- B. Fees and Costs: If, during the course of the construction, a need arises to buy utilities, the Contractor shall pay all fees attendant thereto. If City or privately owned utility piping or electrical cable needs to be extended, relocated, or terminated, the Contractor will pay all permits and construction/inspection fees associated with that particular work.
- C. All work performed on this project is under the authority of the State of Texas, therefore no local construction fees or construction permits will be required except as may be required for new service taps, or new or modified connections to City controlled services. If inspections by City personnel are specifically required by this document, then the Contractor is responsible for any fees or permits in connection to those requirements.
- D. Compliance: The Contractor shall comply in every respect with all requirements of National Fire Protection Association, local Fire Department regulations and utility company requirements. In no case does this relieve the Contractor of the responsibility of complying with these Specifications and Drawings where specified conditions are of higher quality than the requirements of the above-specified authorities. Where requirements of the Specifications and Drawings are more lenient than the requirements of the above authorities having jurisdiction, the Contractor shall make installations in compliance with the requirements of the above authorities with no extra compensation.

1.08 CONTRACT DOCUMENTS:

- A. All dimensional information related to new structures shall be taken from the appropriate Drawings. All dimensional information related to existing facilities shall be taken from actual measurements made by the Contractor on the site.
- B. The interrelation of the Specifications, the Drawings, and the schedules are as follows: The Specifications determine the nature and setting of the several materials, the Drawings establish the quantities, dimensions and details, and the schedules give the performance characteristics. If the Contractor requires additional clarification, he shall request it in writing, following the contractually prescribed information flow requirements.
- C. Should the Drawings or Specifications conflict within themselves, or with each other, the better quality, or greater size or quantity of work or materials shall be performed or furnished.

1.09 FUTURE WORK

- A. Provide for future work under requirements of Section 01 11 00.

1.10 ALTERNATES

- A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at the Owner's option. Accepted Alternates will be identified in Owner-Contractor Agreement.
- B. Coordinate related work and modify surrounding work as required.
- C. Schedule of Alternates: See "Special Conditions" and Bid Form.

1.11 SUBMITTALS

- A. Refer to Uniform General Conditions.
- B. Proposed Products List: Include Products specified in the following Sections:
 - 1. Section 23 05 19 – Variable Frequency Drives
 - 2. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
 - 3. Section 23 05 48 – Vibration Isolation
 - 4. Section 23 05 53 – Mechanical Identification
 - 5. Section 23 07 13 – Ductwork Insulation
 - 6. Section 23 07 16 – Equipment Insulation
 - 7. Section 23 07 19 – Piping Insulation
 - 8. Section 23 09 23 – DDC Control Systems
 - 9. Section 23 09 93 – Sequence of Operation
 - 10. Section 23 31 00 – Ductwork
 - 11. Section 23 33 00 – Ductwork Accessories
 - 12. Section 23 34 00 – Fans
 - 13. Section 23 36 00 – Air Terminal Units
 - 14. Section 23 37 00 – Air Inlets and Outlets
 - 15. Section 23 62 13 – Packaged DX Air Conditioning Units
 - 16. Section 23 63 13 – Variable Refrigerant Volume DX Systems
 - 17. Section 23 73 25 – Heat Recovery Units
 - 18. Section 23 82 16 – Air Coils
 - 19. Section 23 82 19 – Unit Heaters
- C. Submit shop drawings and product data grouped to include complete submittals of related systems, products, and accessories in a single submittal.
- D. Mark dimensions and values in units to match those specified.
- E. Submit Fabrication Drawings whenever (1) equipment proposed varies in physical size and arrangement from that indicated on the Drawings, thus causing rearrangement of equipment space, (2) where tight spaces require extreme coordination between ductwork, piping, conduit, and other equipment, (3) where called for elsewhere in these Specifications; and (4) where specifically requested by the Architect/Engineer. Fabrication Drawings shall be made at no additional charge to the Owner or the Architect/Engineer.
- F. All required Fabrication Drawings, except as noted otherwise, shall be prepared at a scale of not less than 1/4" = 1'-0". Fabrication Drawings for ductwork, air handling units, and sections in Mechanical Rooms shall be drawn at a minimum scale of 3/8" = 1'-0". Submit three blue-line prints of each Fabrication Drawing to the Architect/Engineer for review. Reproduction and submittal of the Construction Documents is not acceptable. The Architect/Engineer will review the drawing and return one print with comments.

1.12 SUBSTITUTION OF MATERIALS AND EQUIPMENT:

- A. Refer to General Conditions for substitution of materials and equipment.
- B. General: Within thirty days after the date of contract award or work order, whichever is later, and before purchasing or starting installation of materials or equipment, the Contractor shall

submit for review, a complete list of suppliers, contractors and manufacturers for all materials and equipment which will be submitted for incorporation into the project. The list shall be arranged in accordance with the organization of the Specifications. This initial list shall include the manufacturer's name and type or catalog number as required to identify the quality of material or equipment proposed. This list will be reviewed by the Engineer and the Owner and will be returned to the Contractor with comments as to which items are acceptable without further submittal data and which items will require detailed submittal data for further review and subsequent approval. The initial list shall be submitted as herein specified. Materials and equipment requiring detailed submittal data shall be submitted with sufficient data to indicate that all requirements of these Specifications have been met and samples shall be furnished when requested. All manufacturers' data used as part of the submittal shall have all inapplicable features crossed out or deleted in a manner that will clearly indicate exactly what is to be furnished.

- C. It is not the intent of the Drawings and/or Specifications to limit products to any particular manufacturer nor to discriminate against an "APPROVED EQUAL" product as produced by another manufacturer. Some proprietary products are mentioned to set a definite standard for acceptance and to serve as a reference in comparison with other products. When a manufacturer's name appears in these Specifications, it is not to be construed that the manufacturer is unconditionally acceptable as a provider of equipment for this project. The successful manufacturer or supplier shall meet all of the provisions of the appropriate specification(s).
- D. The specified products have been used in preparing the Drawings and Specifications and thus establish minimum qualities with which substitutes must at least equal to be considered acceptable. The burden of proof of equality rests with the Contractor. The decision of the designer is final.
- E. When requested by the Architect/Engineer, the Contractor shall provide a sample of the proposed substitute item. In some cases, samples of both the specified item and the proposed item shall be provided for comparison purposes.
- F. Timeliness: The burden of timeliness in the complete cycle of submittal data, shop Drawings, and sample processing is on the Contractor. The Contractor shall allow a minimum of six (6) weeks time frame for review of each submission by the office of the design discipline involved after receipt of such submissions by that design discipline. The Contractor is responsible for allowing sufficient time in the construction schedule to cover the aforementioned cycles of data processing, including time for all resubmittal cycles on unacceptable materials, equipment, etc. covered by the data submitted. Construction delays and/or lack of timeliness in the above regard are the responsibility of the Contractor and will not be considered in any request for scheduled construction time extensions and/or additional costs to the Owner.
- G. All equipment installed on this project shall have local representation, local factory authorized service, and a local stock of repair parts.
- H. Acceptance of materials and equipment will be based on manufacturer's published data and will be tentative subject to the submission of complete shop Drawings indicating compliance with the contract documents and that adequate and acceptable clearances for entry, servicing, and maintenance will exist. Acceptance of materials and equipment under this provision shall not

be construed as authorizing any deviations from the Specifications, unless the attention of the Architect/Engineer has been directed in writing to the specific deviations. Data submitted shall not contain unrelated information unless all pertinent information is properly identified.

- I. Certification: The Contractor shall carefully examine all data forwarded for approval and shall sign a certificate to the effect that the data has been carefully checked and found to be correct with respect to dimensions and available space and that the equipment complies with all requirements of the Specifications.
- J. Physical Size of Equipment: Space is critical; therefore, equipment of larger sizes than shown, even though of specified manufacturer, will not be acceptable unless it can be demonstrated that ample space exists for proper installation, operation, and maintenance.
- K. Materials and Equipment Lists: Eight (8) copies of the list of materials and equipment, the name of manufacturer, trade name, type, and catalog number shall be submitted to the Architect/Engineer. The lists shall be accompanied by eight (8) sets of pictorial and descriptive data derived from the manufacturers' catalogs, sales literature, or incorporated in the Shop Drawings. Such lists shall include but will not be limited to the following items:
- L. Should a substitution be accepted, and should the substitute material prove defective, or otherwise unsatisfactory for the service intended within the guarantee period, this material or equipment shall be replaced with the material or equipment specified at no additional cost to the Owner.

1.13 MATERIALS AND WORKMANSHIP:

- A. All materials, unless otherwise specified, shall be new, free from all defects, suitable for the intended use, and of the best quality of their respective kinds. Materials and equipment shall be installed in accordance with the manufacturer's recommendations and the best standard practice for the type of work involved. All work shall be executed by mechanics skilled in their respective trades, and the installations shall provide a neat, precise appearance. Materials and/or equipment damaged in shipment or otherwise damaged prior to installation shall not be repaired at the job site but shall be replaced with new materials and/or equipment.
- B. The responsibility for the furnishing of the proper equipment and/or material and seeing that it is installed as intended by the manufacturer, rests entirely upon the Contractor who shall request advice and supervisory assistance from the representative of specific manufacturers during the installation.

1.14 FLAME SPREAD PROPERTIES OF MATERIALS:

- A. Materials and adhesives incorporated in this project shall conform to NFPA Standard 255, "Method of Test of Surface Burning Characteristics of Building Materials" and NFPA 90. The classification shall not exceed a flame spread rating of 25 for all materials, adhesives, finishes, etc., specified for each system, and shall not exceed a smoke developed rating of 50 for all materials to be located within a return air plenum.

1.15 REGULATORY REQUIREMENTS

- A. The "Authority Having Jurisdiction" over the project described by these documents is the Owner, as an Agency of the State of Texas. As such, it is required that the installation shall meet the minimum standards prescribed in the latest editions of the following listed codes and standards, which are made a part of these Specifications. All referenced codes and standards shall be those current at the date of issue of the design documents.
- B. National Fire Protection Association Standards (NFPA):
 - 1. NFPA No. 70, National Electrical Code
 - 2. NFPA No. 101, Life Safety Code
 - 3. NFPA No. 241, Standard for Safeguarding Construction, Alteration and Demolition Operations
 - 4. NFPA No. 255, Method of Test of Surface Burning Characteristics of Building Materials
 - 5. NFPA No. 258, Standard Research Test Method for Determining Smoke Generation of Solid Materials
- C. American National Standards Institute (ANSI):
 - 1. A40.8, National Plumbing Code
 - 2. B31.1, Power Piping
 - 3. B9.1, Safety Code for Mechanical Refrigeration
- D. American Gas Association Publications (AGA): Directory of Approved Gas Appliances and Tested Accessories
- E. American Society of Mechanical Engineers (ASME): Boiler and Pressure Vessel Codes
- F. Air Conditioning and Refrigeration Institute Standards (ARI): All standards related to refrigeration and air conditioning equipment and piping furnished under these Specifications.
- G. Air Moving and Conditioning Association (AMCA): All current editions of applicable manuals and standards.
- H. American Society of Testing Materials (ASTM): All current editions of applicable manuals and standards.
- I. American Water Works Association (AWWA): All current editions of applicable manuals and standards.
- J. National Electrical Manufacturers' Association (NEMA): All current editions of applicable manuals and standards.
- K. City of Austin Fire Department as may be applicable to construction on this site.
- L. International Building Code, (Includes the International Mechanical and International Plumbing Codes)
- M. Texas Occupational Safety Act: All applicable safety standards
- N. Occupational Safety and Health Act (OSHA)

- O. ADA and ANSI Standards: All work shall be in accord with all regulations and requirements of the Standards and Specifications for Handicapped and Disabled for the Construction of Public Buildings and Facilities in the State of Texas Usable by Physically Handicapped and Disabled persons, ANSI Standards and the requirements of the American Disabilities Act.
- P. Refer to Specification Sections hereinafter bound for additional Codes and Standards.
- Q. All materials and workmanship shall comply with all applicable state and national codes, Specifications, and industry standards. In all cases where Underwriters Laboratories, Inc. has established standards for a particular type material, such material shall comply with these standards. Evidence of compliance shall be the UL "label" or "listing" under Re-Examination Service.
- R. The Contract Documents are intended to comply with the aforementioned rules and regulations; however, some discrepancies may occur. Where such discrepancies occur, the Contractor shall immediately notify the Architect/Engineer in writing of said discrepancies and apply for an interpretation. Should the discovery and notification occur after the execution of a contract, any additional work required for compliance with said regulations shall be paid for as covered by Division 01 of these Contract Documents, providing no work of fabrication of materials has been accomplished in a manner of noncompliance. Should the Contractor fabricate and/or install materials and/or workmanship in such a manner that does not comply with the applicable codes, rules and regulations, the Contractor who performed such work shall bear all costs arising in correcting these deficiencies to comply with said rules and regulations.

1.16 GENERAL MATERIALS AND EQUIPMENT REQUIREMENTS:

- A. Storage at Site: The Contractor shall not receive material or equipment at the job site until there is suitable space provided to properly protect equipment from rust, drip, humidity, and dust damage.
- B. Capacities shall be not less than those indicated but shall be such that no component or system becomes inoperative or is damaged because of startup or other overload conditions.
- C. Conformance with Agency Requirements: Where materials or equipment are specified to be approved, listed, tested, or labeled by the Underwriters Laboratories, Inc., or constructed and/or tested in accordance with the standards of the American Society of Mechanical Engineers or the Air Moving and Conditioning Association, the Contractor shall submit proof that the items furnished under this Section of the Specifications conform to such requirements. The label of the Underwriters Laboratories, Inc., applied to the item will be acceptable as sufficient evidence that the items conform to such requirements. The ASME stamp or the AMCA label will be acceptable as sufficient evidence that the items conform to the respective requirements.
- D. Prevention of Rust: Standard factory finish will be acceptable on equipment specified by model number; otherwise, surfaces of ferrous metal shall be given a rust inhibiting coating. The treatment shall withstand 200 hours in salt spray fog test, in accordance with Method 6061 of Federal Standard No. 141. Immediately after completion of the test, the specimen shall show no signs of wrinkling or cracking and no signs of rust creepage beyond 1/8" on either side of the scratch mark. Where rust inhibitor coating is specified hereinafter, any treatment that will pass the above test is acceptable unless a specific coating is specified except that coal tar or asphalt

type coating will not be acceptable unless so stated for a specific item. Where steel is specified to be hot-dip galvanized, mill-galvanized sheet steel may be used provided all raw edges are painted with a zinc-pigmented paint conforming to Military Specification MIL-P-26915.

- E. Verification of Dimensions: The Contractor shall be responsible for the coordination and proper relation of his work to the building structure and to the work of all trades. The Contractor shall visit the premises and become thoroughly familiar with all details of the work and working conditions, to verify all dimensions in the field, and to advise the Architect/Engineer of any discrepancy before performing any work. Adjustments to the work required in order to facilitate a coordinated installation shall be made at no additional cost to the Owner or the Architect/Engineer.

1.17 SLEEVES, INSERTS, AND FASTENINGS:

- A. See Section 23 05 29 – Sleeves, Flashings, Supports and Anchors.

1.18 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on Drawings, unless prevented by Project conditions.
- B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission of Owner and Architect/Engineer before proceeding.

1.19 MANUFACTURER'S RECOMMENDATIONS

- A. The manufacturer's published directions shall be followed in the delivery, storage, protection, installation, piping, and wiring of all equipment and material. The Contractor shall promptly notify the Architect/Engineer, in writing, of any conflict between the requirements of the Contract Documents and the manufacturer's directions, and shall obtain the Architect/Engineer's instructions before proceeding with the work. Should the Contractor perform any such work that does not comply with the manufacturer's directions or such instructions from the Architect/Engineer, he shall bear all costs arising in connection with the deficiencies.

1.20 PROTECTION:

- A. The Contractor shall at all times take such precautions as may be necessary to properly protect all materials and equipment from damage from the time of delivery until the completion of the work. This shall include the erection of all required temporary shelters and supports to adequately protect any items stored in the open on the site from the weather, the ground and surrounding work; the cribbing of any items above the floor of the construction; and the covering of items in the incomplete building with tarpaulins or other protective covering; the installation of electric heaters in electrical switchgear and similar equipment to prevent moisture damage. Failure on the part of the Contractor to comply with the above will be sufficient cause for the rejection of the items in question.
- B. Take particular care not to damage the building structure in performing work. All finished floors, step treads, and finished surfaces shall be covered to prevent any damage by workmen or their tools and equipment during the construction of the building.

- C. Equipment and materials shall be protected from rust both before and after installation. Any equipment or materials found in a rusty condition at the time of final inspection must be cleaned of rust and repainted as specified elsewhere in these Specifications.

1.21 COOPERATION BETWEEN TRADES AND WITH OTHER CONTRACTORS:

- A. Each trade, subcontractor, and/or Contractor must work in harmony with the various other trades, subcontractors and/or Contractors on the job as may be required to facilitate the progress to the best advantage of the job as a whole. Each trade, subcontractor, and/or Contractor must pursue its work promptly and carefully so as not to delay the general progress of the job. This Contractor shall work in harmony with Contractors working under other contracts on the premises.

1.22 ELECTRICAL WIRING OF MOTORS AND EQUIPMENT:

- A. The Contractor shall note that the electrical design and Drawings are based on the equipment scheduled and indicated on the Drawings, and should any mechanical equipment be provided requiring changes to the electrical design, the required electrical changes shall be made at no cost to the Owner.
- B. The Electrical Trades shall provide all interconnecting wiring for the installation of all power. The Electrical Trades shall provide all disconnect switches as required for proper operation, as indicated on the Drawings or required by applicable code. All combination starters, individual starters, and other motor starting apparatus not specifically scheduled or specified as provided by the equipment manufacturer under the scope of Division 23, shall be provided under the scope of Division 26.
- C. The Mechanical Trades shall provide complete wiring diagrams indicating power wiring and interlock wiring. Diagrams shall be submitted to the Architect/Engineer for review within thirty (30) days after the submittals for equipment have been reviewed. Diagrams shall be based on accepted equipment and shall be complete full phase and interlock control Drawings, not a series of manufacturer's individual diagrams. After these diagrams have been reviewed by the Architect/Engineer, copies shall be transmitted to the Electrical Trades by the Contractor. They shall be followed in detail. See Section 23 09, TEMPERATURE CONTROLS, for additional clarification.

1.23 SUPERVISION:

- A. Each Contractor and subcontractor shall keep a competent superintendent or foreman on the job at all times. (Refer to the Uniform General Conditions for additional information concerning supervision.)
- B. It shall be the responsibility of each superintendent to study all Drawings and familiarize himself with the work to be done by other trades. He shall coordinate his work with other trades and before material is fabricated or installed, make sure that his work will not cause an interference with another trade. Where interferences are encountered, they shall be resolved at the job site by the superintendents involved. Where interferences cannot be resolved without major changes to the Drawings, the matter shall be referred to the A/E for ruling.

1.24 SITE OBSERVATION:

- A. Site observation by the Architect/Engineer is for the express purpose of verifying compliance by the Contractor with the Contract Documents, and shall not be construed as construction supervision or indication of approval of the manner or location in which the work is being performed as being a safe practice or place.

1.25 PRECEDENCE OF MATERIALS

- A. The specifications determine the nature and setting of materials and equipment. The drawings establish quantities, dimensions and details.
- B. The installation precedence of materials shall be as follows. Note that if an interference is encountered, this shall guide the contractor in the determination of which trade shall be given the "Right-of-Way."
 - 1. Building lines
 - 2. Structural Members
 - 3. Soil and Drain Piping
 - 4. Condensate Drains
 - 5. Vent Piping
 - 6. Supply, Return, and Outside Air Ductwork
 - 7. Exhaust Ductwork
 - 8. HVAC Water Piping
 - 9. Fire Protection Piping
 - 10. Natural Gas Piping
 - 11. Domestic Water (Cold and Hot)
 - 12. Electrical Conduit

1.26 INSTALLATION METHODS:

- A. Where to Conceal: All pipes, conduits, etc., shall be concealed in pipe chases, walls, furred spaces, or above the ceilings of the building unless otherwise indicated.
- B. Where to Expose: In mechanical rooms, janitor's closets tight against pan soffits in exposed "Tee" structures, or storage spaces, but only where necessary, piping may be run exposed. All exposed piping shall be run in the most aesthetic, inconspicuous manner, and parallel or perpendicular to the building lines.
- C. Support: All piping, ducts and conduits shall be adequately and properly supported from the building structure by means of hanger rods or clamps to walls as herein specified.
- D. Maintaining Clearance: Where limited space is available above the ceilings below concrete beams or other deep projections, pipe and conduit shall be sleeved through the projection where it crosses, rather than hung below them in a manner to provide maximum above-floor clearance. Sleeves shall be as herein specified. Approval shall be obtained from the Architect/Engineer for each penetration.
- E. All pipe, conduits, etc., shall be cut accurately to measurements established at the building and shall be worked into place without springing or forcing. All ducts, pipes and conduits run exposed in machinery and equipment rooms shall be installed parallel to the building lines, except that piping shall be sloped to obtain the proper pitch. Piping, ducts and conduits run in furred ceilings, etc., shall be similarly installed, except as otherwise shown. Conduits in furred

ceilings and in other concealed spaces shall be neatly grouped and racked indicating good workmanship. All conduit and pipe openings shall be kept closed until the systems are closed with final connections.

13. All piping in this package shall be considered "exterior piping" and shall be as specified for "underground Piping" in Specification Section 23 20 00A.

1.27 RECORDS FOR OWNER:

- A. The Contractor shall maintain a set of "blueprint" prints in the Field Office for the sole purpose of recording "installed" conditions. Daily note all changes made in these Drawings in connection with the final installation including exact dimensioned locations of all new underground utilities, services and systems and all uncovered existing active and inactive piping outside the building.
- B. At contract completion, the Contractor shall provide a set of reproducible photographic mylar drawings, plus the photo negatives of the revised drawings. The contractor shall transfer the information from the "blueprint" prints maintained as described above, and turn over this neatly marked set of reproducible Drawings representing the "as installed" work to the Architect/Engineers for verification and subsequent transmittal to the Owner. The Contractor shall refer to Division 01 of these Specifications, and to the Uniform General Conditions, for additional information. These Drawings shall include as a minimum:
1. Addendum written drawing changes.
 2. Addendum supplementary drawings.
 3. Accurate, dimensioned locations of all underground utilities, services and systems.
 4. Identification of equipment work shown on Alternates as to whether alternates were accepted and work actually installed.
 5. Change Order written drawing changes.
 6. Change Order supplementary drawings.
- C. Electronic Media:
1. In lieu of the drawings described above in 1.33B, it is preferred the contractor submit one set of blueprint prints, one set of vellum reproducible, and one set of discs containing all the drawings in AUTOCAD 2000 or later format.
- D. "As installed" mylars shall bear a stamp, "stick on decal", or lettered title block generally located in lower right hand corner of Drawing entitled "AS INSTALLED DRAWING" with Company name of the installing trade Subcontractor and with a place for the date and the name of the responsible company representative.
- E. In addition to the above, the Contractor shall accumulate during the progress of the job the following data, in duplicate, prepared in a neat brochure or packet folder and turn over to the Architect/Engineer for review, and subsequent delivery to the Owner.
1. All warranties and guarantees and manufacturers' directions on equipment and material covered by the Contract.
 2. Two sets of operating instructions for heating and cooling and other mechanical and electrical systems. Operating instructions shall also include recommended preventative maintenance and seasonal changeover procedures.
 3. Valve tag charts and diagrams specified herein.
 4. Approved wiring diagrams and control diagrams representing "as installed" conditions.

5. Copies of approved Shop Drawings.
6. Any and all other data and/or drawings required as submittals during construction.
7. Repair parts list of all major items and equipment including name, address and telephone number of local supplier or agent.

F. All of the above data shall be submitted to the Architect/Engineer for approval, and shall be corrected as instructed by the Architect/Engineer prior to submission of the final request for payment.

1.28 CUTTING AND PATCHING:

- A. General: Cut and patch walls, floors, etc., resulting from work in existing construction or by failure to provide proper openings or recesses in new construction.
- B. Methods of cutting: Openings cut through concrete and masonry shall be made with masonry saws and/or core drills and at such locations acceptable to the Architect/Engineer. Impact-type equipment shall not be used except where specifically acceptable to the Architect/Engineer. Openings in precast concrete slabs for pipes, conduits, outlet boxes, etc., shall be core drilled to exact size.
- C. Restoration: All openings shall be restored to "as-new" condition under the appropriate Specification Section for the materials involved, and shall match remaining surrounding materials and/or finishes.
- D. Masonry: Where openings are cut through masonry walls, provide and install lintels or other structural supports to protect the remaining masonry. Adequate supports shall be provided during the cutting operation to prevent any damage to the masonry occasioned by the operation. All structural members, supports, etc., shall be of the proper size and shape, and shall be installed in a manner acceptable to the Architect/Engineer.
- E. Plaster: All mechanical work in areas containing plaster shall be completed prior to the application of the finish plaster coat. Cutting of finish plaster coat will not be permitted.
- F. Special Note: No cutting, boring, or excavating which will weaken the structure shall be undertaken.

1.29 EXCAVATION, TRENCHING AND BACKFILL:

- A. Excavation (See Divisions 00 and 01 for special requirements related to excavation and trenching.):
 1. The Mechanical and Electrical subcontractors shall perform all excavations of every description, for their particular installations and of whatever substances encountered, to the depths indicated on the Drawings and/or required for the installation of piping, conduit, utility systems, etc. All exterior lines shall be installed with a minimum cover of 24", unless otherwise indicated. Generally, more cover shall be provided if grade will permit. All excavation materials not required for backfill or fill shall be removed and wasted as acceptable to the Construction Inspector. All excavations shall be made only by open cut. The banks of trenches shall be kept as nearly vertical as possible and where required, shall be properly sheeted and braced. Trenches shall be not less than 12" wider nor more than 16" wider than the outside edges of the pipe to be laid therein, and shall be

excavated true to line so that a clear space not less than 6" nor more than 8" in width is provided on each side of the pipe. For sewers, the maximum width of trench specified applies to the width at and below the level may be made as wide as necessary for sheeting and bracing, and the proper installation of the work.

2. The bottom of trenches shall be accurately graded to provide proper fall and uniform bearing and support for each section of the pipe on undisturbed soil or 2" of sand fill at every point along its entire length, except for portions of the pipe sections where it is necessary to excavate for bell holes and for the proper sealing of pipe joints. Bell holes shall be dug after the trench bottom has been graded. Where inverts are not shown, grading shall be determined by the National Plumbing Code for the service intended and the size used. Bell holes for lead pipe joints shall be 12" in depth below the trench bottom and shall extend from a point 6" back of the face of the bell. Such bell holes shall be of sufficient width to provide ample room for caulking. Bell holes for sewer tile and water pipe shall be excavated only to an extent sufficient to permit accurate work in the making of the joints and to insure that the pipe, for a maximum of its length, will rest upon the prepared bottom of the trench. Depressions for joints other than bell-and-spigot shall be made in accordance with the recommendations of the joint manufacturer for the particular type of joint used. In general, grading for electrical ductbanks and conduits shall be from building to manhole, and from a high point between manholes to each manhole. Special pipe beds shall be provided as specified hereinafter.
3. The lower 4" of the pipe trenches measuring from an overhead line set parallel to the grade line of the sewer shall be excavated only a few feet in advance to the pipe laying, by men especially skilled in this type of work. Where damage is likely to result from withdrawing sheeting, the sheeting shall be left in place. Except at locations where excavation of rock from the bottom of trenches is required, care shall be taken not to excavate below the depths required. Where rock excavation is required, the rock shall be excavated to a minimum overdepth of 6" below the trench depths specified. The overdepth rock excavation and all excess trench excavation shall be backfilled with sand. Whenever wet or otherwise unstable soil is incapable of properly supporting the pipe is encountered in the trench bottom, such soil shall be removed to a depth and for the trench lengths required, and then backfilled to trench bottom grade, as hereinafter specified, with sand.
4. All grading in the vicinity of excavation shall be controlled to prevent surface ground water from flowing into the excavations. Any water accumulated in the excavations shall be removed by pumping or other acceptable method. During excavation, material suitable for backfilling shall be stacked in an orderly manner a sufficient distance back from edges of trenches to avoid overloading and prevent slides or cave-ins. Material unsuitable for backfilling shall be wasted and removed from the job site as directed by the Construction Inspector.
5. All shoring and sheeting required to perform and protect the excavations and to safeguard employees and/or adjacent structures shall be provided.
6. All surplus materials removed in these trenching operations becomes the property of the contractor, and shall be disposed of at the expense of the contractor, at a legal disposal site, off of the campus.

B. Backfilling:

1. Trenches shall not be backfilled until all required tests are performed and until the piping, utilities systems, etc., as installed are certified by the Owner's inspector to conform to the requirements specified hereinafter. The trenches shall be carefully backfilled with sand

to a depth of 12 inches above the top of the pipe. The next layer and subsequent layers of backfill may be excavated materials approved for backfilling, consisting of earth, loam, sandy clay, sand and gravel, soft shale, or other approved materials free from large clods of earth or stones larger than 1 1/2" in diameter, flooded until the pipe has cover of not less than one foot. The remainder of the backfill material shall then be thrown into the trenches, moistened, and tamped or flooded in one foot layers. Blasted rock, broken concrete or pavement, and large boulders shall not be used as backfill material. Any trenches improperly backfilled, or where settlement occurs, shall be reopened to the depth required for proper compaction, then refilled and mounded over, and smoothed off.

2. Backfill under concrete slabs-on-fill shall be as specified above, shall be gravel, or shall be other such materials more suitable for the application. Installation and compaction shall be as required for compatibility with adjacent materials.

C. **Opening and Re-closing Pavement and Lawns:** Where excavation requires the opening of existing walks, streets, drives, other existing pavement, or lawns, such surfaces shall be cut as required to install new lines and to make new connections to existing lines. The sizes of the cut shall be held to a minimum, consistent with the work to be accomplished. After the installation of the new work is completed and the excavation has been backfilled and flooded, the area shall be patched, using materials to match those cut out. The patches shall thoroughly bond with the original surfaces and shall be level with them, and shall meet all the requirements established by the authorities having jurisdiction over such areas.

D. **Excavation in Vicinity of Trees:** All trees including low hanging limbs within the immediate area of construction shall be adequately protected to a height of at least 5 ft. to prevent damage from the construction operations and/or equipment. All excavation within the outermost limb radius of all trees shall be accomplished with extreme care. All roots located within this outermost limb radius shall be brought to the attention of the Construction Inspector before they are cut or damaged in any way. The Construction Inspector will give immediate instructions for the disposition of same. All stumps and roots encountered in the excavation, which are not within the outermost limb radius of existing trees, shall be cut back to a distance of not less than 18" from the outside of any concrete structure or pipeline. No chips, parts of stumps, or loose rock shall be left in the excavation. Where stumps and roots have been cut out of the excavation, clean compacted dry bank sand shall be backfilled and tamped.

1.30 EXISTING FACILITIES:

- A. The Contractor shall be responsible for loss or damage to the existing facilities caused by him and his workmen, and shall be responsible for repairing or replacing such loss or damage. The Contractor shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and in service maintenance of all plumbing, heating, air conditioning, and ventilating services for the new and existing facilities. The Contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing all such temporary protection upon completion of the work.
- B. The Contractor shall provide temporary or new services to all existing facilities as required to maintain their proper operation when normal services are disrupted as a result of the work being accomplished under this project.

- C. Where existing construction is removed to provide working and extension access to existing utilities, Contractor shall remove doors, piping, conduit, outlet boxes, wiring, light fixtures, air conditioning ductwork and equipment, etc., to provide this access and shall reinstall same upon completion of work in the areas affected.
- D. Where partitions, walls, floors, or ceilings of existing construction are indicated to be removed, all Contractors shall remove and reinstall in locations approved by the Architect/Engineer all devices required for the operation of the various systems installed in the existing construction. This is to include but is not limited to temperature controls system devices, electrical switches, relays, fixtures, piping, conduit, etc.
- E. Outages of services as required by the new installation will be permitted but only at a time approved by the Owner. The Contractor shall allow the Owner two weeks in order to schedule required outages. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner. All costs of outages, including overtime charges, shall be included in the contract amount.

1.31 CHECKING AND TESTING MATERIALS AND/OR EQUIPMENT:

- A. Before the work is accepted, an authorized representative of the manufacturer of the installed materials and/or equipment shall personally inspect the installation and operation of his materials and/or equipment to determine that it is properly installed and in proper operating order. The qualifications of the representative shall be appropriate to the technical requirements of the installation. The qualifications of the representative shall be submitted to the owner for approval. The decision of the owner concerning the appropriateness of the representative shall be final. Testing and checking shall be accomplished during the course of the work where required by work being concealed, and at the completion of the work otherwise. In addition, the Contractor shall submit to the Architect/Engineer a signed statement from each representative certifying as follows: "I certify that the materials and/or equipment listed below have been personally inspected by the undersigned authorized manufacturer's representative and is properly installed and operating in accordance with the manufacturer's recommendations".
- B. Check inspections shall include plumbing equipment, heating, air conditioning, insulation, ventilating equipment, controls, mechanical equipment and such other items hereinafter specified or specifically designated by the Architect/Engineer.

1.32 TESTS:

- A. The Contractor shall make, at no additional cost to the Owner, any tests deemed necessary by the inspection departments having jurisdiction, and in the National Fire Protection Association, ASTM, etc. Standards listed. The Contractor shall provide all equipment, materials, and labor for making such tests. Reasonable amounts of fuel and electrical energy costs for system tests will be paid by the Owner. Fuel and electrical energy costs for system adjustment and tests which follow beneficial occupancy by the Owner will be borne by the Owner.
- B. Additional tests specified hereinafter under the various Specification Sections shall be made.
- C. The Construction Inspector shall be notified in writing at least 10 working days prior to each test and other Specification requirements requiring action on the part of the Construction

Inspector. All equipment shall be placed in operation and tested for proper automatic control requirements before the balancing agency starts their work.

- D. Maintain Log of Tests as hereinafter specified.
- E. See Specifications hereinafter for additional tests and requirements.

1.33 LOG OF TESTS:

- A. All tests shall have pertinent data logged by the Contractor at the time of testing. Data shall include date, time, personnel, description, and extent of system tested, test conditions, test results, specified results, and other pertinent data. Data shall be delivered to the Architect/Engineer as specified under "Requirements for Final Acceptance". All Test Log entries shall be legibly signed by the Project Contractor or his authorized job superintendent.

1.34 COOPERATION AND CLEANUP:

- A. It shall be the responsibility of each trade to cooperate fully with the other trades on the job to help keep the job site in a clean and safe condition. At the end of each day's work, each trade shall properly store all of his tools, equipment and materials and shall clean his debris from the job. Upon the completion of the job, each trade shall immediately remove all of his tools, equipment, any surplus materials and all debris caused by that portion of the work.

1.35 CLEANING AND PAINTING:

- A. All equipment, piping, conduit, ductwork, grilles, insulation, etc., furnished and installed in exposed areas under Divisions 23 and 26 of these Specifications and as hereinafter specified shall be cleaned, prepared, and painted according to the following specification. In the event of a conflict between the specifications referenced, the provisions of this specification shall prevail only for Division 23 and Division 26 work.
- B. All purchased equipment furnished by the mechanical and electrical subcontractors shall be delivered to the job with a suitable factory protective finish with the colors hereinafter specified. The following materials shall not be painted: copper, galvanized metal, stainless steel, fiberglass, PVC, and PVDF.
- C. Before painting, materials and equipment surfaces shall be thoroughly cleaned of cement, plaster, and other foreign materials, and all oil and grease spots shall be removed. Such surfaces shall be carefully wiped and all cracks and corners scraped out. Exposed metal work shall be carefully brushed down with the steel brushes to remove rust and other spots and left smooth and clean.

ITEM	COLOR	"P and L" PAINT NUMBER
Fuel Gas Piping (including natural gas, LPG, etc.)	Safety Yellow	Y361M (Daisy Yellow)
Fire Protection Equipment and Piping	Safety Red	R131R (Vibrant Red)
Primer- Rust Inhibitive Metal Primer Red Oxide		

- D. Jacketing on insulation shall not be painted.
- E. No nameplates on equipment shall be painted, and suitable protection shall be afforded to the plates to prevent their being rendered illegible due to the painting operation.
- F. Scope of painting for Divisions 23 and 26 work in areas other than those defined as "exposed" is as follows:
 - 1. All uncovered steel pipe, supports, exposed pipe and hanger rod threads shall be cleaned and painted with two coats of Tropical Paint Co. No. 77-black asphaltic emulsion. Galvanized steel and copper lines in these spaces shall not be painted.
 - 2. All canvas finishes including those in concealed spaces shall be painted with one sizing coat if not already sized, containing mildew resistant additive and Arabol adhesive prior to any other specified finish paint.
 - 3. All fuel piping (natural gas, LPG, etc.) shall be painted whether concealed or exposed, in all areas of the project without exception. Fuel piping shall be painted safety yellow. This "safety" color shall be as defined by OSHA.
 - 4. If insulated, the piping shall be primed, only, prior to insulation, and the insulation jacketing shall be painted as specified for piping. The requirements of this paragraph are "primary" and have priority over any conflicting specification or instruction, should a conflict in the Construction Documents exist.
- G. Additional areas to be defined as "exposed" for purposes of painting, are defined as follows: (Note that paragraph 1.04 of this Section defines exposed areas for the balance of the project. The areas listed below are to be painted in addition to exposed areas as previously defined.)
- H. The surfaces to be finish painted shall first be prepared as follows:
 - 1. On canvas finishes pretreat as specified above. Insulated surfaces having vapor barrier jacket exposed to view shall first be painted with one (1) coat of sealer.
 - 2. Galvanized and black steel surfaces shall first be painted with one (1) coat of P&L galvanized metal primer. Primer may be eliminated on concealed fire and gas piping.
 - 3. Aluminum surfaces shall first be painted with one (1) coat of P&L zinc chromate primer. (See Section 1.51.5)
 - 4. Cast iron pipe shall first be primed with a "non-bleed" primer.
 - 5. The underside of all cast iron sinks not recessed in a cabinet are included as items to be painted in exposed areas.
- I. Electrical switchgear, disconnect switches, contactors, etc., with suitable factory applied finishes shall not be repainted; except for aesthetic reasons where located in finished areas as directed by the Architect/Engineer and in a color selected by the Architect/Engineer. Where factory applied finishes are damaged in transit, storage or installation, or before final acceptance, they shall be restored to factory fresh condition by competent refinishers using the spray process.

PART 2 - PRODUCTS

2.01 NOT USED.

PART 3 - EXECUTION

3.01 NOT USED.

THE MEN'S CENTER
3809 Main St.
Houston, Texas 77002

END OF SECTION 23 00 00

THE MEN'S CENTER
3809 Main St.
Houston, Texas 77002

SECTION 23 05 13 - MOTORS

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 SECTION INCLUDES

- A. Single phase electric motors
- B. Three phase electric motors
- C. The Contractor shall provide all motors required for equipment supplied under this Division of the work

1.03 RELATED WORK

- A. Section 22 11 23 - Plumbing Equipment: Plumbing pumps
- B. Section 23 73 00 –Fan Coil Units: Fan motors
- C. Section 23 62 13 – Packaged DX Air Conditioning Units: Fan motors
- D. Section 23 63 13 – Variable Refrigerant Volume DX Systems: Fan motors
- E. Section 23 73 25 – Heat Recovery Units: Fan motors
- F. Section 23 82 19 –Unit Heaters: Fan motors
- G. Section 23 34 00 - Fans

1.04 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. ANSI/IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators
- D. ANSI/NEMA MG 1 - Motors and Generators
- E. ANSI/NFPA 70 - National Electrical Code

1.05 SUBMITTALS

- A. Submit product data under provisions of Section 23 00 00

- B. Submit test results verifying nominal efficiency and power factor for motors 1 horsepower and larger.
- C. Submit manufacturer's installation instructions under provisions of Section 23 00 00

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00
- B. Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacture of electric motors for commercial use, and their accessories, with minimum three years documented product development, testing, and manufacturing experience. No Baldor motors will be accepted.

1.08 REGULATORY REQUIREMENTS

- A. Conform to ANSI/NFPA 70.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.
- B. Store and protect products under provisions of Section 23 00 00.
- C. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.10 WARRANTY

- A. Provide five year manufacturer's warranty under provisions of Section 23 00 00.
- B. Warranty: Include coverage for motors 1 horsepower and larger.

PART 2 - PRODUCTS

2.01 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Electrical Service: Refer to Drawing Schedules for required electrical characteristics.
- B. All Motors: Design for continuous operation in 40 degrees C environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, Service Factor, and motor enclosure type.
- C. Totally Enclosed Motors: Design for a service factor of 1.00 and an 80 degrees C maximum temperature rise in the same conditions.

- D. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency.
- E. Electrical Connection: Conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.
- F. Motors shall be built in accordance with the latest ANSI, IEEE, and NEMA Standards, and shall be fully coordinated with the equipment served, shall be of sizes and electrical characteristics scheduled, and of approved manufacture as described herein or of the same manufacture as the equipment which they serve. All motors provided by the Contractor shall be of the same manufacture unless they are an integral part of the piece of equipment to which they are attached. Nameplate rating of motors shall match the characteristics scheduled.
- G. All motors shall be designed for NEMA Design B starting torque unless the driven machine requires high starting torque and shall be selected for quiet operation, free from magnetic hum.
- H. In addition, all motors shall be provided with adequately sized electrical connection box with threaded hub for attachment of flexible conduit, unless bus duct connection is indicated. Where motors are connected to driven equipment by the use of a V-belt drive, they shall be furnished with adjustable rails.
- I. Dynamic Balance shall be no greater than the vibration limits of the driven equipment as defined in Section 23 34 00 for fans and Section 23 20 00 for pumps.
- J. All motors shall be provided with all copper windings, terminal wiring, and copper or bronze lugs. AL/CU rated connectors are not allowed.

2.02 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- A. Starting Torque: Less than 150 percent of full load torque.
- B. Starting Current: Up to seven times full load current.
- C. Breakdown Torque: Approximately 200 percent of full load torque.
- D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, pre-lubricated sleeve or ball bearings.
- E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.
- F. Single phase motors, in general, shall be less than 3/4 horsepower and shall be permanent split phase, capacitor start, induction run, 120 volt, 60 hertz motors with drip-proof enclosures except as hereinafter specified. These motors shall have built-in thermal overload protection with automatic reset, and shall be rated for temperature rise as hereinbefore specified for 3-phase motors.

2.03 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

- A. Starting Torque: Exceeding one fourth of full load torque.
- B. Starting Current: Up to six times full load current.
- C. Multiple Speed: Through tapped windings.
- D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, pre-lubricated sleeve or ball bearings, automatic reset overload protector.
- E. Single phase motors, in general, shall be less than 3/4 horsepower and shall be permanent split phase, capacitor start, induction run, 120 volt, 60 hertz motors. These motors shall have built-in thermal overload protection with automatic reset, and shall be rated for temperature rise as hereinbefore specified for 3-phase motors.

2.04 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A. Starting Torque: Three times full load torque.
- B. Starting Current: Less than five times full load current.
- C. Pull-up Torque: Up to 350 percent of full load torque.
- D. Breakdown Torque: Approximately 250 percent of full load torque.
- E. Motors: Capacitor in series with starting winding; capacitor-start/capacitor-run motors shall have two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- F. Enclosures shall be of the open drip-proof type with a service factor of 1.15 and Class B insulation rated at 90 degrees C temperature rise measured above 40 degrees C room ambient condition at full load, unless otherwise noted.
- G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, pre-lubricated ball bearings.
- H. Single phase motors, in general, shall be less than 3/4 horsepower and shall be permanent split phase, capacitor start, induction run, 120 volt, 60 hertz motors. These motors shall have built-in thermal overload protection with automatic reset, and shall be rated for temperature rise as hereinbefore specified for 3-phase motors.

2.05 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Enclosures shall be of the open drip-proof type with a service factor of 1.15 and Class B insulation rated at 90 degrees C temperature rise measured above 40 degrees C room ambient condition at full load, unless otherwise noted.
- B. In general, all motors 3/4 horsepower and larger, unless smaller motors are indicated to be supplied as 3-phase, shall be 3-phase and shall be squirrel cage high efficiency induction type with standard NEMA frame sizes.
- C. Motors 1 HP and larger shall have integral frames.

- D. Starting Torque: Between one and one and one-half times full load torque.
- E. Starting Current: Six times full load current.
- F. Power Output, Locked Rotor Torque, Breakdown or Pullout Torque: NEMA Design B Characteristics.
- G. Design, Construction, Testing, and Performance: Conform to ANSI/NEMA MG 1 for Design B motors.
- H. Insulation System: NEMA Class B or better.
- I. Testing Procedure: In accordance with ANSI/IEEE 112, Test Method B. Load test motors to determine freedom from electrical or mechanical defects and compliance with performance data. Test and balance motors to limits defined in 2.01J.
- J. Motor Frames: NEMA standard T-frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- K. Bearings: Ball or roller type, double shielded with continuous grease relief to accommodate excessive pressure caused by thermal expansion or over lubrication. All motor bearings shall be factory pre-packed with a non-detergent lubricant, and shall be provided with lubrication fitting arranged to provide easy access when installed on the driven apparatus except as noted hereinafter. Permanently lubricated factory-sealed motors may be provided in fractional HP sizes only where they are an integral part of a piece of approved apparatus. All bearings shall be designed for B-10, 200,000 hour minimum life hours of continuous service. Calculate bearing load with NEMA minimum V- belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- L. Sound Power Levels: Refer to ANSI/NEMA MG 1.
- M. Weatherproof Epoxy Coated Motors (Where Indicated): Epoxy coat windings with rotor and starter surfaces protected with epoxy enamel. Bearings shall be double shielded with waterproof non-washing grease.
- N. Nominal Efficiency: Meet or exceed values listed below at full load and rated voltage when tested in accordance with ANSI/IEEE 112.
- O. Nominal Power Factor: Meet or exceed values listed below at full load and rated voltage when tested in accordance with ANSI/IEEE 112.
- P. Motors 1 HP and larger shall be provided with a copper frame grounding lug of hydraulic compression design, for installation by the electrical subcontractor.
- Q. Motors 10hp and larger shall be inverter duty rated and shall be provided with shaft grounding device.

2.06 STARTING EQUIPMENT:

- A. Each motor shall be provided with proper starting equipment. This equipment, unless hereinafter specified or scheduled to the contrary, shall be provided by the trade furnishing the motor. All motor starting equipment provided by any one trade shall be of the same manufacture unless such starting equipment is an integral part of the equipment on which the motor is mounted. The Mechanical Subcontractor shall furnish all starters for Division 23 work, except those starters scheduled to be provided in Division 26 Motor Control Centers.
- B. Motor starters shall conform to NEMA Standards for Industrial Control, #IC-1, latest issue, and shall be housed in NEMA Standard enclosures. Control voltage in each starter shall be not more than 120 volts to ground, with an individual control transformer provided in each starter as required. Manual starters for fractional horsepower single-phase motors shall be on-off or snap switch type combined with thermal overload device. The switch shall be so constructed so that it cannot be held closed under a sustained motor overload.
- C. Magnetic starters shall have thermal overload protection in each of the ungrounded legs and shall be solenoid operated. Provide the correct size heater element to protect the motor and allow it to operate based on motor nameplate amperes and ambient temperatures anticipated for each individual motor. Each starter shall be provided with a control power transformer or 120v control power circuit.
- D. Pushbuttons with or without pilot lights, hand-off-automatic switches and other scheduled apparatus shall be standard duty type mounted in NEMA enclosures or in cover of starter as specified or scheduled, and shall be furnished by the trade furnishing the starter except as specifically indicated elsewhere.
- E. Hand-Off-Automatic switches for equipment which could damage itself if left in the "hand" position (such as sump pumps), shall be spring return to "off" from the "hand" position.

PART 3 - EXECUTION

3.01 APPLICATION

- A. Motors drawing less than 250 Watts and intended for intermittent service may be germane to equipment manufacturer and need not conform to these specifications.
- B. Motors shall be open drip-proof type, except where specifically noted otherwise.
- C. Motors shall be energy efficient type.
- D. Single phase motors for shaft mounted fans or blowers shall be permanent split capacitor type.
- E. Motors for air-cooled condensers shall be totally enclosed type.
- F. Motors located in exterior locations shall be totally enclosed weatherproof epoxy-treated type.

NEMA OPEN MOTOR SERVICE FACTORS

HP	3600_RPM	1800_RPM	1200_RPM	900_RPM
1/6-1/3	1.35	1.35	1.35	1.35
1/2	1.25	1.25	1.25	1.15
3/4	1.25	1.25	1.15	1.15

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1	1.25	1.15	1.15	1.15
1.5-150	1.15	1.15	1.15	1.15

3.02 MOTOR EFFICIENCIES – NOMINAL, FULL LOAD, THREE PHASE

	Open Drip-Proof (ODP)			Totally Enclosed Fan-Cooled (TEFC)		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1	82.5	85.5	80.0	82.5	85.5	78.5
1.5	86.5	86.5	85.5	87.5	86.5	85.5
2	87.5	86.5	86.5	88.5	86.5	86.5
3	89.5	89.5	86.5	89.5	89.5	88.5
5	89.5	89.5	89.5	89.5	89.5	89.5
7.5	91.7	91.0	89.5	91.7	91.7	91.0
10	91.7	91.7	90.2	91.7	91.7	91.7
15	92.4	93.0	91.0	92.4	92.4	91.7
20	92.4	93.0	92.4	92.4	93.0	92.4
25	93.0	93.6	93.0	93.0	93.6	93.0
30	93.6	94.1	93.0	93.6	93.6	93.0
40	94.1	94.1	93.6	94.1	94.1	93.6
50	94.1	94.5	93.6	94.1	94.5	94.1
60	95.0	95.0	94.1	94.5	95.0	94.1
75	95.0	95.0	94.5	95.0	95.4	94.5
100	95.0	95.4	94.5	95.4	95.4	94.5
125	95.4	95.4	95.0	95.4	95.4	95.0
150	95.8	95.8	95.4	95.8	95.8	95.4
200	95.4	95.8	95.4	95.8	96.2	95.8

END OF SECTION 23 05 13

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SECTION 23 05 19 - VARIABLE SPEED DRIVES

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 SECTION INCLUDES

- A. Variable Speed Drives

1.03 RELATED SECTIONS

- A. Section 23 05 13 - Motors
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 09 23 – Direct Digital Control Systems
- D. Section 23 09 93 – Sequence of Operation
- E. Section 23 34 00 - Fans
- F. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- G. Section 26 27 26 - Wiring Devices and Floor Boxes

1.04 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. AMCA 99 - Standards Handbook
- D. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes
- E. AMCA 300 - Test Code for Sound Rating Air Moving Devices
- F. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices
- G. NEMA MG1 - Motors and Generators
- H. NFPA 70 - National Electrical Code
- I. IEEE - 112B, 587 and 519

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- C. Product Data:
 - 1. Provide literature that indicates dimensions, weights, capacities, ratings, performance, gages and finishes of materials, and electrical characteristics and connection requirements.
 - 2. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- D. Manufacturer's Installation Instructions.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Maintenance Data: Include instructions for routine service, spare parts lists, and wiring diagrams.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience, who issues complete catalog data on total product.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.09 SCHEDULES ON DRAWINGS:

- A. In general, all capacities of equipment and electrical characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the owner. All equipment shall be shipped to the job with not less than a prime coat of paint or as specified hereinafter. Where installation instructions are not included in these Specifications or on the Drawings, the manufacturer's instructions shall be followed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. ABB ACH550
- B. Toshiba Q9 Series
- C. Substitutions: Under provisions of Section 23 00 00. The equipment as supplied by any of the acceptable manufacturers or an approved equal shall comply with all of the provisions of this specification.

2.02 GENERAL

- A. The Variable Speed Drives shall be provided with the proper enclosure rated for the location, or as noted within this specification, whichever is more stringent.
- B. Variable torque, variable voltage/frequency type for centrifugal fan and pump applications and suitable for use with both standard and high efficiency 3-phase, squirrel cage, induction motors.
- C. Solid state with Pulse Width Modulation (PWM) output waveform. Six step and current source are not acceptable. Full wave rectifier (to prevent input line notching), AC line reactor, fuses, capacitors, and insulated bipolar transistors (IBGT's) as the output-switching device (SCR's, GTO's and Darlingtion transistors are not acceptable). All standard and optional features included within the VFD enclosure. Approved by the equipment manufacturer for the particular product(s) and application(s) involved.
- D. Converter and an inverter section. Converter section shall convert fixed frequency and voltage AC utility power to a DC voltage. VFD shall also include three phase input fuses. The inverter section of the VFD shall invert the DC voltage into a quality output wave form, adjustable voltage and frequency output for stepless motor speed control.
- E. Tested to ANSI/UL standard 508. Complete system listed by a nationally recognized testing agency such as UL, ETH CUC or CSA.
- F. The Contractor shall furnish and install Variable Speed Drive motor controllers to vary the speed of the supply, return and relief air fans and pumps as shown in the fan and pump schedules on the Drawings. One controller shall control the speed of one motor only. See schedules and Drawings for quantity of controllers required.
- G. The variable speed drive shall produce an adjustable AC voltage and frequency output for complete motor control using solid-state technology. The VSD shall be automatically controlled by a grounded electronic (4-20 ma) control signal. The drive shall produce an output volts/Hertz pattern to produce adequate starting torque under all conditions and operate smoothly at all operating speeds on variable torque load. The VSD shall be self-contained totally enclosed in NEMA 1 ventilated cabinet and capable of operation between 0 degrees and 40 degrees Celsius or NEMA 3R for outdoor applications.
- H. VSD's shall be ETL or UL listed. All components used on option units shall be ETL or UL listed. VSD's shall be designed to meet IEEE-587 and shall comply with all applicable

provisions of the latest revision of the National Electric Code. The VSD shall comply with IEEE-519 with respect to the line noise generation.

- I. Power line noise limited to a voltage distortion factor and line notch depth as defined in IEEE 519-1992. Prior to installation, the VFD manufacturer shall estimate total harmonic distortion (THD) caused by the VFD. The results based on a computer aided circuit simulation of the total actual system, with information obtained from the power provider and the user.
- J. Pre-wired 3-position mechanical type Hand/Off/Auto (H-O-A) selector switch and speed potentiometer. Means to communicate hand, off, or auto position.
- K. Power on light to indicate that the VFD is being supplied line power. Fault light to indicate that the VFD has tripped on a fault condition.
- L. Plain English, backlit LCD digital display (code numbers and letters not acceptable) and keypad.
- M. Internal self-diagnostics.
- N. Speed control shall be from a 4-20mA, 0-10vdc, 2-10vdc.
- O. The service factor of the controller shall be equal to 0.95 with a power unit rating basis of 100 percent rated current continuous. Rated continuous current of the VSD shall be equal to 110% of driven motor's FLA rating.
- P. Each controller shall consist of a converter, D.C. link filter or supply power backfeed RF (radio frequency) filter, and an inverter section with each section modularized for ease of troubleshooting. PWM controllers shall also have output line filters for motor noise reduction. All components shall be factory mounted and wired on a dead-front, grounded, freestanding or wall mounted minimum NEMA 1 enclosure arranged for top or bottom conduit entry.
- Q. The controller enclosure shall be provided with the manufacturer's illustrated operating instructions and parts list mounted inside the enclosure door, manual speed control potentiometer, three position mode selector switch ("manual - off -auto", or equivalent), "power on" light, auxiliary relays and contacts for interlock and control wiring.
- R. The 6-step VSD shall convert 460 volt, three-phase 60 Hertz utility power to variable voltage and frequency, three phase, AC power. Both 6-step and PWM shall be designed to provide stepless motor control from 20 percent to 100 percent of base speed.

2.03 FEATURES

- A. The VSD shall incorporate the following minimum features:
 - 1. Input power: 460 V/3 phase/60 Hz.
 - 2. Input fused disconnect switch.
 - 3. Input line filter capable of protecting the electronics against transient voltage spikes or notches, as well as backfeed of RF (Radio Frequency) interference, into the incoming power supply.
 - 4. Fuseless electronic power protection for ground fault protection. Isolation transformers for ground fault protection are not acceptable. Ground fault shall not cause fuses to open.

- B. The following door mounted devices:
1. "Power on" light
 2. Hand/off/auto (or equivalent) selector switch
 3. Manual speed potentiometer (1000 ohms) and ammeter
 4. Digital display unit
 5. Status, frequency/percent speed and fault diagnostics
 6. Minimum/maximum adjustable speeds
 7. Disconnect switch and thermal motor overloads
 8. Manual speed control during manual control mode
 9. A thermally protected transfer switch for manual bypass of the VSD
 10. The VSD shall have auto-restart after power failure, power surge, undercurrent and overcurrent. Overcurrent restart shall be limited to a maximum of five attempts.
 11. Electronic and control follower board
 12. External signal shutdown feature (i.e. fire/smoke, freeze, operable and normal bypass mode)
 13. Output terminal for remote frequency and current meters (4 to 20 ma)
 14. Trip relay for remote fault indication
 15. A door interlock, designed to cut power to the unit when the door is opened
 16. Instantaneous overcurrent trip
 17. Unit over temperature protection
 18. A bypass switch which shall simultaneously isolate the VSD from input and output power, and provide line power directly to the motor. The bypass switch shall also have the capability of starting and stopping the motor. The switch shall consist of an enclosure separate from the VSD. The following shall be mounted on the enclosure door:
 19. Door interlocked main input disconnect switch
 20. Power on light
 21. "Drive-off-bypass" manual mode selector switch
 22. A "normal operation-off-test" selector to facilitate static testing of the drive at startup or while the motor is operating in the bypass mode
 23. Speed lockout circuitry to allow the lockout or bypass of at least three speed ranges within the full range of the controller

2.04 DISCONNECT AND INTERFACE

- A. The following shall be mounted within the enclosure:
1. Line, load and bypass contactors capable of interrupting the locked rotor rating of the driven motor. Bypass and load contactors must be mechanically interlocked to prevent simultaneous closure.
 2. Overload relay
 3. A dedicated terminal strip to allow the controller to be interconnected with external shutdown contacts from smoke detectors, fire detectors, damper interlocks, freeze-stats, time clocks, remote master on-off switch, energy management and control system (FCMS) and input signals. The system must be capable of shutdown whether in the drive or in the bypass mode by remote detectors.

2.05 FAULT DETECTION DEVICES

- A. A diagnostic fault detection center shall be integral to each VSD, providing an indication of the following fault conditions:

1. External fault
2. Processor line fault
3. Low AC line voltage
4. High AC line voltage
5. Current overload
6. High DC buss voltage
7. VSD output fault

2.06 CONTROL

- A. All control adjustments shall be made without the necessity of an extender board of specialized meters, but rather from front access adjustable potentiometers.
- B. Low voltage logic and 115 V control circuits shall be electrically isolated from the power circuits. Signal circuit common shall be grounded.
- C. The VSD shall include a power ride-through feature to allow continuous operation through up to a three to five cycle line loss.
- D. Electronic output overload protection shall be provided to eliminate the use of bimetallic overloads. The drive shall not be phase sequence sensitive.
- E. The VSD shall have independently adjustable acceleration and deceleration circuits of 5 to 120 seconds. Extended time periods are also acceptable.
- F. The VSD shall have full function output current limit adjustable from 10 to 100 percent.

2.07 COMMUNICATIONS

- A. EIA-485 and EIA-232 ports as standard.
- B. Communicate with PLC's, DDC's, BACnet, and other communication protocols. Components included for interface with the selected Building Automation System.
- C. Serial port to download drive parameters and fault logs.
- D. Programmable inputs and outputs.

2.08 SYSTEM OPERATION

- A. Selector switch in the "off" position - the controller run circuit shall be open and the system shall not operate.
- B. Selector switch in the "manual" position - the speeds of the motors shall be controlled by the manual speed potentiometer.
- C. Selector switch in the "auto" position - operation shall be via the input 0 to 10 VDC signal with the output speed proportional to the input signal. If required for incorporation into the controls scenario, the VSD manufacturer shall furnish a pressure transducer mounted in the drive enclosure to convert a 3 to 15 psi pressure signal to a 0 to 10 VDC signal.

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- D. The bypass switch shall provide the ability to service the control in bypass operation while not de-energizing the motor. It shall also allow for start/stop functions for the motor.
- E. In case of an output ground fault or similar abnormal output condition, any VSD serving multiple units shall be able to automatically alternate its output to either the duty device or the standby device. The VSD shall be fully operational after an output ground fault condition.

2.09 COORDINATE THE FOLLOWING VFD OPTIONS WITH THE UNIVERSITY:

- A. External bypass switch to operate equipment while VFD is inoperative or being maintained.
- B. Communications interface with building and temperature controls.
- C. Input line reactors for harmonic suppression.
- D. Output line reactors for motor protection.
- E. 6, 12 or 18 pulse shifting transformer or Active Harmonic filtering (AHF) to minimize total harmonic distortion.
- F. Removable VFD keypad with LCD and memory storage.
- G. External Three contactor DRIVE/OFF/BYPASS/TEST SWITCH that allows operation of the motor via line power in the event of VFD failure.

PART 3 - EXECUTION

3.01 GENERAL

- A. The manufacturer's representative shall provide a list of recommended spare parts.
- B. The manufacturer's representative shall provide terminal block to terminal block wiring diagrams coordinated with the owner to provide a complete and functional operating system. Furnish detailed drawings showing construction, dimensions, wiring diagrams and installation procedures for engineer's approval.
- C. The manufacturer shall provide a factory trained technician to start the VSD and place it into operation.
- D. The successful vendor shall provide for and present to the owner, at no cost to the owner, a training and troubleshooting course at the owner's location. This course shall be comprised of a minimum of two (2) days of classroom instruction for a minimum of four (4) hours per day complete with visual aids, documentation, circuit diagrams and hands-on training for a group of approximately 6 people. This course is not to be construed as a sale meeting, but rather as a school to familiarize the owner with the care, troubleshooting and servicing of the VSD.
- E. VSD's shall be wall hung units. Contractor shall provide unistrut mounting bracket for drives. Contractor shall reinforce the wall studs with bracing as required to adequately support the drive. Installation of the VSD shall allow for clearance in front of the drive as required by the latest revision of the National Electric Code for an electrical panel.

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3.02 WARRANTY

- A. 36 months from the date of certified start up. Include all parts, labor, travel time and expenses.
- B. Local factory certified technicians for 24 hours, 7-day a week service. Throughout the warranty service period, response within 24 hours of initial contact for service.
- C. Guaranteed spare parts availability to the University for a minimum of fifteen (15) years from date of purchase. Price escalation for spare parts not to exceed 10% per year over the fifteen (15) year duration.

3.03 TRAINING

- A. On-site instruction included with each VFD and within 30 days of start-up. Factory trained and certified instructor. All training aids shall be provided by trainer. Content to include care, troubleshooting, servicing, and operation of the equipment and systems installed.
- B. Classroom, on-site and in-the-field instruction.

3.04 START-UP

- A. Factory trained and certified technician shall check the installation, start the VFD's and place them into operation. Start-up within two weeks of notification.
- B. Certified start-up report.

3.05 TESTING

- A. VSD's shall be shipped to the air handling unit, pump or fan manufacturer for testing. The units shall be operated over the full speed range to certify noise and vibration limits are met.

END OF SECTION 23 05 19

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SECTION 23 05 29 - SLEEVES, FLASHINGS, SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 53 – Mechanical Identification

1.02 SECTION INCLUDES

- A. Pipe and equipment hangers and supports
- B. Equipment bases and supports
- C. Sleeves and seals
- D. Flashing and sealing equipment and pipe stacks

1.03 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Placement of inserts in concrete formwork.
- B. Placement of roofing pipe and supports.
- C. Placement of equipment roof supports.
- D. Placement of roof sleeves, vents, and curbs.

1.04 RELATED SECTIONS

- A. Section 00 33 00 - Cast-In-Place Concrete: Equipment bases
- B. Section 07 84 00 - Firestopping: Joint seals for piping and duct penetration of fire rated assemblies
- C. Section 09 91 00 - Painting
- D. Section 23 05 4 - Vibration Isolation
- E. Section 23 07 19 - Piping Insulation
- F. Section 23 07 16 - Equipment Insulation
- G. Section 23 07 16 - Ductwork Insulation
- H. Section 21 13 13 - Fire Protection Systems
- I. Section 22 13 16 - Plumbing Piping

1.05 REFERENCES

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- A. ASME B31.1 - Power Piping
- B. ASME B31.2 - Fuel Gas Piping
- C. ASME B31.5 - Refrigeration Piping
- D. ASME B31.9 - Building Services Piping
- E. ASTM F708 - Design and Installation of Rigid Pipe Hangers
- F. MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer
- G. MSS SP69 - Pipe Hangers and Supports - Selection and Application
- H. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices
- I. NFPA 13 - Installation of Sprinkler Systems
- J. NFPA 14 - Installation of Standpipe and Hose Systems
- K. UL 203 - Pipe Hanger Equipment for Fire Protection Service

1.06 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
- C. Product Data: Provide manufacturers catalog data including load capacity.
- D. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- E. Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.07 REGULATORY REQUIREMENTS

- A. Conform to applicable code for support of plumbing and hydronic piping.
- B. Supports for Sprinkler Piping: Shall be in conformance with NFPA 13.
- C. Supports for Standpipes: Shall be in conformance with NFPA 14.

PART 2 - PRODUCTS

2.01 HANGERS AND SUPPORTS

- A. Manufacturers:
 - 1. Grinnell.
 - 2. Kindorf

3. B-Line
 4. Power Strut
 5. Other acceptable manufacturers offering equivalent products.
- B. Supports, hangers, anchors and guides shall be provided for all horizontal and vertical piping. Shop Drawings shall be provided, indicating locations and details of anchors, guides, expansion loops and joints, hangers, etc. The hanger design shall conform to the ASME Code for Pressure Piping.
- C. All auxiliary steel required for supports, anchors, guides, etc. shall be provided by the Mechanical Trades unless specifically indicated to be provided by others.
- D. The supports, hangers, anchors, and guides for the chilled water supply and return piping, steam piping, condensate return piping, etc. of the Campus Loop System routed through utility tunnels and below buildings shall be provided as indicated on the Drawings.
- E. Contractor shall review all Drawings, including Structural Drawings, for details regarding pipe supports, anchors, hangers, and guides.
- F. All Supports shall be of type and arrangement to prevent excessive deflection, to avoid excessive bending stresses between supports, and to eliminate transmission of vibration.
- G. All rod sizes indicated in this Specification are minimum sizes only. This trade shall be responsible for structural integrity of all supports, anchors, guides, etc. All structural hanging materials shall have a minimum safety factor of 5 built in.
- H. Anchor points as indicated on Drawings or as required shall be located and constructed to permit the piping system to take up its expansion and contraction freely in opposite directions away from the anchored points.
- I. Guide points shall be located and constructed wherever required or indicated on Drawings and at each side of an expansion joint or loop, to permit free axial movement only.
- J. Supports, hangers, anchors, and guides shall be fastened to the structure only at such points where the structure is capable of restraining the forces in the piping system.
- K. Hangers supporting and contacting brass or copper lines 3" in size and smaller shall be Grinnell Fig. CT-99c, adjustable, copper plated, tubing ring. Hangers supporting and contacting brass or copper lines 4" and larger shall be Grinnell Fig. 260, adjustable clevis, with a nut above and below the hanger, and approved neoprene isolating material between pipe (or tubing) and hanger on the support rod. For insulated copper or brass domestic water lines, hangers for all sizes of pipe shall be Grinnell Fig. 300, adjustable clevis, with a nut above and below the hanger, and approved neoprene isolating material between pipe (or tubing) and hanger on the support rod. Isolate all copper or brass lines from all ferrous materials with approved dielectric materials. Hangers supporting and contacting plastic or glass piping shall be of equal design, but shall be padded with neoprene material or equal. The padding material and the configuration of its installation shall be submitted for approval.
- L. Hangers supporting insulated lines where the outside diameter of the insulation is the equivalent of 8" diameter pipe or smaller in size and supporting all ferrous lines 6" and smaller in size shall

- be Grinnell Fig. 260, adjustable clevis, with a nut above and below the hanger on the support rod.
- M. Hangers supporting and contacting ferrous lines larger than 6" in size and outside of insulation on lines with the outside diameter equivalent to 10" diameter pipe shall be Grinnell Fig. 260, adjustable clevis, with a nut above and below the hanger on the support rod.
- N. Other special type of hangers may be employed where so specified or indicated on the Drawings, or where required by the particular conditions. In any case, all hangers must be acceptable to the owner.
- O. Each hanger shall be properly sized to fit the supported pipe or fit the outside of the insulation on lines where specified. Hangers for dual or low temperature insulation pipes shall bear on the outside of the insulation, which shall be protected by support shields as specified in Section 23 07 19 - PIPING INSULATION. Protect insulation from crushing by means of a section of rigid insulation to be installed at hanger points. Hangers for high temperature insulated pipes and all insulated hot and cold domestic water pipes shall be encased in the insulation unless supported by trapezes in which case shield and rigid insulation shall be provided as specified above for low temperature insulated pipes.
- P. Supports for vertical piping in concealed areas shall be double bolt riser clamps, Grinnell Fig. 261, or other approved equal, with each end having equal bearing on the building structure, and located at each floor. Two-hole rigid pipe clamps at 4 ft. o.c. or Kindorf channels and Grinnell Fig. 261 riser clamps may be used to support pipe directly from vertical surfaces or members where lines are not subject to expansion and contraction. When piping is subject to expansion and contraction, provide spring isolators (see Section 23 05 48 - Vibration Isolation). Where brass or copper lines are supported on trapeze hangers or Kindorf channels the pipes shall be isolated from these supports with plastic tape with insulating qualities, or strut clamps as manufactured by Specialty Products Company, Stanton, California.
- Q. Supports for vertical piping in exposed areas (such as fire protection standpipe in stairwells) shall be attached to the underside of the building structure above the top of the riser, and the underside of the penetrated structure. The contractor shall use a drilled anchor as specified above, and use a Grinnell No. 595 Socket Clamp with Grinnell No. 594 Socket Clamp Washers, as a riser clamp. The top riser hanger shall consist of two (2) hanger rods (sized as specified) anchored to the underside of the building structure, supporting the pipe by means of the material specified. Risers penetrating floors shall be supported from the underside of the penetrated floor as specified for the top of the riser.
- R. Pipe Supports in Chases and Partitions: Horizontal and vertical piping in chases and partitions shall be supported by hangers or other suitable support. Pipes serving plumbing fixtures and equipment shall be securely supported near the point where pipes penetrate the finish wall. Supports shall be steel plate, angles, or special channels such as Unistrut mounted in vertical or horizontal position. Pipe clamps such as Unistrut P2426, P2008, P1109 or other approved clamps shall be attached to supports. Supports shall be attached to wall or floor construction with clip angles, brackets, or other approved method. Supports may be attached to cast iron pipe with pipe clamp, or other approved method. All copper or brass lines shall be isolated from ferrous metals with dielectric materials to prevent electrolytic action.

- S. All electrical conduits shall be run parallel or perpendicular to adjacent building lines. Single conduits running horizontally shall be supported by "Caddy" or "Minerallac" type hangers from adequately sized rods (minimum 1/4") from the building structure. Where multiple conduits are run horizontally, they shall be supported on trapeze of "Unistrut" type channel suspended on rods or bolted to vertical building members. Conduit shall be secured to channel with galvanized "Unistrut" type conduit clamps or stainless steel "Unistrut" type "Uni-Clips." All hangers shall be fastened to the building structure in the same manner as specified above for pipe hangers. Spacing of hangers shall be adequate for the weight and rigidity of the conduits involved; in any case, no greater than 8' centers, within 12" of each change of direction and on both sides of line valves. Where feasible, conduits may be fastened to the concrete by one-hole straps thoroughly anchored to the concrete in an approved manner. Flexible conduit shall also be supported in an acceptable manner so as not to interfere with the maintenance of above-ceiling equipment, and to support it from touching the ceiling system. Conduit shall be located so as not to inhibit removal of ceiling tiles.
- T. Perforated strap iron or wire will not, under any circumstances, be acceptable as hanger material.
- U. Vibration Isolation: Resilient hangers shall be provided on all piping connected to rotating equipment (pumps, etc.). Piping or ductwork that may vibrate and create an audible noise shall also be isolated. Spring hangers or supports shall be provided where indicated on the Drawings and/or specified under Section 23 05 48.
- V. Attachment:
1. The load and spacing on each hanger and/or insert shall not exceed the safe allowable load for any component of the support system, including the concrete which holds the inserts. Reinforcement at inserts shall be provided as required to develop the strength required.
 2. Inserts shall be of a type which will not interfere with reinforcing as shown on the structural Drawings and which will not displace excessive amounts of structural concrete.
 3. All supports shall be designed and installed to avoid interference with other piping, hangers, ducts, electrical conduit, supports, building structures, equipment, etc. All piping shall be installed with due regard to expansion and contraction and the type of hanger method of support, location of support, etc. shall be governed in part by this Specification.
 4. Hangers shall be attached to the structure as follows:
 - a. Poured In Place Concrete: Where pipes and equipment are supported under poured in place concrete construction, each hanger rod shall be fitted with a nut at its upper end, which nut shall be set into an Underwriters Laboratories, Inc. listed universal concrete insert placed in the form work before concrete is poured. Where inserts are placed in the bottom faces of concrete joists which are too narrow to provide adequate strength of concrete to hold the insert properly or where a larger insert would require displacement of the bottom joist steel, the hanger rod shall be suspended from the center of a horizontal angle iron, channel iron, I-beam, etc. spanning across two adjacent joists. The horizontal support shall be bolted to nonadjustable concrete inserts of the "spot" type, of physical size small enough to avoid the bottom joist steel.
 - b. Steel Bar Joists: Where pipes and loads are supported under bar joists, hanger rods may be run through the space between the bottom angles and secured with a

- washer and two nuts. Where larger lines are supported beneath bar joists, hanger rods shall be secured to angle irons of adequate size; each angle shall span across two or more joists as required to distribute the weight properly and shall be welded to the joists or otherwise permanently fixed thereto.
- c. Steel Beams: Where pipes and loads are supported under steel beams, approved type beam clamps shall be used.
 - d. Wood Framing: Where pipes and loads are supported from wood framing, hanger rods shall be attached to framing with side beam brackets or angle clips.
 - e. Pre-Cast Tee Structural Concrete: Hanger supports, anchors, etc. required for mechanical systems attached to the precast, double tee, structural concrete system are to be installed in accord with approved shop Drawings only. Holes required for hanger rods shall be core drilled in the "flange" of the double tee only; impact type tools are not allowed under any circumstances. Core drilling in the "stem" portions of the double tee is not allowed. Holes core drilled through the "flange" for hanger rods shall be no greater than 1/4" larger than the diameter of the hanger rod. Hanger rods shall be supported by means of bearing plates of size and shape acceptable to the Architect/Engineer, with welded double nuts on the hanger rod above the bearing plate. Cinch anchors, lead shields, expansion bolts, and studs driven by explosion charges are not allowed under any circumstances in the lower 15" of each stem and in the "shadow" of the stem on the top side of the "double tees."
 - f. If it is necessary to install a method of fastening a hanger after the structure has been installed, then only clamps or drilled anchors shall be used.
 - g. Power-actuated fasteners (shooting) will not be acceptable under any circumstances.
 - h. Note: Under no circumstances will the use of plastic anchors or plastic expansion shields be permitted for any purpose whatsoever.
- W. Trapezes: Where multiple lines are run horizontally at the same elevation and grade, they may be supported on trapezes of Kindorf, Uni-Strut, Power Strut, or approved equal, channel-suspended on rods or pipes. Trapeze members including suspension rods shall each be properly sized for the number, size, and loaded weight of the lines they are to support.
- X. Finishes: All hangers on piping including clevis hangers, rods, inserts, clamps, stanchions, and brackets, shall be dipped in Zinc Chromate Primer before installation. Rods may be galvanized or cadmium plated after threading, in lieu of dipping zinc chromate. Universal concrete inserts shall be cadmium plated.
- Y. Ductwork: All ductwork shall be supported in accordance with the SMACNA recommendation for the service involved; however, all horizontal ductwork shall be supported at intervals not to exceed the scheduled values indicated elsewhere in this section. Horizontal ducts shall be supported using galvanized steel bands extending up both sides and onto the construction above, where they shall turn over and be secured with bolts and nuts fitted in inserts set in the concrete bolted to angles secured to the construction above, or secured in another approved manner. For attaching methods for precast double tee structural concrete, refer to details on the Drawings and as specified herein.
- Z. Terminal units shall be supported by four 16 gauge, 1" wide sheet metal straps with ends turned under bottom of box at corners. Each band shall be secured by not over 3/4" in length, 1/4"

diameter sheet metal screws - two on bottom of box and one on side. The other strap end shall be attached to the structure by 1/4" diameter threaded bolt into the concrete insert or into drilled-hole threaded concrete expansion anchor. Where interferences occur, overhead of the box, not allowing direct vertical support by straps, provide trapezes of Kindorf, Unistrut, or B-Line channel suspended by 1/4" diameter galvanized threaded rods providing such channels do not block access panels of boxes. Threaded rods shall be supported from structure by concrete insert or by drilled-hole threaded concrete expansion anchor.

- AA. Miscellaneous: Provide any other special foundations, hangers and supports indicated on the Drawings, specified elsewhere herein; or required by conditions at the site. Hangers and supporting structures for suspended equipment shall be provided as required to support the load from the building structure in a manner acceptable to the Architect/Engineer.
- BB. Fire Protection Systems: All hangers and supports for fire standpipe systems and fire sprinkler systems shall be Factory Mutual and Underwriters Laboratories, Inc. listed and labeled. Construction of hangers shall be as described above for common piping, except for the above-mentioned requirements.

2.02 ACCESSORIES

- A. Hanger Rods: Galvanized mild steel threaded both ends, galvanized threaded one end, or galvanized continuous threaded.
- B. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods. Suitable concrete inserts for pipe and equipment hangers shall be set and properly located for all pipe and equipment to be suspended from concrete construction. If the inserts are later found not to be in the proper location for the placement of hangers, then drilled anchors shall be installed. Drilled anchors in concrete or masonry shall be submitted for the approval by the Owner.

2.03 FLASHING AND EQUIPMENT CURBS

- A. Metal Flashing: 26 gauge galvanized (stainless steel) steel.
- B. Metal Counterflashing: 22 gauge galvanized (stainless steel) steel.
- C. Roofing Flashing: See specifications for Roofing, elsewhere in these Specifications.
- D. Caps: Steel, 22 gauge minimum; 16 gauge at fire resistant elements.
- E. Curbs: Welded 18 gauge galvanized steel shell and base, mitered 3 inch cant, variable step to match roof insulation, factory installed wood nailer.

2.04 HOUSEKEEPING PADS

- A. Concrete foundations for the support of equipment such as floor mounted panels, pumps, fans, air handling units, etc., shall extend 6" on all sides beyond the limits of the mounted equipment unless otherwise noted and shall be poured in forms built of new dressed 4" nominal lumber. All corners of the foundations shall be neatly chamfered by means of sheet metal or triangular

wood strips nailed to the form. Foundation bolts shall be placed in the forms when the concrete is poured, the bolts being correctly located by means of templates. Each bolt shall be set in a sleeve of size to provide 1/2" clearance around bolt. Allow 1" below the equipment bases for alignment and grouting. After grouting, the forms shall be removed and the surface of the foundations shall be hand rubbed with Carborundum. Foundations for equipment located on the exterior of the building shall be provided as indicated. Foundations shall be constructed in accordance with Shop Drawings submitted by the Contractor for review by the Architect/Engineer.

2.05 WALL, FLOOR AND CEILING PLATES:

- A. Except as otherwise noted, provide C.P. (Chrome plated) brass floor and ceiling plates around all pipes, conduits, etc., passing exposed through walls, floors, or ceilings, in any spaces except underfloor and attic spaces. Plates shall be sized to fit snugly against the outside of the pipe or against the insulation on lines which are insulated and positively secured to such pipe or insulation. Plates will not be required for piping where pipe sleeves extend 3/4" above finished floor. All equipment rooms are classified as finished areas. Round and rectangular ducts shall have closure plates (NOT chrome plated) made to fit accurately at all floor, wall and ceiling penetrations. Floor penetrations in exposed (except in stair wells) areas shall be finished using 'bell' fitting to fit pipe or insulation and sleeve and shall be painted to match the pipe. Penetrations in stairwells shall have flat floor plate painted to match pipe.

2.06 SLEEVES

- A. General: All openings through all floors, walls, and roofs, etc., regardless of material for the passage of piping, ductwork, conduit, cable trays, etc., shall be sleeved. All penetrations must pass through sleeves. Sleeves shall be set in new construction before concrete is poured, as cutting holes through any part of the concrete will not be permitted unless acceptable to the Architect/Engineer. If a penetration is cored into an existing vertical solid concrete, masonry or stone structure, then the installation of a sleeve will not be necessary.
1. Sleeve material for floors and exterior walls shall be Schedule 40 galvanized steel with welded water stop rings.
 2. Sleeves through interior walls to be galvanized sheetmetal with gauge as required by wall fire rating, 20 gauge minimum.
 3. Sleeves through load-bearing surfaces shall be constructed of uncoated carbon steel pipe.
- B. The minimum clearance between horizontal penetrations including insulation where applicable, and sleeve shall be 1/4", except that the minimum clearance shall accommodate a Thunderline Link-seal closure where piping exits the building, or penetrates a wall below ground level. Contractor shall be responsible for the accurate location of penetrations in the slab for his pipe, duct, etc. All penetrations shall be of ample size to accommodate the pipe, duct, etc., plus any specified insulation. Void between sleeve and pipe in interior penetrations shall be filled with Nelson Flameseal Firestop or approved equal caulk or putty.
- C. Floor sleeves shall extend above the finished floor as detailed on the drawings, except that floor sleeves in stairwells shall be flush with the finished floor. Sleeves in walls shall be trimmed flush with wall surface. Refer to the details on the project drawings. Where the details differ from these specifications, the drawings take precedence.

- D. Sleeves for penetrations passing through walls or floors on or below grade shall be removed, if practical, and after the pipes have been installed, the void space around the pipe shall be caulked with a suitable material to effect a waterproof penetration. Note that the practicality of the removal of the sleeve shall be the decision of the Construction Inspector. The decision of the Inspector shall be final.
- E. Sleeves shall not be installed in structural members unless specifically approved by the University.
- F. Vermin proofing: The open space around all ductwork, piping, etc., passing through the ground floor and/or exterior walls shall be vermin proofed in a manner acceptable to the Architect/Engineer.
- G. Waterproofing: The annular space between a pipe and its sleeve in interior floors shall be filled with polyurethane foam rods 50 percent greater in diameter than the space as backing and fill material and made watertight with a permanent elastic polysulfide compound. Seal both surfaces of floor.
- H. Air Plenums: The space around piping, ductwork, etc., passing through air plenums shall be made airtight in a manner acceptable to the Architect/Engineer.
- I. Fireproofing: Seal all cable trays, pipe, conduit, duct, etc., penetrations through roof, fire rated walls and floors with a foam or sealant as described below, that will form a watertight, vermin tight barrier that is capable of containing smoke and fire up to 2000° F for two hours. Sealing of cable trays and conduits that extend through rated walls from ends of cable tray shall be done after conductors have been installed. For wet locations, the foam material shall be a silicone RTV foam or an approved equal. For dry locations, a premixed putty equal to Nelson Flameseal Firestop putty may be used.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.02 INSERTS

- A. Provide inserts for placement in concrete formwork.
- B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
- D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.03 PIPE HANGERS AND SUPPORTS

- A. Support horizontal piping as scheduled.
- B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
- C. Place hangers within 12 inches of each horizontal elbow.
- D. Use hangers with 1-1/2 inch minimum vertical adjustment.
- E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
- F. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub. For pipe risers exceeding three floors, evaluate pipe supports for longitudinal expansion and support requirements. Support riser piping independently of connected horizontal piping.
- G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Support riser piping independently of connected horizontal piping.
- I. Provide copper plated hangers and supports for copper piping.
- J. Design hangers for pipe movement without disengagement of supported pipe.
- K. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed, but shall be corrosion protected with galvanized plating. Repair any damaged galvanized plating with a coating of 'Galvalum'.
- L. Hanger Rods: (NOTE: All hanger rods shall be trimmed neatly so that no more than 1 inch of excess hanger rod protrudes beyond the hanger nut. In the event a rod is intentionally but temporarily left excessively long (for sloped or insulated lines for example), the contractor shall take appropriate measures to protect the pipe or other materials from damage.)

3.04 FLASHING

- A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
- B. Flash vent and soil pipes projecting 3 inches minimum above finished roof surface with lead worked one inch minimum into hub, 8 inches minimum clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk, metal counterflash, and seal.
- C. Flash floor drains in floors with topping over finished areas with lead, 10 inches clear on sides with minimum 36 x 36 inch sheet size. Fasten flashing to drain clamp device.
- D. Seal floor, shower, mop sink, and floor drains watertight to adjacent materials.

- E. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control.
- F. Provide curbs for mechanical roof installations 12 inches minimum high above roofing surface to allow future roof maintenance. Flash and counterflash with sheet metal; seal watertight. Attach counterflashing mechanical equipment and lap base flashing on roof curbs. Flatten and solder joints.
- G. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.05 SLEEVES

- A. Set sleeves in position in formwork. Provide reinforcing around sleeves.
- B. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
- C. Extend sleeves through floors (except in stairwells) two inches above finished floor level. Sleeves through floors shall have welded waterstop rings. Sleeves shall be sealed watertight to floors and pipe.
- D. Where piping, ductwork or conduit penetrates floor, ceiling, or wall, close space between pipe or duct and adjacent work with fire stopping insulation and caulk airtight. Provide close fitting metal collar or escutcheon covers, as appropriate, at both sides of penetration.
- E. Install chrome plated steel or stainless steel escutcheons at finished surfaces.

3.06 PIPE SUPPORT SCHEDULES

STEEL PIPE SIZE	MAX. HANGER SPACING	HANGER ROD DIAMETER
Inches	Feet	Inches
1/2 to 1-1/4	6.5	3/8
1-1/2 to 2	10	3/8
2-1/2 to 3	10	1/2
4 to 6	10	5/8
8 to 12	14	7/8
14 and Over	20	1
PP, PVDF, PVC, CPVC (All Sizes)	4	3/8
C.I. Bell and Spigot (or No-Hub), and at all Joints	5	5/8
Glass, and at all Joints	4	1/2

3.07 LOW PRESSURE DUCT SUPPORT SCHEDULE:

- A. All horizontal ducts up to and including 40 inches in their greater dimension shall be supported by means of No. 18 U.S. gauge band iron hangers attached to the ducts by means of screws, rivets, or clamps and fastened to above inserts with toggle bolts, beam clamps or other approved means. Duct shall have at least one pair of supports 8' 0" on centers. Clamps shall be used to fasten hangers to reinforcing on sealed ducts.
- B. Horizontal ducts larger than 40 inches in their greatest dimension shall be supported by means of hanger rods bolted to angle iron trapeze hangers. Duct shall have at least one pair of supports 8' 0" on centers according to the following:

Length	Angle	Rod Diameter
4' 0"	1-1/2" x 1-1/2" x 1/8"	1/4"
6' 0"	1-1/2" x 1-1/2" x 1/8"	1/4"
8' 0"	2" x 2" x 1/8"	5/16"
10' 0"	3" x 3" x 1/8"	3/8"

- C. Vertical ducts shall be supported where they pass through the floor lines with 1-1/2" x 1-1/2" x 1/4" angles for ducts up to 60." Above 60", the angles must be increased in strength and sized on an individual basis considering space requirements.

3.08 MEDIUM PRESSURE DUCT SUPPORT SCHEDULE:

- A. All horizontal rectangular ducts shall have duct hanger requirements as follows:

Max. Duct Dimen.	Minimum Hanger Size				
	Rod	Steel Strap Width	Galv. Steel Spacing	Max. Hngers	Min.# Trapeze Size
0 through 18"	--	1" x 16 ga.	10'	2	--
19" through 36"	--	1" x 16 ga.	10'	2	--
37" through 60"	3/8"	1" x 16 ga.	8'	2	2" x 2" x 1/4"
61" through 120"	3/8"	1-1/2" x 12 ga.	8'	2	2" x 2" x 1/4"
121" through 240"	3/8"	--	4'	3	2 1/2" x 2 1/2" x 3/16"

- B. All horizontal round ducts shall have ducts hangers spaced 10' 0" maximum with requirements as follows:

Duct Diameter	Min. Hanger Size	No. Hangers	Hanger Ring Size
Up through 18"	1" x 16 gauge	1	1" x 16 ga.
19" to 36"	1" x 12 gauge	1	1" X 12 ga.
37" to 50"	1-1/2" x 12 gauge	1	1-1/2" x 12 ga.
51" to 84"	1-1/2" x 12 gauge	2	Support Bracing Angle

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3.09 DUCT HANGERS - GENERAL NOTES (ALL PRESSURES)

- A. Hanger straps on duct width of 60 inches and under shall lap under the duct a minimum of 1 inch and have minimum of one fastening screw on the bottom and two on the side.
- B. Hanger straps on duct widths over 60 inches shall be bolted to duct reinforcing with 3/8" bolts minimum.
- C. Use 3/8" minimum bolts for securing duct hanger to band straps.
- D. All round ducts shall be supported within 3 feet of all horizontal or vertical turns.

END OF SECTION 23 05 29

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SECTION 23 05 48 - VIBRATION ISOLATION

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. 23 00 00 -- Basic Mechanical Requirements
- B. 23 05 29 -- Sleeves, Flashings, Supports and Anchors
- C. 23 05 53 -- Mechanical Identification

1.02 WORK INCLUDED

- A. Inertia bases
- B. Vibration isolation

1.03 SCOPE OF WORK:

- A. Furnish and install all labor, materials, equipment tools and service and perform all operations required in connection with or properly incidental to the construction of complete system of vibration and noise control, as indicated on the Drawings, reasonably implied therefrom or as specified herein, unless specifically excluded.

1.04 REFERENCES

- A. ASHRAE - Guide to Average Noise Criteria Curves

1.05 QUALITY ASSURANCE

- A. Maintain ASHRAE criteria for average noise criteria curves for all equipment at full load condition

1.06 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 00 00.
- B. Indicate inertia bases on shop drawings.
- C. Indicate vibration isolator locations, with static and dynamic load on each, on shop drawings and described on product data.
- D. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

1.07 CERTIFICATES

- A. Submit a certificate from the manufacturer that isolators are properly installed and properly adjusted to meet or exceed specified requirements.

1.08 INTENT OF RESPONSIBILITY:

- A. It is the intent of this specification to provide for vibration isolation supports for all equipment, piping, and ductwork as set out below. The transmission of perceptible vibration, structural borne noise, or objectionable air borne noise to occupied areas by equipment installed under this contract will not be permitted. The Contractor shall be held responsible for installing the vibration isolators as specified herein or shown on the drawings or otherwise required to prevent the transmission of vibration which would create objectionable noise levels in occupied areas. The isolation supplier must be a firm capable of dealing effectively with vibration and noise characteristics effects and criteria, and one which can provide facilities and capabilities for measuring and evaluating the aforementioned disturbances.
- B. All vibration isolation devices, including auxiliary steel bases and pouring forms, shall be designed and furnished by a single manufacturer or supplier who will be responsible for adequate coordination of all phases of this work. Concrete housekeeping pads and inertia bases shall be included as part of mechanical work. Pads under electrical gear shall be included as part of electrical work. The concrete work shall meet the requirements specified in the General Contract Specifications.
- C. The Contractor shall furnish complete submittal data, including Shop Drawings, which shall indicate the size, type, and deflection of each isolator; and the supported weight, disturbing frequency, and efficiency of each isolator proposed; and any other information as may be required for the Architects and Engineers to check the isolator selection for compliance with the specification. All steel bases and concrete inertia bases shall be completely detailed, and shall show completely any reinforcing steel that may be required to provide a rigid base for the isolated equipment. Further, the submittal data shall indicate, clearly, outlined procedures for installing and adjusting the isolators and bases mentioned above.
- D. The vibration isolation manufacturer, or his qualified representative, shall be responsible for providing such supervision as may be required to assure correct and complete installation and adjustment of the isolators. Upon completion of the installation and after the system is put into operation and before acceptance by the Owner, the isolation manufacturer or his qualified representative, in company with the Architect or his designated representative, shall make a final inspection and submit his report to the Architects and Engineers, in writing, certifying the correctness of the installation and compliance with approved submittal data. Any discrepancies or maladjustments found shall be so noted in the report. Should any noise or vibration be objectionable to the Owner, Architect or Engineer, a field instrumentation test and measurement must be made to determine the source, cause, and path of any such disturbance. Any variation or noncompliance with these specification requirements is to be corrected by the installing contractor in an approved manner.
- E. Vibration isolation devices shall be as manufactured by Amber/Booth Company, Consolidated Kinetics, Korfund Dynamics Corporation, or approved equal.

PART 2 - PRODUCTS

2.01 GENERAL DESIGN FEATURES:

- A. All vibration isolators and bases furnished by the Contractor shall be designed for and treated for resistance to corrosion.

- B. Steel components shall be PVC coated or phosphated and painted with industrial grade enamel. All nuts, bolts and washers shall be zinc-electroplated or cad-plated. Structural bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer. A finish coat of industrial grade enamel shall be applied over the primer.
- C. All isolators exposed to the weather shall have steel parts PVC coated, hot-dip galvanized or zinc-electroplated plus coating of Neoprene or Bitumastic paint. Aluminum components for outdoor installation shall be etched and painted with industrial grade enamel.
- D. Required spring deflections for isolators supporting various items of equipment are shown on the Drawings or tabulated elsewhere in these specifications, but in no case shall be less than one inch. The springs shall be capable of 30% over-travel before becoming solid.
- E. Where height-saving brackets for side mounting of isolators are required, the height-saving brackets shall be designed to provide for an operating clearance of 2" under the isolated structure, and designed so that the isolators can be installed and removed when the operating clearance is 2" or less. When used with spring isolators having a deflection of 2-1/2" or more, the height-saving brackets shall be of the pre-compression type to limit exposed bolt length between the top of the isolator and the underneath side of the bracket.
- F. All isolators supporting a given piece of equipment shall limit the length of the exposed adjustment bolt between the top and base to a maximum range of 1" to 2".
- G. All isolators supporting a given piece of equipment shall be selected for approximately equal spring deflection.
- H. Isolators for equipment installed out-of-doors shall be designed to provide adequate restraint due to normal wind conditions and to withstand wind load of 55 PSF (pounds per square foot) applied to any exposed surface of the equipment without failure.

2.02 ISOLATOR TYPES:

- A. Isolator types and required deflections are specified under "Schedule of Isolated Equipment," paragraph 3.02. The isolators shall comply with the following descriptions for each type required on the project:
- B. Type 1 - An adjustable, free-standing, open-spring mounting with combination leveling bolt and equipment fastening bolt. The spring(s) shall be rigidly attached to the mounting base plate and to the spring compression plate. The isolator shall be designed for a minimum K_x/K_y (horizontal to vertical spring rate) of 1.0. A Neoprene pad having a minimum thickness of 1/4" shall be bonded to the base plate. Base plates shall be sized to limit pad loading to 100 psi.
- C. Type 2 - An aluminum-housed, or cast iron housed, adjustable, spring mounting having telescoping top and bottom sections separated by resilient inserts of Neoprene or other suitable material to limit horizontal motion. The inserts shall be permanently lubricated to minimize vertical friction. Sheet or cast iron housings may be used if they are hot-dip galvanized after fabrication. A Neoprene pad having a minimum thickness of 1/4" shall be bonded to the base plate.

- D. Type 4 - A pad-type mounting consisting of two layers of 3/8" thick, ribbed or waffled, Neoprene pads bonded to a 16 gauge galvanized steel separator plate. Bolting not required. Pads shall be sized for approximately 20 to 40 psi load, or a deflection of 0.10" to 0.16".
- E. Type 5 - A spring hanger consisting of a rectangular steel box, coil springs, spring cups, Neoprene impregnated fabric washer, steel washer, and Neoprene insert designed to prevent metal to metal contact between the hanger rod and bottom of the hanger box. The hanger box shall be capable of supporting a load of 200% of rated load without noticeable deformation or failure.
- F. Type 7 - An elastomeric hanger, consisting of a rectangular steel box and an elastomeric isolation element, which shall be of Neoprene or high quality synthetic rubber with anti-ozone and anti-oxidant additive. The elements shall be so designed for approximately 1/4" deflection and loaded so that deflection does not exceed 15% of the free height of the element. The design shall be such as to prevent metal-to-metal contact between the hanger rod and the steel box.
- G. Type 8 - 1/4" thick closed cell Neoprene ASTM Grade S.E.C. 44 in sheets cut to fit penetrations, as required.

2.03 BASE TYPES:

- A. Base types and required deflections are specified under "Schedule of Isolated Equipment," paragraph 7.8, or are indicated on the Drawings. The bases shall comply with the following descriptions for each type required on the project.
- B. Type B-1 - A structural steel base.
- C. Type B-2 - A concrete inertia base, consisting of a perimeter steel pouring forming, reinforcing bars welded in place, bolting templates, anchor bolts, and height-saving brackets for side mounting of the isolators. The perimeter steel members shall be structural channels having a minimum depth of 1/12 of the longest span, but not less than 6" deep. The inertia base for pumps shall be at least equal in weight to the pump with its driving motor and be sized for a minimum overlap of 4" around the base of the equipment. Concrete inertia bases for pumps shall be sized to support the suction elbow of end suction pumps and both the suction and discharge elbows of horizontal split-case pumps. The bases shall be T-shaped where necessary to conserve space.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS:

- A. Install vibration isolators for motor driven equipment.
- B. Set steel bases for 1-inch clearance between housekeeping pad and base. Set concrete inertia bases for 2-inch clearance. Adjust equipment level.
- C. Provide spring isolators on piping connected to isolated equipment as follows: Up to 4 inch diameter, first three points of support; 5 to 8 inch diameter, first four points of support; 10 inch diameter and over, first six points of support. Static deflection of first point shall be twice deflection of isolated equipment.

D. Pumps:

1. Each centrifugal pump and its driving motor shall be mounted on a common inertia base and the base, in turn, to be mounted on the scheduled vibration isolator type to prevent the transmission of vibration and noise to the building structure.
2. In general, all inertia bases shall be formed and poured in place onto a hard, flat surface from which the base can be separated when cured. The base shall be shimmed, using flat material, to the intended final height prior to equipment mounting and piping connection.
3. After the piping connections are made and the system filled with water and ready to put into service, the isolator adjustment bolts shall be extended until the shim blocks can be removed. The isolators may then be backed down slightly to restore the intended height. The locknuts should then be tightened on the isolators. Jack bolts shall be trimmed to a length which will allow no more than 1 inch of additional height adjustment. After final adjustment, the inertia base shall not support any piping load.

E. Piping:

1. Floor mounted supports shall have the same type of isolator or media as is used for the nearest isolated equipment connected to the piping.
2. The pipe hanger system shall have provisions for all piping to be shimmed or blocked in place until all connections are made and the system filled with water; then, the isolators adjusted to support the weights, and the shim blocks removed.
3. The first three support points from a piece of isolated equipment shall be of the positioning type and provide not less than the static deflection of the equipment isolators.
4. All springs supporting piping shall be capable of an additional 1/2" deflection prior to complete compression and springs supporting vertical risers shall have provisions for limit stops.

F. Resilient Sleeves:

1. Resilient sleeves shall be provided at all points where equipment room walls, floors, or ceilings are penetrated by ducts, piping, or refrigerant line, etc.

G. Fans and Air Handling Units:

1. Such units shall have electrical flexible connections not less than 36" long and the flexible duct connections with a free length of not less than 8".

3.02 SCHEDULE OF ISOLATED EQUIPMENT:

- A. Tabulated below is a schedule of equipment on this project requiring vibration isolation and base isolators of the types listed above. Any equipment, system, construction or condition that may be altered, added, or changed; or that is not specifically considered herein or on the plans shall be treated in a manner that is set out for similar equipment system or construction in order to comply with the above requirements heretofore cited.

EQUIPMENT	ISOLATOR EQUIP. TYPE	ISOLATOR DEFLECTION	BASE ISOL. TYPE
Exhaust Fans	1	2"	---
Transformers	8	---	B-1
Piping	5	1"	---

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Pumps	2	1"	B-2
DX and Heat Recovery Rooftop Units	4	FAN ISOLATED INTERNALLY	Provide with isolation curb
DX Condensing Units	4	ISOLATED INTERNALLY	
Hung Fan Coil Units	7	1"	---

END OF SECTION 23 05 48

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SECTION 23 05 53 - MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors

1.02 SECTION INCLUDES

- A. Nameplates
- B. Tags
- C. Stencils
- D. Pipe Markers

1.03 RELATED SECTIONS

- A. Section 09 91 00 - Painting: Identification painting

1.04 REFERENCES

- A. ASME A13.1 - Scheme for the Identification of Piping Systems

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.
- E. Samples: Submit two of each type of label, tag, etc., of the approximate size specified or implied in the specification.
- F. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

1.06 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.
- B. Record actual locations of tagged valves.

PART 2 - PRODUCTS

2.01 NAMEPLATES

- A. Description: Laminated three-layer plastic with engraved black letters on light contrasting background color.

2.02 TAGS

- A. Manufacturers:
- B. Metal Tags: Stainless Steel with stamped letters; tag size minimum 1-1/2 inch (40 mm) diameter with smooth edges.
- C. Chart: Typewritten letter size list in anodized aluminum frame.

2.03 PIPE MARKERS

- A. Color: Conform to ASME A13.1.
- B. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches (150 mm) wide by 4 mil (0.10 mm) thick, manufactured for direct burial service.

2.04 PIPING

- A. Pipe markers and arrow markers also shall be provided on but not limited to the piping of the following systems:
 - 1. VRF Lines

2.05 ELECTRICAL:

- A. Nameplates shall be 2 or 3 ply laminated plastic, a minimum of 3/32" thick, such that letters will be white on black background. Letters shall be similar to Roman Gothic of a size that is legible and appropriate to the application. Attachment of nameplates shall be by screws. Rivets or adhesives are not acceptable.
- B. Electrical equipment to be identified includes: All switchgear, distribution panels, transformers, motor control centers, panel boards, disconnect switches, starters, contactors and time switches.
- C. Nameplates on distribution panels, motor control centers and panel boards shall give voltage characteristics.

Example:

PANEL LA
120/208V, 3 PH, 4 W

served from .

- D. Individual circuit breakers in distribution panels, individual units in motor control centers, disconnecting means, and motor starters, shall have nameplates showing the load served.
- E. Branch circuit panel boards shall have neatly typed circuit directories behind clean plastic. Identify circuits by room numbers. Room numbers shall be those finally selected by the Owner, not necessarily those given on contract Drawings. If a circuit serves more than one room, list each room. Spares and spaces shall be indicated with erasable pencil, not typed.

2.06 VALVE CHART:

- A. The Contractor shall prepare and install, in a suitable glazed frame, typewritten valve charts giving the number, location and function of each line valve installed under this Contract. Each valve shall be numbered on these charts in accordance with the system of which it is a part of its location. For example, valves in different systems would be designated as follows:

CHS-2-4 Chilled Water Supply 2nd Level - Valve No. 4

2.07 VALVE TAGS:

- A. The Contractor shall provide and install identification tags lettered and numbered to correspond to the information shown on the charts described above. These tags are to be affixed to all valves except simple service and drain valves located within 10' and within sight of the device or equipment served. For example, it would not be expected that valves at a pressure reducing station in a machine room would be tagged. These tags shall be 1/8" thick brass discs, 1 1/2" in diameter. Each tag shall be attached to its valve with copper clad annealed iron wire or other approved material.
- B. Valves at water headers and other valves as specified shall also be tagged with standardized color coded plastic tags. These tags shall be 2 1/2" wide by 1 1/2" high with these color codings: Red = normally closed; Green = normally open; Blue = open in winter, closed in summer; and Yellow = closed in winter, open in summer. Tags should be engraved on both sides.

2.08 SPECIALS: REFER TO SPECIAL REQUIREMENTS NOTED IN THE VARIOUS SECTIONS HEREINAFTER BOUND.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with Section 09 91 00 for stencil painting.

3.02 INSTALLATION

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

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- B. Install tags with corrosion resistant chain.
- C. Apply stencil painting in accordance with Section 09 91 00.
- D. Install plastic pipe markers in accordance with manufacturer's instructions.
- E. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- F. Install underground plastic pipe markers 6 to 8 inches (150 to 200 mm) below finished grade, directly above buried pipe.
- G. Identify valves in main and branch piping with tags.

END OF SECTION 23 05 53

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SECTION 23 05 93 - SYSTEM TESTING, ADJUSTING AND BALANCING (TAB FIRM)

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. 23 00 00 -- Basic Mechanical Requirements
- B. 23 05 29 -- Sleeves, Flashings, Supports and Anchors
- C. 23 05 53 -- Mechanical Identification

1.02 SUMMARY

- A. Testing, adjusting and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by an impartial technically qualified TAB firm selected and employed by the Mechanical Contractor.
- B. The firm shall be capable of performing the services specified at the location of the facility described within the time specified, of preparing and submitting the detailed report of the actual field work performed, and following up the basic work as may be required.

1.03 QUALIFICATIONS

- A. The Firm shall be one which is organized to provide professional services of this specified type in the State of Texas and as a minimum shall have one (1) professional engineer licensed in the State of Texas, with current registration, to perform such professional services. This engineer shall be personally responsible for developing the job site data as required in the test procedures outlined in these Specifications.
- B. The Firm shall have operated a minimum of five (5) years under its current Firm name, and shall be in good standing with the State of Texas, Franchise Tax Board. The firm shall submit their full incorporated name, Charter Number and Taxpayer's I.D. Number for proper verification of the firm's status.
- C. The Firm shall be capable of providing a performance bond, by a bonding company licensed to do business in the State of Texas, if determined by the Owner that such a bond is required. The amount of the bond which may be required shall be equal to the cost of the proposal submitted, or in the case of more than one proposal, the sum of all such proposals and any awarded work in progress.
- D. All personnel used on the job site shall be either professional engineers or engineering technicians, who shall have been permanent, full time employees of the firm for a minimum of six (6) months prior to the start of work for this specific project.
- E. The TAB firm shall submit biographical data on the individual proposed who will directly supervise the TAB work, as well as other personnel scheduled to perform the technical work under the contract. It shall also submit a background record of at least five years of specialized experience in the field of air hydronic system balancing, and shall possess properly calibrated instrumentation. The supervisory personnel for the TAB firm shall be registered engineers in

the mechanical field and all of the employees used in the TAB firm shall be permanent, full-time employees of the firm.

1.04 REFERENCES

- A. AABC - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems, Sixth Edition 2002.
- B. ASHRAE - 2007 HVAC Applications Chapter 37: Testing, Adjusting and Balancing.
- C. ANSI/ASHRAE Standard 111-2008 - Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

1.05 DOCUMENTS

- A. The TAB firm shall, as a requirement of the TAB contract, arrange with the Architect to compile one set of mechanical specifications, all pertinent change orders, and the following:
 - 1. One complete set of Drawings less the structural sheets.
 - 2. One set of mechanical floor plans of the conditioned spaces. These Drawings shall be ozalid type (blue or black on light background) reproductions to facilitate marking.
- B. Approved submittal data on equipment installed, and related changes as required to accomplish the test procedures outlined in Paragraphs 1.06 through 1.10 of this Specification will be available through the Construction Inspector.

1.06 RESPONSIBILITIES OF THE TAB FIRM

- A. The TAB personnel shall check, adjust, and balance the components of the air conditioning system which will result in optimal noise, temperature, and airflow conditions in the conditioned spaces of the building while the equipment of the system is operating economically. This is intended to be accomplished after the system components are installed and operating as provided for in the contract documents. It is the responsibility of the Mechanical Contractor to place the equipment into service. Variable air volume systems shall be balanced in accordance with AABC 2002 Standard, Sixth Edition.
- B. SHSU has requested to be notified during all testing to be able to accompany the TAB agent. Notify the SHSU PM for TAB scheduling.
- C. Liaison and Early Inspection:
 - 1. The TAB firm personnel on the job shall act as liaison between the Owner, Architect and Contractor. The following reviews (observations) and tests shall be performed by the TAB Agency:
 - a. As part of scope prior to performance of work, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to commissioning work and balanceability.
 - b. Allow for a fixed number of trips to the project site, over and above those required for testing and balancing for inspection of installation of the mechanical piping systems, sheet metal work, temperature controls and other component parts of the heating, air conditioning and ventilating systems during the construction stage.

These inspections shall be made prior to and/or at the above ceiling inspection. Commentary will be provided to the DPS Project Manager of each observation.

- c. Test one (1) lab configuration including fume hood with air valve, general exhaust air with air valve and supply air with air valve for performance capability through a full range of inlet pressures. The tracking capability of the exhaust air versus the supply air will be with the submitted hood sash fully open and as the sash is closed in 2" increments until fully closed. Track the three (3) valves' response time in relation to sash movement and the lab differential.
- D. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the Construction Inspector shall be advised in writing so that the condition can be corrected by the Mechanical Contractor. The written document need not be formal, but must be understandable and legible. Data from malfunctioning equipment shall not be recorded in the final TAB report. The TAB firm shall not instruct or direct the Contractor in any of the work, but will make such reports as are necessary to the Owner.

1.07 FINAL AIR BALANCE

- A. General: When systems are complete and ready for operation, the TAB Consultant will perform a final air balance for all air systems and record the results. The outside, supply, exhaust and return air volume for each air handling unit, supply fan and exhaust fan and the supply, exhaust or return air volume for each distribution device shall be adjusted to within +5% of the value shown on the drawings. Air handling unit and fan volumes shall be adjusted by changing fan speed and adjusting volume dampers associated with the unit. Air distribution device volume shall be adjusted using the spin-in tap damper for flexible duct connected devices and the device OBD for duct connected devices. Air distribution devices shall be balanced with air patterns as specified. Duct volume dampers shall be adjusted to provide air volume to branch ducts where such dampers are shown. The general scope of balancing by the TAB Consultant will include, but is not limited to, the following:
 1. Filters: Check air filters and filter media and balance only system with essentially clean filters and filter media. The Division 23 Contractor shall install new filters and filter media prior to the final air balance.
 2. Blower Speed: Measure RPM at each fan or blower to design requirements. Where a speed adjustment is required, the Division 23 Contractor shall make any required changes.
 3. Ampere Readings: Measure and record full load amperes for motors.
 4. Static Pressure: Static pressure gains or losses shall be measured across each supply fan, cooling coil, heating coil, return air fan, air handling unit filter and exhaust fan. These readings shall be measured and recorded for this report at the furthest air device or terminal unit from the air handler supplying that device. Static pressure readings shall also be provided for systems which do not perform as designed.
 5. Equipment Air Flow: Adjust and record exhaust, return, outside and supply air CFM (s) and temperatures, as applicable, at each fan, blower and coil.
 6. Coil Temperatures: Set controls for full cooling and for full heating loads. Read and record entering and leaving dry bulb and wet bulb temperatures (cooling only) at each cooling coil, heating coil and HVAC terminal unit.
 7. Zone Air Flow: Adjust each HVAC terminal unit and air handling unit for design CFM.
 8. Outlet Air Flow: Adjust each exhaust inlet and supply diffuser, register and grille to within +5% of design air CFM. Include all terminal points of air supply and all points of

exhaust. Note: For Rooms that are negative exhaust air flow shall be set to design +10% and supply to design -5%. Positive areas will have opposite tolerances.

9. Pitot Tube Traverses: For use in future troubleshooting by maintenance personnel, all exhaust ducts, main supply ducts and return ducts shall have air velocity and volume measured and recorded by the traverse method. Locations of these traverse test stations shall be described on the sheet containing the data.
10. Maximum and minimum air flow on terminal boxes.

1.08 SOUND VIBRATION AND ALIGNMENT

- A. Sound: Read and record sound levels at up to 15 locations in the building designated by the Engineer. All measurements shall be made using an Octave Band Analyzer. All tests shall be conducted when the building is quiet in the presence of the Engineer, if he so desires.
- B. Vibration: Read and record vibration for all air handling units, and fans which have motors larger than 10 HP. Include equipment vibration, bearing housing vibration, foundation vibration, building structure vibration, and other tests as directed by the Engineer. Readings will be made using portable IRD (or approved equal) equipment capable of filtering out various unwanted frequencies and standard reporting forms. Maximum vibration at any point listed above, or specified, shall not exceed 1 mil on fans and 1 mil on pumps unless otherwise specified. Equipment manufacturers shall rectify all systems exceeding vibration tolerances.

1.09 TESTING OF TEMPERATURE CONTROL SYSTEMS

- A. In the process of performing the TAB work, the TAB Agency shall:
 1. Work with the temperature control contractor to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of intended control performance.
 2. Verify that all control devices are properly connected.
 3. Verify that all dampers, valves and other controlled devices are operated by the intended controller.
 4. Verify that all dampers and valves are in the position indicated by the controller (open, closed or modulating).
 5. Verify the integrity of valves and dampers in terms of tightness of close-off and full-open positions. This includes dampers in terminal boxes and fire/smoke dampers.
 6. Observe that all valves are properly installed in the piping system in relation to direction of flow and location.
 7. Observe the calibration of all controllers.
 8. Verify the proper application of all normally opened and normally closed valves.
 9. Observe the locations of all thermostats for potential erratic operation from outside influences such as sunlight, drafts or cold walls.
 10. Observe the locations of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media. Control Contractor will relocate as deemed necessary by the TAB Agency.
 11. Verify that the sequence of operation for any control mode is in accordance with approved shop drawings and specifications. Verify that no simultaneous heating and cooling occurs.
 12. Verify that all controller setpoints meet the design intent.
 13. Check all dampers for free travel.

14. Verify the operation of all interlock systems.
15. Perform variable volume system verification to assure the system and its components track with changes from full flow to minimum flow.

- B. A systematic listing of the above testing and verification shall be included in the final TAB report.

1.10 REPORTS

- A. The activities described in this section shall culminate in a report to be provided in quadruplicate (4) individually bound to the DPS Project Manager. Neatly type and arrange data. Include with the data the date tested, personnel present, weather conditions, nameplate record of test instrument and list all measurements taken after all corrections are made to the system. Record all failures and corrective action taken to remedy incorrect situation. The intent of the final report is to provide a reference of actual operating conditions for the Owner's operations personnel.
- B. All measurements and recorded readings (of air, electricity, etc.) that appear in the reports must have been made onsite by the permanently employed technicians or engineers of the firm.
- C. At the option of the Construction Inspector, all data sheets tabulated each day by TAB personnel shall be submitted for initial by the Construction Inspector. Those work sheets so initialed, or copies thereof, shall be presented as a supplement to the final TAB report.
- D. Submit reports on forms approved by the Owner & Engineer which will include the following information as a minimum:
1. Title Page
 - a. Company Name
 - b. Company Address
 - c. Company telephone number
 - d. Project name
 - e. Project location
 - f. Project Manager
 - g. Project Engineer
 - h. Project Contractor
 - i. Project Identification Number
 2. Instrument List
 - a. Instrument
 - b. Manufacturer
 - c. Model
 - d. Serial Number
 - e. Range
 - f. Calibration date
 - g. What test instrument was used for
 3. Fan Data (Supply and Exhaust)
 - a. Location
 - b. Manufacturer
 - c. Model
 - d. Air flow, specified and actual

- e. Total static pressure (total external), specified and actual
- f. Inlet pressure
- g. Discharge pressure
- h. Fan RPM
4. Return Air/Outside Air Data (If fans are used, same data as for 3 above)
 - a. Identification/location
 - b. Design return air flow
 - c. Actual return air flow
 - d. Design outside air flow
 - e. Return air temperature
 - f. Outside air temperature
 - g. Required mixed air temperature
 - h. Actual mixed air temperature
5. Electric Motors
 - a. Manufacturer
 - b. HP/BHP
 - c. Phase, voltage, amperage, nameplate, actual
 - d. RPM
 - e. Service factor
 - f. Starter size, heater elements, rating
6. V-Belt Drive
 - a. Identification/location
 - b. Required driven RPM
 - c. Driven sheave, diameter and RPM
 - d. Belt, size and quantity
 - e. Motor sheave, diameter and RPM
 - f. Center-to-center distance, maximum, minimum and actual
7. Duct Traverse
 - a. System zone/branch
 - b. Duct size
 - c. Area
 - d. Design velocity
 - e. Design air flow
 - f. Test velocity
 - g. Test air flow
 - h. Duct static pressure
 - i. Air temperature
 - j. Air correction factor
8. Air Monitoring Station Data
 - a. Identification/location
 - b. System
 - c. Size
 - d. Area
 - e. Design velocity
 - f. Design air flow
 - g. Test velocity
 - h. Test air flow
9. Air Distribution Test Sheet

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- a. Air terminal number
 - b. Room number/location
 - c. Terminal type
 - d. Terminal size
 - e. Area factor
 - f. Design velocity
 - g. Design air flow
 - h. Test (final) velocity
 - i. Test (final) air flow
10. Cooling Coil Data
- a. Identification/number
 - b. Location
 - c. Service
 - d. Manufacturer
 - e. Entering air DB temperature, design and actual
 - f. Entering air WB temperature, design and actual
 - g. Leaving air DB temperature, design and actual
 - h. Leaving air WB temperature, design and actual
 - i. Air pressure drop, design and actual
11. Sound Level Report
- a. Location (Location established by the design engineer)
 - b. NC curve for eight (8) bands - equipment off
 - c. NC curve for eight (8) bands - equipment on
12. Vibration Test on equipment having 10 HP motors or above
13. Location of points:
- a. Fan bearing, drive end
 - b. Fan bearing, opposite end
 - c. Motor bearing, center (if applicable)
 - d. Motor bearing, drive end
 - e. Motor bearing, opposite end
 - f. Casing (bottom or top)
 - g. Casing (side)
 - h. Duct after flexible connection (discharge)
 - i. Duct after flexible connection (suction)
14. Test readings:
- a. Horizontal, velocity and displacement
 - b. Vertical, velocity and displacement
 - c. Axial, velocity and displacement
15. Normally acceptable readings, velocity and acceleration
16. Unusual conditions at time of test
17. Vibration source (if non-complying)
18. Control verification indicating date performed and any abnormalities identified.
19. Point Location/Description
20. EMS Readout (Setpoint and Actual)
21. Actual Readout
22. Interlocks
23. Safeties
- d. VSD Normal Operation

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- e. VSD Bypass Operation
- 24. Alarms
- 25. Sequences of Operation

PART 2 - PRODUCTS

2.01 NOT USED.

PART 3 - EXECUTION

3.01 NOT USED.

END OF SECTION 23 05 93

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SECTION 23 05 94 - SYSTEM PREPARATION FOR TESTING, ADJUSTING AND BALANCING
(MECH. CONTRACTOR)

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 SUMMARY

- A. Perform all work required to prepare the building HVAC systems for testing, adjusting and balancing indicated by the Contract Documents as follows:
 - 1. Responsibilities of project contractor
 - 2. Preparation for balancing of air systems
 - 3. Preparation for balancing of hydronic and steam systems
- B. The scope of the TAB work as defined in Section 23 05 93 is indicated in order that the Contractor will be advised of the coordination, adjustment, and system modification which will be required under the project work in order to complete the Owner's requirements for final TAB. The TAB firm will be hired by the mechanical contractor. The Contractor in his original bid shall allow for the costs required to cover all work which may be required in the TAB phases as defined herein and as may be necessary for the completion of the TAB work as defined by the TAB firm.

1.03 RELATED SECTIONS

- A. Section 01 75 00- Starting of Systems
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 82 16 - Air Coils
- D. Section 23 73 00 – Fan Coil Units
- E. Section 23 34 00 - Fans
- F. Section 23 31 00 - Ductwork
- G. Section 23 33 00 - Ductwork Accessories
- H. Section 23 36 00 - Air Terminal Units
- I. Section 23 37 00 - Air Outlets and Inlets
- J. Section 23 09 23 - Direct Digital Control Systems

- K. Section 23 09 93 - Sequence of Operation
- L. Section 23 05 93 - System Testing, Adjusting & Balancing

1.04 SCOPE OF WORK

- A. Testing, adjusting, and balancing (TAB) of the air conditioning systems and related ancillary equipment will be performed by an impartial technically qualified TAB firm selected and employed directly by the Owner, separate and apart from the Construction Contract. However, the preparation for and corrections necessary for the Testing, Adjusting and Balancing of these systems, as described herein, are the responsibility of the Contractor.
- B. As a part of this project Construction Contract, the Contractor shall make any changes or replacements to the sheaves, belts, dampers, valves, etc. required for correct balance as advised by the TAB firm, at no additional cost to the Owner.
- C. The Contractor shall provide and coordinate the services of qualified, responsible Subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including the testing, adjusting and balancing period.
- D. In order that all systems may be properly tested, balanced, and adjusted as required herein by these Specifications, the Contractor shall operate said systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB. This length of time shall be subject to the approval of the Construction Inspector.
- E. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. The contractor shall allow adequate time for the testing and balancing activities of the owner provided services, during the construction period, and prior to Substantial Completion as defined in the Uniform General Conditions of this Construction Document.
- F. The Drawings and Specifications indicate valves, dampers and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the Contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access as requested by the TAB firm. Also, any malfunction encountered by TAB personnel and reported to the Contractor or the Construction Inspector shall be corrected by the Contractor immediately so that the balancing work can proceed with the minimum of delays.

1.05 RESPONSIBILITIES OF THE PROJECT CONTRACTOR:

- A. The Contractor shall:
 - 1. Have the building and air conditioning systems in complete operational readiness for TAB work to begin.
 - 2. The contractor shall allow sufficient time for the TAB firm to perform his contracted work within the construction schedule. The contractor shall complete his work by systems or floors whichever is the most efficient for scheduling. After awarding of the contract and the contractor has developed a construction schedule, a TAB coordination

meeting shall be held at the SHSU Construction Manager's office with the TAB agency, the general contractor and his primary subcontractors (i.e. mechanical, electrical, building automation etc.) to develop a testing schedule for the project. The contractor shall submit copies of the proposed schedule two (2) weeks prior to this meeting to the SHSU Construction Manager and TAB Agency.

- B. The following are minimum time requirements:
- C. TAB Agency will provide Engineer with tentative schedules for each area, floor and/or system to be included in this section.
- D. Note: The air systems are pressure independent and can be balanced by floors, risers, systems, etc., but once the total system is complete the total flows and system tracking will require finalization. Lab certification will be performed when the building is 100% operational and balanced.
 - 1. Promptly correct deficiencies of materials and workmanship identified as delaying completion of TAB work.
 - 2. Be responsible for any added costs to the Owner resulting from his failure to have the building and air conditioning systems ready for TAB when scheduled, or from his failure to correct deficiencies promptly.
- E. Complete operational readiness of the building requires that construction status of the building shall permit the closing of doors, windows, ceilings installed, etc., to obtain simulated or projected operating conditions.
- F. Complete operational readiness of the air conditioning systems also requires that the following be accomplished:
 - 1. Air Distribution Systems:
 - a. Verify installation for conformity to design. All supply, return and exhaust ducts terminated and pressure tested for leakage as required by the Specification.
 - b. All volume, smoke and fire/smoke dampers are properly located and functional. Dampers serving requirements of minimum and maximum outside, return and relief air shall provide tight closure and full opening, smooth and free operation.
 - c. All supply, return, exhaust and transfer grilles, registers, diffusers and terminal devices installed.
 - d. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be blanked and/or sealed to eliminate excessive bypass or leakage of air.
 - e. All fans (supply, return and exhaust) operating and verified for freedom from vibration, proper fan rotation and belt tension; heater elements in motor starters to be of proper size and rating; record motor amperage and voltage on each phase at start-up and running, and verify they do not exceed nameplate ratings.
 - f. All single variable and constant volume terminal units ("mixing boxes") and fan powered boxes shall be installed and functional (i.e. controls functioning).
 - 2. Automatic Controls:
 - a. The Contractor shall schedule a meeting with the Engineer, Control Contractor, TAB firm and Owner's representative for a pre-submittal review to establish that their interpretations of the sequences of operation are correct.

- b. Verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, dampers sequences, air resets, fire and freeze stats, high and low temperature thermostats, safeties, etc.
 - c. Verify that all controlling instruments are calibrated and set for design operating conditions with the exception of room thermostats or sensors, which shall be calibrated at the completion of TAB services with cooperation between the TAB firm and Control Contractor.
 - d. The Automatic Temperature Control Contractor and/or Energy Management System Contractor shall thoroughly check all controls, sensors, operators, sequences, etc. before notifying the TAB agency that the Automatic Temperature Controls and Energy Management System are operational. The Automatic Temperature Contractor and/or Energy Management System Contractor shall provide technical support (technicians and necessary computers) to the TAB agency for a complete check of these systems.
3. Tabulated Data: The motor amperages, voltages shall be recorded showing "actual" and "nameplate" voltage and amperage and submitted and actual RPM. This applies to each piece of electrically driven air conditioning equipment in the system including supply and exhaust fans, fans of fractional horsepower, pumps, etc.

G. Notification of System Readiness:

1. After completion of the work in Paragraph 1.05 A through C above, the Contractor shall notify the Owner in writing, certifying that the work has been accomplished and that the building and the air conditioning systems are in operational readiness for testing, adjusting, and balancing. He shall include a copy of the tabulated data of Paragraph 1.05C.4 above.
2. The Owner will, in turn, notify the TAB firm of the readiness for balancing and forward copies of the Contractor's certification and the tabulated voltages and currents.
3. Should the TAB firm be notified as described above, and the TAB work commenced and the systems are found NOT to be in readiness or a dispute occurs as to the readiness of the systems, the Contractor shall request an inspection be made by duly appointed representative of the Owner, Architect, TAB firm and the Contractor. This inspection will establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for TAB services. Should the inspection reveal the TAB services notification to have been premature, all cost of the inspection and wasted work accomplished by the TAB firm shall be reimbursed to the appropriated parties by the Project Contractor.

1.06 RESPONSIBILITIES OF THE TAB FIRM

- A. Refer to Section 23 05 93 entitled "System Testing, Adjusting and Balancing".

PART 2 - PRODUCTS

2.01 NOT USED.

PART 3 - EXECUTION

3.01 NOT USED.

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END OF SECTION 23 05 94

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SECTION 23 07 13 - DUCTWORK INSULATION

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 SECTION INCLUDES

- A. Ductwork insulation
- B. Insulation jackets

1.03 RELATED SECTIONS

- A. Section 09 91 00 - Painting: Painting insulation jackets
- B. Section 23 31 00 - Ductwork: Duct liner
- C. Section 23 33 00 - Ductwork Accessories: Duct liner

1.04 REFERENCES

- A. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate
- B. ASTM C518 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- C. ASTM C553 - Mineral Fiber Blanket and Felt Insulation
- D. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation
- E. ASTM E84 - Surface Burning Characteristics of Building Materials
- F. ASTM E96 - Water Vapor Transmission of Materials
- G. NFPA 255 - Surface Burning Characteristics of Building Materials
- H. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
- I. UL 723 - Surface Burning Characteristics of Building Materials

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.

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- B. Product Data: Provide product description, list of materials and thickness for each service, and locations.
- C. Samples: Submit two samples of any representative size illustrating each insulation type.
- D. Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.06 QUALITY ASSURANCE

- A. Materials: Flame spread/smoke developed rating of 25/50 in accordance with NFPA 255.

1.07 QUALIFICATIONS

- A. Applicator: Company specializing in performing the work of this section with minimum three years experience.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Deliver materials to site in original factory packaging, labeled with manufacturer's density and thickness.
- C. Store insulation in original wrapping and protect from weather and construction traffic.
- D. Protect insulation against dirt, water, chemical, and mechanical damage.

1.09 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 - PRODUCTS

2.01 INSULATION WRAP:

- A. Blanket insulation with a thermal conductivity (K) of 0.27 or less similar in construction to Owens-Corning Fiberglass Series one pound per cubic foot minimum density with foil reinforced Kraft (FRK) vapor barrier facing. Insulation shall be wrapped tightly on the ductwork with all circumferential joints butted and longitudinal joints overlapped a minimum of 2". Adhere insulation to metal with 4" strips of insulation bonding adhesive at 8" on center. On circumferential and longitudinal joints, the 2" flange of the facing shall be secured using 9/16" flare door staples applied 6" on center and taped with 4" wide fiberglass tape embedded in Childers CP-10 white vapor barrier Emulsion and covered with Childers CP-10 white vapor barrier Emulsion until the tape is completely covered. All pin penetrations or punctures in facing shall also be taped. Vapor sealing of joints is not required on hot duct application where concealed.

- B. All outside air and supply air ductwork in the building shall be insulated externally with 2" of wrap unless specifically excluded. Only sound attenuated return ducting may be insulated internally, if specifically designated as such.
- C. Where ducts are lined internally, (see Drawings for Scope) no exterior insulation will be required, except where specifically stated otherwise. Where internal and external insulation join, they shall lap at least 24 inches.
- D. Low pressure supply duct taps to ceiling diffusers shall be externally insulated including top of ceiling diffuser with 2" Insulation wrap.
- E. Flexible round ducts are specified in Section 23 31 00 as factory insulated.
- F. Kitchen exhaust shall be provided with 2" 2-hour fire blanket as detailed or provided as an engineered 2-hour rated duct system approved by the City of Houston for grease exhaust duct.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify that ductwork has been tested before applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

- A. Install materials in accordance with manufacturer's instructions.
- B. Insulated ductwork conveying air below ambient temperature:
 - 1. Provide insulation with vapor barrier jackets.
 - 2. Finish with tape and vapor barrier jacket.
 - 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - 4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- C. Insulated ductwork conveying air above ambient temperature:
 - 1. Provide with or without standard vapor barrier jacket.
 - 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- D. Duct Wrap Insulation Application:
 - 1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive to match jacket.
 - 2. Secure insulation without vapor barrier with staples, tape, or wires.
 - 3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
 - 4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
 - 5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
 - 6. All exposed ductwork shall be finished to accept paint by the Architect.

- E. Duct and Plenum Liner Application:
1. Adhere insulation with adhesive for 100 percent coverage.
 2. Secure insulation with mechanical liner fasteners. Refer to SMACNA Standards for spacing.
 3. Seal and smooth joints.
 4. Seal liner surface penetrations with adhesive.
 5. Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.
- F. All piping, equipment, ductwork, all plenums including metal and masonry construction, fans, etc., shall be insulated as indicated on the Drawings, as specified herein, and as required for a complete system. In each case, the insulation shall be equal to that specified and materials applied and finished as described in these Specifications.
- G. All insulation shall be applied by mechanics skilled in this particular work and regularly engaged in such occupation. All insulation shall be applied in strict accordance with these Specifications and with factory printed recommendations on items not herein mentioned. Unsightly, inadequate, or sloppy work will not be acceptable, and all such work shall be removed and replaced as many times as necessary to achieve an acceptable installation.
- H. All insulation, jacket, adhesives, mastics, sealers, etc., utilized in the fabrication of these systems shall meet NFPA for fire resistant ratings (maximum of 25 flame spread and 50 smoke developed ratings) and shall be approved by the insulation manufacturer for guaranteed performances when incorporated into their insulation system, unless a specific product is specified for a specific application, and is stated as an exception to this requirement. Certificates to this effect shall be submitted along with Contractor's submittal data for this section of the Specifications. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.
- I. All surfaces to be insulated shall be clean and dry before applying the insulation. All sections of molded pipe covering shall be firmly butted together. Where an insulation covering is applied, it shall lap the adjoining section of insulation by at least three inches (3"). Where insulation terminates, it shall be neatly beveled and finished. No insulation shall be applied until the pipe, duct, etc., have been pressure tested and found tight. Piping, flexible connections, flanges, valves, strainers, and unions shall be covered unless specifically noted otherwise. Flexible connections on duct shall not be covered. All materials used shall be fire retardant or nonflammable. Refer to Section 15A.
- J. Where vapor barriers are required, the vapor barrier shall be on the outside. Extreme care shall be taken that the vapor barrier is unbroken. Joints, etc., shall all be sealed. Where insulation with a vapor barrier terminates, it shall be sealed off with the vapor barrier being continuous to the surface being insulated. Ends shall not be left raw.
- K. Extreme care shall be taken in covering high and medium pressure (high and medium pressure ductwork shall be all ductwork between the fan discharge and all mixing boxes) ductwork to insure the duct is not pierced with sheet metal screws or other fasteners. All high and medium pressure ducts in these specifications are classified as high velocity ductwork.

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- L. Where specified, aluminum bands shall be used on piping insulation. The bands shall be applied three (3) to a section of pipe. Fittings, valves, etc., shall have bands on each side.
- M. Where canvas finish is specified, use Arabol lagging adhesive to prevent mildew in securing canvas. Do not use wheat paste. In addition, cover all canvas insulation with a fire retardant coating.
- N. For purpose of definition in this Specification: "concealed" areas are those areas which cannot be seen by the building occupants, and "exposed" areas are all areas which are exposed to view by the building occupants, including under counter and inside cabinet areas, plus all mechanical rooms.
- O. The handling and installation of all insulation materials shall be performed in strict accordance with the manufacturer's recommendations.

3.03 TOLERANCE

- A. Substituted insulation materials shall provide thermal resistance within 10 percent at normal conditions, as materials indicated.

END OF SECTION 23 07 13

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SECTION 23 07 19 - PIPING INSULATION

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. 23 00 00 -- Basic Mechanical Requirements
- B. 23 05 29 -- Sleeves, Flashings, Supports and Anchors
- C. 23 05 53 -- Mechanical Identification

1.02 SECTION INCLUDES

- A. Piping insulation
- B. Jackets and accessories

1.03 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 21 13 13 - Fire Protection Piping: Placement of hangers and hanger inserts.
- B. Section 22 13 16 - Plumbing Piping: Placement of hangers and hanger inserts.
- C. Section 23 21 00 - Hydronic Piping: Placement of hangers and hanger inserts.

1.04 RELATED SECTIONS

- A. Section 09 91 00 - Painting: Painting Insulation Jacket.

1.05 REFERENCES

- A. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- B. ASTM C177 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded- Hot-Plate Apparatus.
- C. ASTM C195 - Mineral Fiber Thermal Insulation Cement.
- D. ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
- E. ASTM C449 - Mineral Fiber Hydraulic-setting Thermal
- F. ASTM C518 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- G. ASTM C533 - Calcium Silicate Block and Pipe Thermal Insulation.
- H. ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- I. ASTM C547 - Mineral Fiber Preformed Pipe Insulation.

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- J. ASTM C552 - Cellular Glass Block and Pipe Thermal Insulation.
- K. ASTM C578 - Preformed, Block Type Cellular Polystyrene Thermal Insulation.
- L. ASTM C585 - Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
- M. ASTM C591 - Rigid Preformed Cellular Urethane Thermal Insulation.
- N. ASTM C610 - Expanded Perlite Block and Pipe Thermal Insulation.
- O. ASTM C640 - Corkboard and Cork Pipe Thermal Insulation.
- P. ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
- Q. ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber.
- R. ASTM D1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed Cell Foam).
- S. ASTM D2842 - Water Absorption of Rigid Cellular Plastics.
- T. ASTM E84 - Surface Burning Characteristics of Building Materials.
- U. ASTM E96 - Water Vapor Transmission of Materials.
- V. NFPA 255 - Surface Burning Characteristics of Building Materials.
- W. UL 723 - Surface Burning Characteristics of Building Materials.

1.06 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Product Data: Provide product description, list of materials 'k' value, 'R' value, mean temperature rating, and thickness for each service, and locations.
- C. Samples: When requested, submit two samples of any representative size illustrating each insulation type.
- D. Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.

1.07 QUALITY ASSURANCE

- A. All insulation, jacket, adhesives, mastics, sealers, etc., utilized in the fabrication of these systems shall meet NFPA for fire resistant ratings (maximum of 25 flame spread and 50 smoke developed ratings) and shall be approved by the insulation manufacturer for guaranteed performances when incorporated into their insulation system, unless a specific product is specified for a specific application, and is stated as an exception to this requirement. Certificates to this effect shall be submitted along with Contractor's submittal data for this

section of the Specifications. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.

- B. All surfaces to be insulated shall be clean and dry before applying the insulation. All sections of molded pipe covering shall be firmly butted together. Where an insulation covering is applied, it shall lap the adjoining section of insulation by at least three inches (3"). Where insulation terminates, it shall be neatly beveled and finished. No insulation shall be applied until the pipe, duct, etc., have been pressure tested and found tight. Piping, flexible connections, flanges, valves, strainers, and unions shall be covered unless specifically noted otherwise. Flexible connections on duct shall not be covered. All materials used shall be fire retardant or nonflammable. Refer to Section 23 00 00.
- C. All piping, equipment, ductwork, all plenums including metal and masonry construction, fans, etc., shall be insulated as indicated on the Drawings, as specified herein, and as required for a complete system. In each case, the insulation shall be equal to that specified and materials applied and finished as described in these Specifications.
- D. To be considered, alternate materials shall have equivalent thermal and moisture resistance of the specified materials.

1.08 QUALIFICATIONS

- A. All insulation shall be applied by mechanics skilled in this particular work and regularly engaged in such occupation.
- B. All insulation shall be applied in strict accordance with these Specifications and with factory printed recommendations on items not herein mentioned. Unsightly, inadequate, or sloppy work will not be acceptable, and all such work shall be removed and replaced as many times as necessary to achieve an acceptable installation. The company performing the work of this section shall have a minimum of three years experience specializing in the trade.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect, and handle products to site under provisions of Section 23 00 00.
- B. Deliver materials to site in original factory packaging, labeled with manufacturer's identification, including product thermal ratings and thickness.
- C. Store insulation in original wrapping and protect from weather and construction traffic. Protect insulation against dirt, water, chemical, and mechanical damage.

1.10 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.
- C. All insulation materials to be asbestos free.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Quality: The type of insulation and its installation in accordance with this Section of the Specifications for each service and the application technique shall be as recommended by the manufacturer.
- B. Fire Rating: All insulation shall have a composite (insulation, jacket or facing and adhesive used to adhere facing or jacket to insulation) fire and smoke hazard, as tested by ASTM E84, NFPA 255, and UL 723, not to exceed:
- C. Flame Spread 25.
- D. Smoke Developed 50.
- E. Accessories: Accessories such as adhesives, mastics, tapes, and cements shall have the same component ratings as listed.
- F. Labels: Label products and their shipping cartons indicating that flame spread and smoke developed ratings do not exceed the above requirements.
- G. Material Table:

Service	Material	Continuous Vapor Barrier
DX piping	Armaflex	No
Domestic Cold	None	No
Domestic Hot	Copper Fiberglass or Phenolic	No
PEX	Armaflex	No
Storm	Fiberglass	Yes
Condensate	Fiberglass or Armaflex	Yes

2.02 PLUMBING PIPING INSULATION THICKNESS:

- A. Minimum: Insulation thickness shall not be less than the following:

Equipment Surface (Non-factory Insulated Equipment Cold or Hot Surfaces)	
Condensate drain pans	1"
Piping Surface	
Condensate drain piping (except above drain pans and less than one foot (1') at floor drains)	1"
Roof and overflows drains (underside), horizontal downspouts, underside of drains (including traps) and horizontal	

PEX domestic hot water lines 2" and smaller	1/2"
Copper domestic hot water lines	1"
All exposed lavatory traps, tailpieces hot and cold water supplies	1-1/2"
All otherwise uninsulated pipe exposed to outdoor temperatures	2-1/2"

2.03 PIPING:

- A. Fiberglass Pipe Insulation: Provide Schuller Micro-Lok AP/AP-T, Owens/Corning ASJ/SSL, Certain-Teed Snap-on ASJ/SSJ or an approved equal pre-formed glass fiber pipe insulation with a white all service jacket/vapor barrier. Glass fiber pipe insulation shall have a K factor of 0.23 at 75° F mean, a jacket tensile strength of 40 pounds per inch of width, a Mullen Burst of 70 psi, a Beach Puncture of 50 ounce inch per inch and a permeability of 0.02 perm. Longitudinal laps on refrigerant suction pipe insulation shall have a factory-applied pressure sensitive tape closure system. Three inch (3") wide factory-supplied pressure sensitive closure strips shall be provided for butt joints.
- B. Fitting Insulation: Provide pre-molded rigid insulation for valves, fittings, flanges, strainers, and unions. Insulation shall be as specified for pipe insulation, except without the all-service jacket, where applicable.
- C. Manufactured Fitting Covers: Provide matching 25/50 rated PVC covers for insulation on valves, fittings, flanges, strainers, and unions. Covers shall be sealed at cover lap joints and at lap joints to adjacent pipe insulation with an approved vapor barrier mastic. All circumferential joints shall be taped with Manville Z-tape or an approved equal. Covers shall be designed to allow strainer removal or flange removal without destruction of the insulation or cover.
- D. Field Fitting Covers: Provide Foster 30-35 Tite-Fit coating or an approved equal set with Foster Mast-A-Fab or equal reinforcing mesh. Color shall be white unless noted otherwise.
- E. PVC Jacketing: Provide pre-rolled protective jacketing where required or specified for protection of the insulation all service jacket. PVC jacketing shall be 30 mil thickness. All joints shall be made by lapping the jacket and sealing with an approved PVC welding adhesive.
- F. Metal Jacketing: Provide 0.016" thick aluminum jacketing where required or specified. 3/4" x 0.015" stainless steel bands and straps shall be provided for banding insulation jacketing.
- G. Elastomeric Insulation: Provide Armstrong Type II "Armaflex" or approved equal closed cell elastomeric insulation. Insulation shall have a K factor of not more than 0.28 Btu/inch per degree F-per hour at 75° F mean temperature and a water vapor permeability of 0.15 perm-inch or less. Insulation shall have a flame spread rating of 25 and a smoke developed rating of 50. Provide manufacturers recommended adhesive (Armstrong 520 or Manville No. 57). Provide two coats of finish on all exterior exposed insulation to protect from UV rays.
- H. Lavatory Piping: Provide Truebro Model #102 or Plumberex PR0-2000 series or equal fully molded, flexible vinyl insulation system for insulating lavatory traps and hot and cold water supplies.

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- I. Miscellaneous: Provide all miscellaneous accessories, components and materials required for installation of a complete insulation system.

2.04 TRAPS OVER BREEZEWAY:

- A. Insulation for piping traps located in the breezeway ceiling shall be the same as for roof drain horizontal piping.

2.05 FIRE PROTECTION PIPING:

- A. Fire protection piping, exposed or concealed, subject to freezing temperatures, shall be insulated with fiberglass UL rated noncombustible pipe insulating system using sectional pipe covering, jacketed with a factory applied ASJ vapor barrier jacket. Exposed piping shall be sized for painting. Thickness shall be as scheduled for Hot (1) systems.
- B. Refer to details on the Drawings. The phrase "subject to freezing temperatures" shall be interpreted to mean all areas not within the confines of heated building spaces. The piping running through the breezeway on the first level shall be insulated.

2.06 CONDENSATE DRAIN PIPING:

- A. Condensate drain piping from fan and coil units, coil banks and other items of piping or equipment subject to condensation forming on the surface shall be insulated with a "25-50" rated, closed cell elastomeric thermal insulation. Elastomeric products shall be supplied in a pre-slit tubular form with a pressure sensitive adhesive system for closure and vapor sealing of the longitudinal joint. All elastomeric insulating products shall be guaranteed not to react with copper piping.
- B. Drain piping from mechanical rooms, and other areas potentially receiving chilled water or condensate from air handlers, shall be similarly insulated for a minimum of 15 feet from the floor drains receiving the cold fluid.

2.07 PROTECTIVE JACKETING:

- A. Provide protective jacketing as described elsewhere and on all exterior or exposed piping and piping in mechanical rooms up to 6'0" AFF.
- B. Jacketing and fitting covers shall be .016 aluminum smooth as manufactured by Premetco or Childers. The jacket shall be pre-cut, pre-rolled, and lapped a minimum of two inches (2") in all directions to shed water. The metal shall be secured at each joint with a minimum of one each (1 ea.) 3/4" wide .020 aluminum or stainless steel band and seal. The metal jacketing and fitting covers shall be fabricated of 0.016" aluminum or stainless steel with a smooth finish.
- C. In indoor applications, Proto Corp. LoSmoke PVC jacketing and fitting covers may be used. Material shall have 25/50 rating and shall be limited to piping systems operating at 140 degrees or below.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

- A. Install materials in accordance with manufacturer's instructions in the absence of specific instruction herein.
- B. On exposed piping, locate insulation and cover seams in least visible locations, but not higher than at the side of the pipe at the "90°" position, with the seam lapped such that the lap is directed down.
- C. Insulated condensate or drain lines carrying condensate: Vapor barriers are required. The vapor barrier shall be on the outside. Extreme care shall be taken that the vapor barrier is unbroken. Joints, etc., shall be sealed. Where insulation with a vapor barrier terminates, it shall be sealed off with the vapor barrier being continuous to the surface being insulated. Ends shall not be left raw.
 - 1. Provide vapor barrier jackets, factory applied or field applied.
 - 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe.
 - 3. Finish with glass cloth and vapor barrier adhesive.
- D. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations.
- E. For insulated pipes conveying fluids above ambient temperature:
 - 4. Provide standard jackets, with or without vapor barrier, factory applied or field applied.
 - 5. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
 - 6. If PVC fitting covers are used they shall have 25/50 rating.
 - 7. For hot piping conveying fluids 140°F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
 - 8. For hot piping conveying fluids over 140°F, insulate flanges and unions, including those at equipment, but label the insulation to indicate a concealed flange or union. See 2.04K.

3.03 INSERTS, SUPPORTS AND SHIELDS:

- A. Application: Piping 2 inches diameter or larger for all systems except direct buried.
- B. Shields: Install between pipe hangers or pipe hanger rolls and inserts. Hangers shall be on the outside of the insulation and shall not be in contact with the pipe. Curved metal shields shall be used between the hangers or support points and the bottom of the insulated pipe for Insulated pipes 2" and larger. Curved metal shields shall be designed to limit the bearing stress on the insulation to 35 psi and shall be curved to fit up to mid-perimeter of the insulated pipe. Shields shall be made of galvanized iron, or black iron painted on both sides with two coats of aluminum paint. Required metal shield sizes are as follows:

Nominal IPS	Metal Thickness	Lengths of Shield
up thru 2"	14 gauge	12"

thru 6"	12 gauge	16"
and above	10 gauge	20"

- C. Insert Location: Between support shield and piping and under the finish jacket.
- D. Insert Configuration: Minimum 2" inches longer than length of shield, of same thickness and contour as adjoining insulation; may be factory fabricated.
- E. Insert Material: Heavy density insulating material suitable for the planned temperature range, and the weight of the pipe.
- F. The shields at support points shall be secured with ½" x 0.016" stainless steel bands and seals.
- G. Finish insulation at supports, protrusions, and interruptions.
- H. The application of the protective shields at rack and guide points in tunnels and in central chilling stations shall be as detailed on the accompanying Drawings.
- I. In lieu of the above the following system of support may be used:
 - 1. At the pipe support positions, the insulation and vapor barrier shall be continuous and shall not be punctured by the support. The insulation at the support shall be the full circumference of 5lbs/ft³ Koolphen K Phenolic Foam material to withstand the bearing loads transmitted from the pipe to the support, it shall extend for at least 1" on either side of the support to allow sealing of the joints with the pipe insulation jacket.
 - 2. The load bearing insulation at the support shall be capable of withstanding the maximum static compressive loads generated by pipe supported at the centers shown in Table 1. Variations: Pipe loads greater than those generated at the support centers shown in Table 1 shall be referred to the manufacturer to establish the length and density of the insulated support block. The support centers are based on the weight of Sch 80 pipe filled with water and covered with 1" thickness of 2.2 lbs/ft³ standard insulation including FSK/ASJ vapor barrier.

Table 1 K Block Support Centers

Nominal Pipe Size	3/4	1	1 1/4	2	2 1/2	3	4	6	8	10	12	14	16	18	20	24
Max support centers (feet) Sch 80 pipe filled with water covered with 1" of Standard Insulation	6.5	6.5	6.5	10	10	10	10	10	14	14	14	20	20	20	20	20
Metal Saddle Gauge (Galvanized Steel)	22	22	22	20	20	20	16	14	14	14	14	14	114	14	14	14
Length of K Block (inches)	6	6	6	6	6	6	6	9	9	9	9	9	9	12	12	12

3. The Insulation at supports shall be a Kooltherm K Block. K Blocks shall be faced with factory applied FSK/ASJ vapor barrier and fitted with a galvanized steel 1800 saddle bonded to the bottom section of the K Block, for all pipe sizes 1 1/2" and larger.
 4. The vapor barrier shall be completed by the use of a FSK/ASJ overlap and factory applied self-seal lap tape and sealed with vapor barrier adhesive.
 5. At all support positions, other than those where the insulated pipe support block is surrounded by a clip or saddle in direct contact with the block, a block designed to accept the loads generated by the pipe shall be presented to the engineer for approval. e.g. Of the type Kooltherm Insulation products K Block. Ref:- Kooltherm sketch 106/2c for use with Roller or flat beam support.
 6. In all cases where roller supports are used the length of the insulation and the wearing plate where fitted shall extend beyond the limits of the pipe movement.
- J. For heat traced piping, insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.
- K. Where canvas finish is specified, use Arabol lagging adhesive to prevent mildew in securing canvas. Do not use wheat paste. In addition, cover all canvas insulation with a fire retardant coating.
- L. For purpose of definition in this Specification: "concealed" areas are those areas which cannot be seen by the building occupants, and "exposed" areas are all areas which are exposed to view by the building occupants, including under counter and inside cabinet areas, plus all mechanical rooms.
- M. Self Sealing Lap and butt joints will not be acceptable as the only seal on piping insulation joints. Self Sealing Lap and butt joints may be utilized only if the joints are additionally secured with field applied vapor barrier adhesive (on piping Systems requiring vapor barriers) or staples and field applied adhesive (on piping system which do not require a vapor barrier jacket). Mechanical fasteners shall be used whenever possible to assure permanent installation per the manufacturer's recommendations.
- N. Insulation minimum thickness shall be as scheduled; however, additional thickness shall be provided to prevent condensation on the cold surfaces and to provide a maximum exterior insulation surface of 140°F on the hot surfaces.
- O. Special Protection: All insulated piping in the mechanical rooms within 6'-0" of the floor shall be encased in a protective jacket, and where applicable, finish at top with nickel-plated brass flange plate with set screws or end joint sealing butt strips.
- P. All exposed outdoor piping shall have metal jacket.
- Q. Fitting insulation shall be applied in same manner as pipe application. Protruding metal parts (such as valve stems) shall be completely sealed off. Fitting cover jacketing shall be equal to Gasco, Pabco or RPR Metals prefabricated fitting covers of 0.016" paper coated aluminum, secured as recommended by the manufacturer.
- R. Valves, fittings, etc., in congested areas around coil and heat exchanger equipment, etc., shall be insulated by building up fitting segments and pre-molded sections as necessary.

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- S. No pipe supporting device (other than guides or anchors attached directly to the pipe) shall penetrate the insulation.

3.04 PAINTING:

- A. All exposed insulation shall be prepared to receive painting specified under Section 09 91 00.
- B. The pipe primer shall be Pittsburgh Corning Corporation Pittcote 300.

END OF SECTION 23 07 19

SECTION 23 09 23

DIRECT DIGITAL CONTROL SYSTEMS

PART 1 GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 SECTION INCLUDES

- A. Control equipment.
- B. Software.

1.03 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 23 21 00 - Hydronic Piping: Installation of control valves, flow switches, temperature sensor sockets, gage taps, flow meters.
- B. Section 23 33 00 - Ductwork Accessories: Installation of automatic dampers, smoke detectors. Connection of damper end switches.

1.04 RELATED SECTIONS

- A. Section 23 09 93. - Sequence of Operation.
- B. Section 26 05 00 - Equipment Wiring Systems.

1.05 REFERENCES

- A. ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, Air Conditioning.
- B. ASME MC85.1 - Terminology for Automatic Control.
- C. NEMA EMC1 - Energy Management Systems Definitions.

1.06 DEFINITIONS

- A. Ensure terminology used in submittals conforms to ASHRAE 85.

1.07 ACCEPTABLE MANUFACTURERS

- A. The following manufacturers will be considered by Houston Area Safety Council. Any controls contractor that provides a bid on the controls systems for this scope of work shall be compatible with the existing BAS system.
1. Andover controls, inc. Controls.
 2. JCI.
 3. Siemens.
 4. Digital Air Control.
 5. OpenTec.
 6. Automated Logic.
 7. Controls Unlimited.
 8. HTS
 9. Climatec

1.08 DELIVERY PROCESS

- A. General: the work described by this section of the specifications shall be provided and installed by the manufacturer.
- B. Work included: the contractor shall provide a complete network and head end system installation that allows the lab installation to connect to the designated power supplies, control air riser and interface panels.

1.09 SCOPE OF WORK

- A. Work under this section of the specifications shall include the installation of system components furnished under this section of divisions 23, and connection to existing systems. The guidelines and provisions for all system interface, relays, wiring, etc. Shall be under the scope of section 23 09 23. Work under this section shall include the installation of all automation and general building control system ddc panels cans/terminals, automatic temperature controls, field devices and instrumentation necessary for the basic building control system as specified herein, so as to obtain all functions and results hereinafter specified. The entire system shall be provided and installed by the automatic controls trades. All electrical work associated with the control system shall be performed under the sections of these specifications and in accordance with the requirements of section 23 00 00 and division 26 (unless noted otherwise).
- B. The automatic controls trades shall cooperate fully with the fire protection system, fire alarm system, electrical power system, and other trades as they affect the work under this section. Weld-o-let fittings for pipe mounted sensors shall be located by this contractor but provided by the mechanical trades. Access holes in ducts and duct-mounted fittings for duct sensors shall be provided by the control trades.
- C. The automatic temperature control system shall be complete, including all such items as thermostats, transmitters, transformers, controllers, valves, damper operators, cables, associated regulators and relays required to accomplish the work specified herein. The automatic temperature control system shall be electronic type. This system shall be completely installed, calibrated, and warranted by personnel regularly employed by the temperature control manufacturer for at least 5 years, including wiring, temperature

control components and interlock relays. The automatic temperature control manufacturer shall provide all necessary grounding, shielding and installation techniques required for protection against signal interference by external voltages and noise generated by other electrical equipment.

- D. Temperature control equipment shall be standard catalog products as manufactured by the temperature control manufacturer listed herein, provided they comply with the specifications hereinafter in every detail, which shall include but not be limited to tolerance, quality, performance and reliability. The temperature control equipment furnished under this section of the specifications shall be furnished together with the automation system as a complete and functioning system produced under the responsibility of the temperature control manufacturer utilizing all of the various components specified to meet the functions and accuracy's described within the specifications.
- E. The building automation system must be compatible with the VRF system.
- F. **MONITORING SYSTEM:**
 - 1. **General:** Provide all relays, switches, control panels, cable, network interface, instrumentation, setup, software and other devices required for the installation of the monitoring.
 - 2. **Work Included:** Provide all materials, equipment, software and programming, related miscellaneous components and labor as indicated by these Specifications and required for seamless interface by the lab control systems.
 - 3. **Types:** The components of Monitoring and Data Acquisition (MDA) system include but are not limited to:
 - a. Connection & additions to the existing central workstation with graphics development software and full graphics displays for the areas included in this scope of work.
 - b. All network cable that interconnects the existing MDA with the local panels shown on the drawings.
 - c. All gauges or trouble shooting instruments, not included with the system software, required for monitoring the control systems, air systems and interface panels shall be provided to the Owner at the completion of the project or when maintenance responsibility shifts from the contractor to the Owner.
 - d. Special tools shall be provided to the Owner at the completion of the project or when maintenance responsibility shifts from the contractor to the Owner.
 - e. This contractor shall provide all miscellaneous devices required for the completion of the installation.

1.10 RELATED WORK

A. RELATED WORK IN OTHER SECTIONS:

Special Note: "Related Work" listed hereinafter is for reference guide only and is not intended to define limits of work necessary for a complete installation.

Section No.	Section Title
23 00 00	Mechanical General Provisions
23 21 00/23 21 13	HVAC Piping and Accessories
23 31 00/23 21 00	Ductwork and Accessories
23 07 13/23 07 16/23 07 19	Insulation
23 05 48	Vibration Isolation
23 05 93/23 05 94	Testing, Adjusting and Balancing
23 36 00	HVAC Terminal Units
23 73 23	Custom Air Handling Units
23 73 00	Fan Coil Units
23 34 00	Fans

1. DDC Controllers and associated zone space sensors shall be furnished for installation under this section.
2. DDC controller panel back cans, terminal strips, and termination drawings shall be under 23 09 23 and building temperature controls will be furnished and installed/terminated under this Section 23 09 23.
3. Fire alarm systems, emergency power system and electrical switchgear to be provided under work Division 16. Any specified signal wiring to DDC controllers shall be under work of this Section 23 09 23.
4. Refer to Division 26 specifications for additional information relating to electrical work to be accomplished under Division 26.

1.11 QUALIFICATION REQUIREMENTS

- A. Installers shall have not less than five years of experience with and shall be knowledgeable of the Controls systems.

1.12 SERVICE AND GUARANTEE

- A. This system specified under this section of the specifications shall be guaranteed from defects in workmanship and material under normal use and service for a period of twenty-four (24) months from the date of acceptance by the owner. If, during that period, any of the factory equipment or material provided in the system is found to be defective in material or workmanship, it shall be replaced or repaired by the contractor at no additional cost to the owner. The contractor shall require the temperature and humidity controls' manufacturer to submit evidence satisfactory to the owner of his ability to make repairs or replacements to this system from local shop experienced personnel facilities.
- B. Upon completion of the installation, the control trades shall thoroughly inspect, check, adjust, calibrate, and make ready for use all devices and sensors comprising the building control system and certify that they are installed and functioning in accordance with their "as built" drawings. For quality control, all building automation sensors, transmitters, actuators, control valves, etc, shall be calibrated by the controls contractor using instruments certified or traceable to nist (national institute of standards and technology). The instruments, meters, signal generators, anemometers, etc shall be certified to be calibrated within the last six (6) months prior to start of project. All loops for temperature control, and fluid flow control in ddc controller, plc's (programmable logic controller) shall be tuned for an underdamped response of a system with second-order lag as defined and illustrated in isa handbook (instrument society of america) volume ii,

section isa-s51.1-1979. For pressure control in air handlers and hydronic systems with adjustable speed drives, control loops shall be tuned for an overdamped response such that there shall be only a small amount of overshoot or no overshoot at all of controlled variable.

- C. Unless otherwise negated in other contract documents or in project specifications the controls contractor shall submit to the owner calibration or setup data sheets of sensors, transmitters, actuators, valves, meters and other related measurement and control instruments showing zero and span, input and output signals, controller action, ranges, and coefficients as the case may be.
- D. Unless otherwise negated in other contract documents or in project specifications the controls contractor shall submit to the owner a tuning report of controller loops showing final settings of p =proportional (gain), i =integral (auto reset), and d =derivative (rate)

1.13 DRAWINGS AND MANUALS

- A. Shop drawing submittals prior to installation shall include, but not be limited to, the following:
 - 1. Certified drawings showing overall dimensions of completed assemblies only, with weights, mounting requirements and parts lists.
 - 2. Cut sheets on all equipment showing adjustment capabilities, performance criteria and accuracy limits for each specific application.
 - 3. Floor plan drawings showing proposed locations of all wall-mounted panels, control air and communication cable risers, workstation and control air filter dryers.
 - 4. Wiring diagrams showing all components and how those components are interfaced.
 - 5. Labeling system for equipment and cable.
 - 6. A complete software description, graphics software with the graphics for the sample labs, internet communication link description, data management software description and sample user call-up programs that could be used with the first four sample labs.
- B. The control trades shall be required to submit shop drawings of the control system covered under work of this section complete with specification data sheets for all devices and instrumentation for owners approval prior to starting work. Upon completion of the work, the contractor shall provide the owner with autocad "as built" of the system. The autocad "as-built" drawings referred to in this section shall indicate, show, explain, in complete detail the sequence of events during startup, normal operation, power failure, resumption of normal power, and system under emergency power. The description of the sequence of operation shall specifically identify all software commands, software algorithms, and software acronyms associated with any input/output signal relating to driving a mechanical or electrical device, calculating setpoints(s), resetting events or sequences, etc. The "as-built" schematic diagram illustrations will contain but shall not be limited to wiring terminations, terminal block connections, power wiring and grounding terminations, electrical or mechanical interconnection of devices, pneumatic connections and pneumatic ports. Bill of materials showing device name or tag number,

manufacturer, manufacturers model number description of device and device function. Other pertinent information such as fail position of controlled devices (relays, control valves, dampers, damper actuators), setpoints high and low alarm limits, time functions (time delay, start time, stop time, etc) be provided in the "as-built drawings".

- C. The contractor shall provide a minimum of six (6) copies of owner operating and service manuals covering the entire system and six (6) copies of the blackline "as built" drawings.

1.14 INSTALLATION REQUIREMENTS

A. General:

1. The Contractor shall provide all openings and install all receptacles required for thermostat bulbs and sensing elements in mechanical equipment. The mechanical trades shall make penetrations and install temperature wells, valves, pressure sensing devices, etc., in piping systems. The mechanical trades shall install all dampers.
2. All switches, panels, etc., furnished and/or installed by control trades shall be identified by means of plates using acronyms as indicated in System I/O summary made of plastic, suitably engraved; embossed or punched plastic tape will not be acceptable.

B. Work included:

1. Control and control interlock wiring and other necessary devices such as relays and auxiliary contactors necessary to accomplish sequences, automation and interlocks specified in this section shall be provided by this control subcontractor.
2. Motor starters, switches, outlet boxes, breakers and other material and devices necessary to accomplish power wiring are specified in Division 16 -Electrical.
3. Division 16 shall provide 120 VAC power wiring, raceway, receptacles, etc., "power supply" source at local control panels (LCP). Dedicated power source is provided for temperature control system installer's use in electrical rooms and other locations throughout the buildings. Refer to electrical drawings. This contractor shall route 120V and 24V power wiring to the panels, controllers, etc., as necessary from this dedicated power source.
4. Section 23 09 23 Work:
 - a. All electrical wire, cable, fittings, conduit, etc., associated with the systems under this Section of the specifications and not indicated above to be provided under Division 16 shall be furnished and installed complete under this section of the specifications. All work shall be in accordance with the requirements of NFPA, National Electrical Code and Division 16 requirements. Wiring shall be terminated by connecting to control devices, or to a local control panel with numbered terminal strips. All wiring shall be color-coded and shall be tagged for future identification.
 - b. All electrical work included under this general building control section shall be complete with labor and materials and shall include but not be limited to the following broadscope definition:

- (1) All control wiring, conduit, etc., in building, and in control panels, etc., which interconnect electronic control devices, sensors, transmitters, coils, relays, etc.
- (2) Wiring, conduit, etc. from the high and low static switches, low and high temperature cutout switches and air damper end switches to the motor starter for emergency shutdown.
- (3) All other control wiring required by the sequence of operation, Section 15950.

PART 2 - PRODUCTS

2.01 DDC CIRCUIT REQUIREMENTS

- A. General: all control wiring to be installed within a metal raceway system under work of this section shall conform to specification division 16 requirements. Control wiring raceway shall be a minimum of 3/4" trade size with 40% maximum conductor/cable fill in all raceways.
- B. Communications circuits (see paragraph 3.07 for additional criteria):
 1. All trunk circuits originating at the Controls panels and terminating at the remote controllers shall be wired or routed in a series path (daisy chained), linking one controller to the other. Trunk wiring with branch or star configurations are totally unacceptable. Communications wiring polarity must be observed throughout the trunk and continuous wire size shall be maintained throughout the trunk.
 2. Cables shall not be installed closer than six feet (6 ft) from building power transformers or run parallel within six feet (6 ft) of electrical, 460 volt or higher voltage power feeder cables. Care shall be taken to route the cable as far from interference generating devices as possible.
 3. All shields shall be grounded (earth ground) at one point only, to eliminate ground loops.
 4. Trunk communications cable for network cable shall be 18 AWG stranded, twisted pair, shielded with drain which shall be installed by the controls contractor and terminated under this section.
- C. Sensor control wiring shall be provided under 23 09 23: use only stranded conductors. All wiring sizes specified herein for analog inputs, analog outputs, digital inputs and digital outputs shall apply to the controls system.
 1. RTD wiring shall be 3-wire or 4-wire twisted, shielded, 18 gauge minimum. Splices not permitted. Belden 8770 or equal (3-wire).
 2. Thermistor wiring shall be minimum 18 gauge, twisted pair, shielded. Splices not permitted. Belden 2760 or equal.
 3. Other analog inputs shall be a minimum 18 gauge, twisted pair, shielded. Splices not permitted. Belden 8760 or equal.

4. Binary control function wiring shall be minimum of 16 gauge. Belden 9409 or equal.
5. Binary input wiring shall be a minimum of 18 gauge. Wiring installed in areas of high levels of electrical interference such as electrical vaults shall be shielded. Belden 8760 or equal (shielded)
6. Wiring for air terminal box controller/room Sensor SM2-RS shall be 6-conductor, twisted, shielded, 22 gauge minimum. Splices not permitted. Alpha 5196 or equal.
7. Wiring for 120V line voltage control to motor interlock/shutdown to be minimum of 12 gauge and shall be in raceway separate from control wiring.

2.02 CONTROL VALVES

A. General:

1. Magnetic valves up to 4 inch shall be sized for a 3 to 5 psi differential drop. Valves shall be packless, electrically modulated by 0-10VDC or 0-20VDC or 0-20V Phase Cut control signals and actuated by a magnetic core. Valves shall have a rangeability (stroke, CV) of 500:1, linear characteristics (stroke, CV), proportional type of operation, with a maximum allowable leakage of 0.05% CVs (two-way) and maximum allowable leakage of 2% CVs when used in a 3-way connection. Valve body material shall be cast iron, seat and inner valve material shall be chrome nickel steel. Valves shall be equipped with handwheel to allow manual stroking of valve during absence of control power. All valves up to 2 inch shall be supplied with NPT threaded connections, 2-1/2 inch and larger shall be flanged.
 2. Minimum wire size for all control wiring between controller and magnetic valve shall be #12 AWG. Magnetic valves 2 inch up to 4 inch shall require a 24 VAC, 120 watt amplifier module to linearly drive each valve. The amplifier module shall be capable of converting the phase cut output signals of the DDC controller in order to overcome line losses and be able to modulate the valve to its full stroke.
 3. Spring/diaphragm actuated control valves 1 inch to 6 inch shall be rotary type. Quick change trim for anti-cavitation or low -noise trim or reduced trim or abrasion sleeve shall be a standard valve feature. All trims shall use a 90 degree plug rotation, disassembly, inspection, and reassembly of the trims shall be accomplished without disturbing the packing, linkage or positioner calibration. Valve shall be equipped with a top mounted handwheel for manual actuation. Valves shall be rated to operate with pressure drops from 150 to 1400 psi. All valve positioners shall be electro-pneumatic (I/P) type, capable of accepting universal input signals, 4 to 20 milliamp is preferred.
- B. 1/2 inch to 4 inch: valves shall be equipped with a handwheel, or manual positioner mounted adjacent to valve, to allow manual positioning of valve in the absence of control power (excluding terminal unit valves).
- C. 8 inches to 20 inches: valves shall be spring/diaphragm actuated, rotary type (preferred) or globe type. Valve positioners shall be electro-pneumatic type (i/p). The positioner shall operate with an electro-mechanical signal transducer and with the force balance

principle an electromagnetic coil internally converts the electronic input signal (4-20ma) into a proportional pneumatic signal. Valve body shall be flanged, ansi rated (classes 150,300,600).

- D. Hot and chilled water valves: shall be rated as required on drawings. Provide bypass piping and isolation hand valves (to facilitate maintenance and service) as required on drawings.
- E. Valve constant (cv) charts: control drawings shall indicate the valve constant (cv rating) of all valves used so that the valve pressure drop may be used for balancing and performance tests. Submittal data shall also state calculated shut-off pressure for each valve.

2.03 DAMPER ACTUATORS

- A. Electronic damper operators shall be fully proportioning and shall be either push-pull or rotor as required. Motors shall be of the low voltage synchronous type and shall be non-overloading at a continuous stall. Provide each motor with rust protection. Control signal shall be 0-20 vdc 2-wire phase cut, or three point floating as required. Provide spring return for normally open/closed positioning. The minimum actuator impedance shall be 800 ohms even when more than one actuator is connected or parallel. They shall be of ample size to develop a torque 50% greater than required by the load imposed on them (15 inch-pounds minimum) and shall conform to all requirements of sequence descriptions specified or scheduled.

2.04 CURRENT SENSING SWITCHES

- A. Run status for fans as listed in the sequence of operation as noted on the drawings or required shall be indicated by current sensing switches.
- B. Each current sensing switch shall include two solid-state switches with independently adjustable operating thresholds, responsive to ac current flow through the switch sensor. Switches shall be powered by induction from the circuit being monitored. The current sensing switches shall be installed in each motor starter (either in motor control center or stand-alone device).
- C. Switches shall be hawkeye 708 solid state or an approved equal.

2.05 TEMPERATURE SENSORS/THERMOSTATS

- A. Temperature sensors:
 - 1. Room temperature sensors shall be of the "treated" thermistor type for accuracy. Thermistors shall be treated with series and parallel resistors to fix the span, provide linearity, and ensure interchangeability. Untreated thermistors are not acceptable. Resolution shall be 1 degree fahrenheit for display and control. Repeatability shall be 0.25 degrees F.
 - 2. All other sensors may be resistance temperature detector. RTD shall be either 3 wire 1000 ohm platinum RTD, or 2-wire 1000 ohm platinum RTD. Overall accuracy shall be +/-0.5 degrees F.
 - 3. Combination temperature and humidity sensors shall have thermistor and hydrostatic plastic elements mounted in a common enclosure.
- B. Thermostats (where applicable):

1. Thermostats provided shall control within +/-1 degree Fahrenheit of the temperature setting at the Thermostats location, unless otherwise specified.
 2. Remote bulb type thermostats shall have fully compensated liquid filled capillaries and shall be completely job adjustable, both as to control point and sensitivity. Sensing elements shall be secured in the controlled medium streams so as to respond to the overall temperature within the duct or pipe.
- C. Insulating bases shall be provided for thermostats where indicated on the drawings, where subject to extreme temperatures, and for all sensors and thermostats which are mounted on the inside surface of a wall which is exposed to outside ambient temperatures.
- D. Low limit thermostats (switch) manual reset, double block switch action (one normally open and one normally closed contact), remote bulb (20 foot long sensing element to respond to the lowest temperature to which one (1) foot portion of the element may be subjected) thermostat switch. Thermostat shall be located in the plenum between the pre-heat and the chilled water coil where air handling units are equipped with a pre-heat coil and shall be located on the cooling coil air inlet on units not equipped with pre-heat coils. When temperature sensed drops below 36 degrees f. (adjustable) the thermostat shall cause the outside air dampers to close, de-energize the supply fan and provide a separate alarm signal to the ddc controller.

2.06 PRESSURE SENSORS

- A. All pressure sensors shall be sized to withstand 100% over-range without damage and to hold calibrated accuracy when subjected to a momentary 40% over-range input.
- B. Pressure measurement accuracy for all pressure sensors shall be within 1% of the span over an ambient operating temperature of 30 degrees to 140 degrees f.
- C. Pressure transmitters shall provide a 0 to 5 vdc, 0 to 10 vdc, or 0 to 20 ma output signals.

2.07 PRESSURE SWITCHES

- A. Static pressure switch to be a manual reset, double-block (with one normally open and one normally closed) static pressure switch to sense the discharge or low suction pressure of the ahu supply and return fans. The pressure switch shall stop its respective fan on reaching a predetermined (adjustable) setting and shall provide a separate alarm to controls.
- B. Fluid differential pressure switch contacts shall be snap action type. Sensor assembly shall operate automatically and reset automatically when conditions return to normal. Pressure sensing elements shall be bourdon tubes, bellows, or diaphragm type.

2.08 SMOKE DETECTORS

- A. Smoke detectors shall be furnished and installed under division 16 of these specifications as an integral part of the fire alarm system. Interlock wiring between fans starters, damper actuators, low/high limit, and fan shut-down relays, shall be furnished and installed under work of this section. It shall be the responsibility of fire alarm system installer to insure that such detectors are provided in all locations dictated by nfpa standard 90a and other governing criteria and installed in an environment not to exceed normal operating temperature and humidity tolerances according to manufacturers specifications.

2.09 START-STOP CONTROL

- A. Remote controls start-stop control shall be provided on all motors indicated in the input/output summary.
- B. Magnetic motor starters, starter control transformers and interposing starter relays are to be provided as directed per section 15140.
- C. All control and sensing wiring from the motor starters to the main ddc panel is to be provided under work of this section.

2.10 AIR HANDLING UNIT DIRECT DIGITAL CONTROLLER

- A. General: the air handling unit shall be provided with individual, dedicated ddc controllers. The ddc controllers shall be completely stand alone for all required control functions and cannot be shared by other air handling units, other mechanical or electrical equipment. Monitoring and control functions of the ddc controller shall be strictly limited to the dedicated or assigned air handling unit. The use of available inputs or outputs of the ddc controller for other purposes other than controlling and monitoring the air handling unit shall require owner approval, which shall require expressed written request from the controls contractor or general contractor.
- B. Control trade shall mount and make all field device wiring termination's to ddc controller "back pans" and terminal strips. Control trades to provide connection to this ddc controller and shall assist in field test verification of all wiring circuits and control devices for signal strength, reliability, repeatability, accuracy and compatibility with the controls processor.
- C. All control functions specified under air handling unit sequence of operation in the input/output summary matrix shall be provided and terminated in the ddc controller.

2.11 FACILITIES CONTROL AND MONITORING SYSTEM POINT DESCRIPTION

- A. The following devices and associated wiring, etc. Are to be furnished and installed under work of this section. The point type noted in the i/o summary indicated the corresponding device described below. The catalog numbers indicated constitute the type, product quality, material and desired operating features.
- B. Point type 1 - start/stop: connect remote control wiring to motor starter control circuits in motor control center, at separately-mounted starter locations, or a variable speed drive as required. All start/stop circuits shall require hoa switches, electrically wired for manual or automatic operation.
- C. Point type 1b - high limit sensor: averaging type, auto-reset.
- D. Point type 2 - motor current sensing: connect to dry contacts of current sensing relay. Motor current sensing ct, transducer and relay assembly to be rated at 150% of motor full load current, field adjustable, initially set for contact closure of 30% full load.
- E. Point type 3 - low limit sensor: averaging type, man-reset.
- F. Point type 4 - differential pressure transmitter - water: with range to match application, 0-5 vdc output signal, stainless steel construction, complete with mounting bracket and power supply.

- G. Point type 5 - contact closure: connect to auxiliary contacts and remote signal terminal points which have been installed under work of this section, other division 15 sections or division 16. Control closure shall represent activation of process or alarm condition as required by the specified system function.
- H. Point type sa - pressure transmitter - water: with range to match application, 0-5 vdc output signal, stainless steel construction, complete with mounting bracket and power supply.
- I. Point type 6 - differential pressure switch: provide a differential pressure switch to monitor the differential pressure status across a piece of equipment. Design and sensitivity shall match application with spdt contacts to make/break from a field adjustable differential pressure setting.
- J. Point type 7 hi/low static cutout switch with manual reset.
- K. Point type 8c - temperature sensors/transmitter: platinum wound resistance thermal detector (rtd), 3-wire, 1000 ohms at 32 degrees f, 0.0385 ohms/ohms/degrees c.
 - 1. Immersion Sensor: Hy-Cal Engineering No. RTS-S737-P, all to be provided with matching stainless steel immersion well fitting.
 - 2. Duct Averaging: 1000 ohm avg.
 - 3. Outside Air Sensors: Viasala HMD 30YB.
 - 4. Space Sensors.
- L. Point type ba - pressure transmitter - air: with range to match application. 0-5 vdc output signal, complete with mounting bracket and power supply.
- M. Point type lob - differential pressure transmitter - air: with range to match application, 0-5 vdc output signal, complete with mounting bracket and power supply.
- N. Point type 11 - duct smoke detector: specified and wired in division 16.
- O. Point type 12 - pulse accumulation: connect to pulse generators that have been installed under work of this section, other division 15 sections or division 16.
- P. Point type 14 - transmitter - vsd control: provide signal wiring between transmitter and controls panel or between variable frequency drive (vsd) and ddc panel.
- Q. Point type 15 - variable speed status indication: provide necessary voltage isolation relay contacts and all connections from contacts to the ddc controller panel to report speed, drive normal run status and by-pass run status at variable frequency settings and control points.
- R. Point type 16 - actuator control: provide 0-20 volt, 3-conductor, control signal wiring between valve damper actuator motor and the ddc controller.
- S. Point type 17 - open/close: connect 16 gauge 2-conductor wire between damper and/or valve actuator and ddc controller
- T. Point type 18 - flow transmitter: provide ultrasonic type as manufactured by balance master or accepted substitution.
- U. Point type 22 - flow switch.

- V. Point type 23 - single point flow sensor.

2.12 MONITORING:

- A. All components shall conform to manufacturer's standard materials and components as published in their product information, designed and constructed as recommended by the manufacturer, and as required for the application indicated or required. These specifications shall be considered minimum standards in all situations.
- B. Provide electric-pneumatic or pneumatic-electric switches and electrical devices that are ul-listed and of a type meeting current and voltage characteristics of the project.
- C. System capacity: the lmda system shall have adequate capacity to accommodate the existing controls system (load from the existing computer that the new computer will be replacing), the new work included in this contract and 15% growth capability.
- D. Electrical junction boxes:
1. This contractor shall install junction boxes, conduit and cable, 20 amp, single pole, 120 volt circuit breakers in existing emergency panels and all mounting accessories necessary to serve the labs in the related building sections.
 2. NEC: The entire electrical installation shall be per the NEC. Retain qualified electricians for all electrical work.
- E. Local control (interface) panels:
1. Type: Provide interface control panels with suitable brackets for wall mounting. Locate panels as noted on the drawings.
 2. Construction: Install manufacturer's standard panel for use above the ceiling, totally enclosed on all four sides, with hinged door and keyed lock, with manufacturer's standard shop-painted finish and color.
 3. UL-listing: Provide UL-listed cabinets for use with line voltage devices.
 4. Panel-mounted Equipment: Include relays, electronic boards, automatic switches, and other devices required for the interface with all future or planned lab systems. Mount devices with adjustments accessible through the front of the panel.
 5. Provide all panels with all related components that will be necessary to interface with and monitor all planned labs as described on the plans issued with this RFP.
 6. Provide a data outlet for each panel for connection to the laptop computer.
- F. Software (general)
1. Software packages shall include, but not be limited to:
 - a. Windows based graphics package that allows the users to easily build graphics from an established library of symbols and functions or using an AutoCad graphics file as a base and placing active data points on the graphics.
 - b. All necessary software to facilitate the display of active data on the graphics developed with the graphics package and the use of windows, graphics and pointer to move through the screen views to a building,

floor, area, system and component each of which may display active data or project information.

- c. Alarm management software that reports, logs and notifies (AutoDial) a designated pager of the alarm.
- d. Data management software that facilitates the development of historic data trends and historic data files for use by other Windows based data manipulation programs.
- e. Internet data distribution programs to allow the use of Internet browsers with the proper passwords to view current system data related to authorized spaces.

G. Alarm management

1. Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to noncritical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC workstation or local I/O device, or communications with other panels on the network. Alarm acknowledgments shall be displayed on all terminals. Unacknowledged alarms shall not prevent operator from performing other tasks.
 - a. First in, first out handling of alarms in accordance with alarm priority ranking is required with buffer storage for a minimum of 20 alarms in case of simultaneous multiple alarms. Alarm handler shall be active in both the Signed On and Signed Off modes to assure that alarms will be processed even though an operator is not currently signed on.

H. Historical data and trend analysis

1. A variety of historical data collection and data base management utilities shall be provided to automatically sample, store, and display system data in all of the following ways.
 - a. Continuous Point Histories: Standalone DDC panels shall store Point History Files for all analog and binary inputs and outputs. The Point History routine shall continuously and automatically sample the value of all analog inputs. Samples for all points shall be stored for the past day (minimum) to allow the user to immediately analyze equipment performance and all problem-related events for the past day. Point History Files for binary input or output points and analog output points shall include a continuous record of changes or commands for each point.
 - b. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user defineable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of one (1) minute to 2 hours, in one (1) minute intervals, shall be provided. Each standalone DDC panel shall

have a dedicated buffer for trend data, and shall be capable of storing a minimum of 5000 data samples.

- c. Data Storage and Archiving: Trend data capability for all input and output points shall be stored at the Standalone DDC panels, and uploaded to hard disk storage when archival is desired or per a programmer schedule. Uploads shall occur based upon user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file form for use in third party personal computer applications. Data shall be stored in ASCII format or an ODBC compliant format, in addition to any other common formats provided.
 - d. Trend report shall allow the operator to randomly select points to be recorded and the time interval at which samples are to be taken. Time interval shall be assignable from 1 to 60 minutes. It shall be possible to assign up to ten variables to a trend report. Trend report assignments are to be made directly through the operators terminal. A numeric listing of the points to be trended along with a complete English group and point description shall be printed out as a trend header at the start of the report. Following the header the trend report number shall be listed followed by the column headers one through ten with appropriate engineering unit abbreviations; i.e., "DEG" or "PSI" printed under the column head number. At each specified interval, the selected data shall be printed under the column headers one through ten. If, on an alarm printer, a trend is interrupted by a higher priority activity such as an alarm, it shall finish the line being printed then immediately print the alarm.
2. Bar charting capability shall be provided. It shall be possible to extract data from the historical database and format the data into meaningful full color bar chart displays.
 - a. Up to seven variables per chart.
 - b. Each bar to have a specified width and color fill.
 - c. Each bar shall be assigned a title to be displayed at the bottom of the chart. Titles shall appear in the same color as the associated bar.
 - d. Bar charts to be provided are as noted in the I/O summary.
 3. Curve Plot Capability: Curve plot capability is to be provided allowing up to seven variables to be displayed simultaneously. Data to be displayed is to be extracted from the historical data base.
 - a. Each curve plot shall have a specifiable color.
 - b. The independent (X) axis of the plot shall be defined as time or as an analog variable.
 - c. Curve plots to be provided are as noted in the I/O summary.
- i. Dynamic color graphic displays
 1. Color graphic floor plan displays, and system schematics for each piece of mechanical equipment, including all components of the systems airflow and

temperature control systems, shall be provided to optimize system performance analysis and speed alarm recognition.

2. The operator interface (existing campus laptops) shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands (user's option).
3. Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their actual respective locations, and shall automatically update at intervals not to exceed 30 seconds to represent current conditions without operator intervention.
4. The windowing environment of the PC operator workstation (existing user laptops) shall allow the user to simultaneously view several graphics at the same time to analyze total system operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
5. Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
6. The system supplier shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
7. The graphic development package shall use a mouse or similar pointing device in conjunction with a graphics development program to allow the user to perform the following:
 - a. Define symbols.
 - (1) Position and size symbols.
 - (2) Define background screens.
 - (3) Define connecting lines and curves.
 - (4) Locate, orient and size descriptive text.
 - (5) Define and display colors for all elements.
 - (6) Establish correlation between symbols or text and associated system points or other displays.

J. Reports

1. Reports shall be generated and directed to one of the following: workstation displays, printers, or disk. As a minimum, the system shall provide the following reports:
 - a. All points in the network.
 - b. All points in a specific controller.
 - c. A listing of a user-defined group of points in the network. There shall be no limit to the number of user-defined groups
 - d. All points currently in alarm.

- e. All points in hardware override.
 - f. All disabled points.
 - g. All weekly schedules.
 - h. All or selected point attributes, including, but not limited to:
 - i. Values
 - j. Setpoints
 - k. Alarm Limits
 - l. Statistics
 - m. Run Times
 - n. All programmed holidays and associated schedules.
 - o. All disabled alarms.
 - p. All active, unacknowledged alarms.
 - q. All active, acknowledged alarms.
 - r. Any and all other controller operating parameters.
 2. Reports shall be provided for specific point types, for each logical point group, for user-defined groups, or for the entire facility without restriction due to the hardware configuration of the control system or communications network.
 3. The system shall allow for the creation of custom report point groups that shall be capable of including points from multiple controllers. Systems limiting point report displays to only a single controller's point database shall not be accepted.
 4. The number of custom reports or display groups shall be limited by the amount of available system memory.
 5. Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report on the system printer for use as a building management and diagnostics tool.
- K. Password
1. Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display, and database manipulation capabilities as he or she deems appropriate for each user, based on an assigned password.
 2. Each user shall have the following: a user name; a password, and an access level (from 1 - 5).
 3. The system shall allow each user to change his or her password at will.
 4. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
 5. A minimum of five levels of access shall be supported as follows:
 - a. Level 1 = Data Access and Display

- b. Level 2 = Level 1 and Operator Overrides
 - c. Level 3 = Level 2 and Database Modification
 - d. Level 4 = Level 3 and Database Generation
 - e. Level 5 = All privileges, including Password Add/Modify
6. A minimum of 100 unique passwords, including user initials, shall be supported.
 7. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
 8. The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.
 9. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving the operator workstation logged on.
- L. Special tools:
1. Furnish to the Owner not less than two sets of tools necessary to service and maintain tamperproof panels and/or any other such items requiring special tools.
- M. Warranties and guarantees
1. Product warranties and guarantees
 - a. Warranty shall commence upon the date of owner beneficial use and extend through the construction period for the overall project plus twenty-four months after the completion of the scope of work.
 - b. The warranty length shall be based on the total project completion and specific lab completions relative to each interface. During the warranty period the manufacturer shall repair any defects in materials or system performance, at no cost to the owner.
 - c. The manufacturer shall provide an option to extend the warranty for an additional 3 years to Baylor for all materials installed during this scope of work.

PART 3 - PRODUCTS

3.02 PROJECT MANAGEMENT

- A. Provide a project manager who shall, as a part of his duties, be responsible for the following activities:
1. Coordination between work under this Section, and all other trades, Owner, local authorities and the design team.

2. Scheduling of temperature control system and Controls manpower, material delivery equipment installation and checkout.
3. Maintenance of temperature control system and Controls construction records such as project scheduling, manpower planning, and AutoCAD drawings for project coordination and as-built drawings.

3.03 INSTALLATION METHODS

- A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable division 16 sections of these specifications.
- B. The term "control wiring" is defined to include providing of wire, conduit, and miscellaneous materials as required for mounting and connecting electric or electronic control devices.
- C. Install control wiring system in conduit for electric/electronic control systems. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed.
- D. Number-code or color-code conductors appropriately for future identification and servicing of control system.
- E. All line voltage power wiring required because of substitution of equipment specified in this section, shall be provided by this section.
- F. All electrical grounding of mechanical equipment, electrical equipment, instrumentation and control devices shall be per manufacturers recommendation and instruction, and all applicable codes and div 26 specifications.

3.04 SYSTEM ACCEPTANCE

- A. General: the system installation shall be complete and tested for proper operation prior to acceptance testing for the owner's authorized representative. A letter shall be submitted to the architect requesting system acceptance; and provide documentation certifying that the contractor, owner's construction inspector, and owner's operating personnel have witnessed the COMMISSIONING OF EACH SYSTEM AND AGREE THAT EACH SYSTEM IS INSTALLED AND OPERATES AS SPECIFIED. THIS LETTER SHALL CERTIFY ALL CONTROLS ARE INSTALLED AND THE SOFTWARE PROGRAMS HAVE BEEN COMPLETELY EXERCISED FOR PROPER EQUIPMENT OPERATION. ACCEPTANCE TESTING WILL COMMENCE AT A MUTUALLY AGREEABLE TIME WITHIN TEN (10) CALENDAR DAYS OF REQUEST. UPON COMPLETION OF FIELD TESTING AND SYSTEM COMMISSIONING, THE CONTROLS CONTRACTOR SHALL DEMONSTRATE TO THE OWNER THE ENTIRE SEQUENCE OF OPERATION IN ALL PHASES SUCH AS STARTUP PROCEDURES NORMAL OPERATION, POWER FAILURE, RESUMPTION OF NORMAL POWER, SYSTEM RESPONSE AND OPERATION DURING EMERGENCY POWER. ONLY WHEN ALL SYSTEMS HAVE BEEN SUCCESSFULLY TESTED, DEMONSTRATED AND VERIFIED BY THE OWNERS REPRESENTATIVE SHALL BE ACCEPTED.
 1. Prior to acceptance, all DDC zone and local controllers shall be tested via a functional point to host testing, as follows:

- a. All output channels shall be commanded (on/off, start/stop) and the operation of the device controller to be verified.
 - b. All analog input channel devices shall be verified for accuracy over the entire span of the device when possible and documented at what points of the span were checked and calibrated.
 - c. All digital input channels shall be verified by changing the state of the field device and observing the appropriate change of displayed value.
 - d. Automatic control operation shall be verified by documentation of the changing of the set point and observing a smooth and timely system response.
 - e. Time event and set point schedules shall be verified before acceptance testing.
- B. Field equipment test procedures: the contractor shall provide documentation of their testing and provide documentation with the technicians' initials for each point tested. All problems shall be added to a punch list for correction. The contractor shall be responsible for rescheduling retesting after correction of deficiencies. Coordinate with section 15020 & 15021, tab.
- C. Workstation test procedures: the system workstation test procedures shall be as follows:
1. Communication with each DDC Zone and Local Controller shall be demonstrated.
 2. Operator commands will be explained and demonstrated.
 3. Control sequences shall be demonstrated for proper operation.
 4. All available system reports and logs shall be demonstrated at the System Workstation.
 5. Correct system start-up and shutdown procedures shall be demonstrated.
 6. All controllers shall be demonstrated to operate in a standalone mode.
- D. As-built documentation: after a successful acceptance demonstration, the contractor shall submit as-built drawings of the completed project for final approval. After receiving final approval, supply six (6) complete 11x17 as-built drawing sets, together with autocad diskettes to the owner.
- E. Operation and maintenance manuals: submit three (3) copies of operation and maintenance manuals. Include the following in each manual:
1. Manufacturer's catalog data and specifications on all sensors, transmitters, controllers, control valves, damper actuators, gauges, indicators, terminals, and any miscellaneous components used in /1/ this system and the Controls System.
 2. An Operator's Manual that will include detailed instructions for all operations of this system and the Controls System.
 3. An Operator's Reference Table listing the addresses of all connected input points and output points. Settings shall be shown where applicable.

4. A Programmer's Manual that will include all information necessary to perform programming functions.
 5. A language manual that will include a detailed description of the language used and all routines used by the system.
 6. Flow charts of the control software programs utilized in the Temperature Control System.
 7. Complete program listing file and parameter listing file for all programs.
 8. A copy of the warranty.
 9. Operating and maintenance cautions and instructions.
 10. Recommended spare parts list.
- F. The contractor of this section shall be required to participate in the fire alarm system checkout to ensure that the hvac sequence of operation are responding to the requirements of the fire alarm system in all buildings.

3.05 TRAINING

- A. Contractor shall provide to the owner for approval a training class program prior to any scheduled training. The program shall include materials, instructor's qualifications, and proposed schedule for the two 4-hour courses.
- B. Training sessions shall be provided for the owner's personnel by factory trained control engineers and technicians. A minimum of 4 bound copies of training materials shall be provided for the two courses.
- C. The contractor shall conduct two (2) four (4) hour training course for the designated owners' personnel in the maintenance and operation of the control system. Training shall include but not be limited to applications to the actual systems and devices to be controlled.
- D. The courses shall include instruction on specific systems and instructions for operating the installed system to include as a minimum:
 1. HVAC system overview
 2. System Operating Procedure
 3. Programming Procedure
 4. Maintenance Procedures

3.06 WARRANTY

- A. The entire control system shall be warranted to be free from defects in both material and workmanship for a period of two (2) years of normal use and service from the date of acceptance of the system.

END OF SECTION

SECTION 23 09 93 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 SECTION INCLUDES

- A. Work Included: Sequence of operation is hereby defined to mean the manner in which and methods by which the building control and automation system functions. The requirements for each type of operation are specified in this Section.
- B. Work of Other Sections: The operating equipment, devices, and system components required for the building control and automation system are specified in other Division 15 Sections.
- C. Extent: The extent of the building control and automation system work is as shown on the Drawings and in schedule and as required by the Control Sequence requirements specified in this Section.

1.03 RELATED SECTIONS

- A. Section 23 09 23 - Direct Digital Control Systems

1.04 SYSTEM DESCRIPTION

- A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other Sections.

1.05 SUBMITTALS

- A. Submit under provisions of Section 01 33 00.
- B. Submit diagrams indicating mechanical system controlled and control system components. Label with settings, adjustable range of control and limits. Include written description of control sequence.
- C. Include flow diagrams for each control system, graphically depicting control logic.
- D. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.

1.06 PROJECT RECORD DOCUMENTS

- A. Submit documents under provisions of Section 01 77 00.

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- B. Accurately record actual setpoints and settings of controls, including changes to sequences made after submission of shop drawings.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 GENERAL:

- A. The building is a dormitory building and, thus shall operate on a 24/7 time schedule. This sequence of operation shall be as written on the control diagrams.
- B. Control Sequences for Single Duct, Outside Air, Floor Air Handling Units, Exhaust Fan Systems, Cooling Systems and other Mechanical/Electrical equipment shall be electrically and/or mechanically designed such that all of the systems mentioned herein and hereafter, shall operate, fail, restart (as the case may be) to satisfy the following conditions:
 - 1. All interlocks associated with equipment safety such as heaters, low/high temperature switches, freezstats, high/low pressure switches, proximity and limit switches, vibration switches, differential switches, smoke detectors, control valves, dampers, damper motors, relays, shall be electrically hardwired. Unless otherwise approved by DPS any software generated commands from a DDC controller, PLC, multiplexer, host computer CPU, to be used for equipment safety interlocks is not allowed.

3.02 CONDUIT SYSTEM AND WIRING

- A. Temperature control system installer shall be responsible for all termination's to all temperature control system and FCMS equipment and for all cabling between terminal cabinets and point devices. The integrated cable subcontractor shall be responsible for other cabling, i.e., and cabling from terminal cabinets to other cabinets. The temperature control system and FCMS system installer shall indicate on detailed shop drawings which cable is in his work and which cable is in the integrated cable responsibility. This effort will require coordination between both to assure the total installation is done.
- B. Cabling for these systems shall be 24 AWG unshielded twisted copper pair.

3.03 EMERGENCY POWER DELAYS

- A. There shall be delays in start-up of equipment for emergency power. The BAS shall delay the start of all DX units by one minute after switch-over to emergency power.

3.04 SYSTEM NON-PERFORMANCE

- A. Should for any reason the system testing described above prove that the system or any system components do not perform as specified, the system manufacturer shall be responsible for all subsequent labor, travel, travel expenses, and incidental expenses, penalties, or other costs required to prove the system performs as specified. This shall include, but not be limited to, the labor, travel and incidental expenses of not only the Architect/Engineer and Owner's TAB consultant, but also those incurred by the Owner as may be specially required for this purpose.

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END OF SECTION 23 09 93

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SECTION 23 31 00 - DUCTWORK

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 WORK INCLUDED

- A. Low Pressure Ducts
- B. Medium Pressure Ductwork
- C. Casings

1.03 RELATED WORK

- A. Section 09 91 00 - Painting: Weld Priming, Weather Resistant Paint or Coating
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 07 13 - Duct Insulation
- D. Section 23 33 00 - Ductwork Accessories
- E. Section 23 36 00 - Air Terminal Units
- F. Section 23 37 00 - Air Inlets and Outlets
- G. Section 23 05 93.A - Testing, Adjusting and Balancing

1.04 REFERENCES

- A. ASHRAE - Handbook of Fundamentals; Duct Design
- B. ASHRAE - Handbook of Equipment; Duct Construction
- C. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
- D. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- E. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
- F. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality

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- G. ASTM B209 - Aluminum and Aluminum Alloy Sheet and Plate
- H. ASTM C 14 - Concrete Sewer, Storm Drain, and Culvert Pipe
- I. ASTM C 443 - Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
- J. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
- K. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems
- L. NFPA 96 - Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooling Equipment
- M. SMACNA - Low Pressure Duct Construction Standards
- N. SMACNA - High Pressure Duct Construction Standards
- O. UL 181 - Factory-Made Air Ducts and Connectors
- P. Fundamentals Handbook, American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).
- Q. Equipment Handbook, ASHRAE.
- R. HVAC Duct Construction Standards, Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
- S. HVAC Duct System Design, SMACNA.
- T. Round Industrial Duct Construction Standards, SMACNA.
- U. Engineering Design Manual for Air Handling Systems, United McGill Corporation (UMC).
- V. Assembly and Installation of Spiral Duct and Fittings, UMC.
- W. Engineering Report No. 132 (Spacing of Duct Hangers), UMC.

1.05 DEFINITIONS

- A. Duct Sizes: Inside clear dimensions. For lined ducts, maintain sizes inside lining.
- B. Low Pressure: 1 inch WG positive or negative static pressure and velocities less than 1,500 fpm.
- C. Medium Pressure: 4 inch WG positive static pressure and velocities greater than 1,500 fpm.

1.06 REGULATORY REQUIREMENTS

- A. Construct ductwork to NFPA 90A, NFPA 90B and NFPA 96 standards.

1.07 SUBMITTALS

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- A. Shop Drawings shall be submitted on all items of sheet metal work specified herein. Shop Drawings of ductwork at air units shall be submitted at a minimum scale of 3/8" equal to one foot.
 - B. Shop Drawings shall be submitted on all other ductwork per Section 23 00 00. Shop Drawings shall indicate location of all supply, return, exhaust and light fixtures from the approved reflected ceiling plans.
 - C. Submit shop drawings and product data under provisions of Section 23 00 00.
 - D. Submit samples under provisions of Section 23 00 00.
- 1.08 DELIVERY, STORAGE, AND HANDLING
- A. Deliver products to site under provisions of Section 23 00 00.
 - B. Store and protect products under provisions of Section 23 00 00.

PART 2 - PRODUCTS

2.01 DUCTWORK GENERAL:

- A. All ductwork indicated on the Drawings, specified or required for the air conditioning and ventilating systems shall be of materials as hereinafter specified unless indicated otherwise. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA Duct Manuals where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein. All exhaust ductwork including toilet room exhausts shall be constructed and leak tested as specified for medium pressure supply ducts at negative pressure.
- B. All ductwork shown on the Drawings, specified or required for the heating, ventilating and air conditioning systems shall be constructed and erected in a first class workmanlike manner. The work shall be guaranteed for a period of one (1) year from and after the date of acceptance of the job against noise, chatter, whistling, vibration, and free from pulsation under all conditions of operation. After the system is in operation, should these defects occur, they shall be corrected as directed by the Architect.
- C. All duct sizes shown on the Drawings are air stream sizes. Allowance shall be made for internal lining where required, to provide the required cross sectional area.
- D. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for any length of time.
- E. Except for special ducts specified elsewhere herein, all sheet metal used on the project shall be constructed from prime galvanized steel sheets and/or coils up to 60" in width. Sheet metal must conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards."

- F. Where ducts, exposed to view in occupied spaces, pass through walls, floors or ceilings, furnish and install sheet metal collars around the duct.

2.02 DUCTWORK LOW PRESSURE: (INCLUDES ALL RELIEF DUCTWORK)

- A. The scope of low pressure ductwork is defined as all ductwork downstream of terminal units and relief ductwork. Construction of all low pressure duct shall be in accordance with Low Velocity Duct Construction Standards as published by Sheet Metal and Air Conditioning Contractors National Association (SMACNA) and shall be sealed at 1" static.
- B. Spiral wound round duct shall be as manufactured by United McGill Sheet Metal Company or approved equal.
- C. The metal gauges listed in the 1995 SMACNA HVAC Duct Construction Standards for Metal and Flexible Duct are the minimum which shall be used for this project. It shall be noted that the Contractor is responsible that the metal gauge selected is heavy enough to withstand the physical abuse of the installation.
- D. Elbows shall be radius type and have a centerline radius of 1-1/2 times the duct diameter or width. Elbows in round ducts may be smooth radius as described above or 5-piece 90 degree elbows and 3-piece 45 degree elbows. Joints in round ducts shall be slip type with a minimum of three sheet metal screws. Joints in sectional elbows shall be sealed as specified for duct sealing.
- E. SEALANT: All ductwork (except welded exhaust duct) shall be sealed with either "MP" (Multi-Purpose), Hardcast "Iron-grip 601", Polymer Adhesive "Airseal #11", or "United Duct Seal" (United McGill Corp.) water base, latex or acrylic type sealant. Note that, except as noted, oil or solvent based sealants are specifically prohibited for use on this project. For exterior applications, "Uni-Weather" (United McGill Corp.) neoprene based sealant shall be used. No other sealants may be used. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3" wide open weave fiberglass tape. Sufficient additional sealant shall then be applied to completely imbed the cloth. All sealants shall be UL rated at no more than flame spread of 5 and smoke developed of 0. At contractor's option Hardcast 1602 sealant tape may be used in lap joints and flat seams.

2.03 DUCTWORK MEDIUM PRESSURE(INCLUDES ALL EXHAUST DUCTWORK):

- A. The scope of medium pressure ductwork is defined as all ductwork downstream of all air handlers, up to and including terminal units, all exhaust ductwork and all ductwork located in inaccessible chases. Construction of all ducts shall be in accordance with High Velocity Construction Standards as published by SMACNA. All round and rectangular duct construction, duct fittings, dampers, etc., are covered in this manual and it is to be adhered to.
 - 1. Spiral wound round duct shall be as manufactured by United McGill Sheet Metal Company or approved equal.
 - 2. The metal gauges are listed herein for round duct and for rectangular duct.
- B. All ductwork (except welded exhaust duct) shall be sealed with either "MP" (Multi-Purpose), Hardcast "Iron-grip 601", or "United Duct Seal" (United McGill Corp.) water base, latex or acrylic type sealant. Note that, except as noted, oil or solvent based sealants are specifically prohibited for use on this project. For exterior applications, "Uni-Weather" (United McGill Corp.) solvent based

sealant shall be used. No other sealants may be used. All seams and joints in shop and field fabricated ductwork shall be sealed by applying one layer of sealant, then immediately spanning the joint with a single layer of 3" wide open weave fiberglass tape. Sufficient additional sealant shall then be applied to completely imbed the cloth. At contractor's option Hardcast 1602 sealant tape may be used in lap joints and flat seams.

- C. Oval ducts shall be spiral flat oval or welded flat oval equal to those of United McGill Sheet Metal Company with gauges and reinforcing as recommended by the manufacturer for medium pressure or the ducts may be Shop fabricated of completely welded construction of the following gauge:
- | | |
|----------------------|--------------|
| Major Axis 12 to 20 | No. 24 gauge |
| Major Axis 20 to 30 | No. 22 gauge |
| Major Axis 30 to 46 | No. 20 gauge |
| Major Axis 46 to 50 | No. 18 gauge |
| Major Axis 50 and Up | No. 16 gauge |
- D. Oval fittings shall be equal to those of United McGill Sheet Metal Company with requirements, sealing, etc., similar to that specified for round medium pressure work.
- E. Oval duct reinforcing methods shall be submitted as Shop Drawings for approval. Reinforcing galvanized angles shall be of sizes specified for same size rectangular ducts. Galvanized angles shall be used where standing seams are specified for rectangular ducts. Attaching methods shall be shown on Shop Drawings and submitted for approval.
- F. Testing of Medium Pressure Ductwork: (Includes from fan discharge through to the inlet of terminal units for the kitchen unit only.)
1. All medium pressure ducts shall be pressure tested according to SMACNA Chapter 10 test procedures. Design pressure for testing ductwork shall be four inches (4") of water. Total allowable leakage shall not exceed 1% of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all Sections shall not exceed the total allowable leakage.
 2. The entire system of medium pressure ductwork shall be tested, excluding the VAV/Constant Volume Terminal Units (i.e. The ductwork shall be capped immediately before the flex connection to the Terminal Units, and tested as described above). After testing has proven that the ductwork is installed and performs as specified, the terminal units shall be connected to the ductwork and the connections sealed with extra care. The contractor shall inform the project inspector when the joints may be visually inspected for voids, splits, or improper sealing of the joints. If any leakage in the terminal unit connections/joints after the systems have been put into service, the leaks shall be repaired by: 1) complete removal of the sealing materials, 2) thorough cleaning of the joint surfaces, and 3) installation of multiple layers of sealing materials.
- G. Contractor may at his option use DUCTMATE or Ward coupling system on rectangular ductwork. Contractor may at his option (where space permits) use rectangular ductwork with DUCTMATE or Ward system in lieu of oval ductwork.
- H. Rectangular 90 degree elbows shall be constructed with single thickness turning vanes. Radius type rectangular elbows shall have a centerline radius of 1-1/2 times the duct diameter or width. Contractor shall have the option to substitute short radius vaned elbows, but shall request the substitution at the time of submittal of Shop Drawings, and shall request the substitution as

required in Section 23 00 00. Elbows in round or oval ducts may be smooth long radius as described above or 5-piece 90 degree elbows and 3-piece 45 degree elbows. Joints in round ducts shall be slip type with a minimum of three sheet metal screws. Joints in sectional elbows shall be sealed as specified for duct sealing.

2.04 ELBOWS:

- A. Where rectangular elbows are shown, or are required for good air flow, contractor shall provide and install turning vanes. Job fabricated turning vanes, if used, shall be fabricated of the same gauge and type of material as the duct in which they are installed. Vanes must be fabricated for same angle as duct offset. Radius elbows shall have a centerline radius of not less than one and one-half (1-1/2) times the duct width. Submit Shop Drawings on factory fabricated and job fabricated turning vanes. Provide turning vanes in all rectangular radius elbows and offsets.
- B. All turning vanes shall be anchored to the cheeks of the elbow in such a way that the cheeks will not breathe at the surfaces where the vanes touch the cheeks. In most cases, this will necessitate the installation of an angle iron support on the outside of the cheek parallel to the line of the turning vanes.
- C. All turning vanes shall be single thickness vanes.

2.05 FLEXIBLE DUCTS:

- A. Low Pressure Insulated Flexible Duct may be used where shown on the drawings. Duct shall be made with factory preinsulated duct composed of dead soft, spiral wound, corrosive resistant galvanized steel helix formed and mechanically locked to the PE inner liner fabric and covered with a minimum of 1-1/2" thick, 3/4 lb. density fiberglass blanket sheathed in a vapor barrier of fiberglass reinforced aluminum foil and mylar laminate. The insulation shall have an R value of 8 and a vapor barrier permeability rating of 0.05 per ASTM method E96-66, Procedure A. The duct shall be rated for a positive working pressure of 10" w.g. and a temperature of up to 250 degrees F. The duct must comply with the latest NFPA Bulletin 90A and be listed and labeled by Underwriters Laboratories, Inc., as Class I Air Duct, Standard 181, and meet GSA, FHA and other U. S. Government standards; flame spread, not over 15; smoke developed, not over 10. Flexible ducts shall be not more than 10' in length, no less than 4' in length, and shall be installed with no more than 90 degrees of bend in the horizontal provided that the radius is a full 1.5 times the radius of the duct. No sharp bends will be allowed. An additional 90 degree bend in the vertical to drop into diffusers as long as a flexmaster flexflow elbow is used. Flex duct shall be Flexmaster Type 1-M or approved equal.
 - 1. The terminal ends of the duct core shall be secured by compression coupling or stainless steel worm gear type clamp equal to Ideal Series 56 Snaplock. The fittings on air mixing devices and on sheet metal duct shall be coated with the sealant specified for low pressure ductwork, then flexible duct core slipped over duct and coupling or clamp tightened, then connection sealed with more sealant. Insulation of flexible duct shall be slipped over connection to point where insulation abuts mixing box or insulation on duct. These insulation connections shall be sealed by imbedding fiberglass tape in the sealant specified for medium pressure ductwork and coating with more sealant to provide a vapor barrier. (This applies to all flex connections to diffusers, grilles, etc. when allowed on the drawings.)

- B. Medium Pressure Insulated Flexible Duct shall be the same construction as the Low Pressure Duct, factory applied insulation of 1" minimum thickness, 3/4 lb. density with a permeability rating of 0.30. The duct shall be supported by a corrosion resistant metal spiral, or a coated spring steel helix and solid inner liner mechanically interlocked or permanently bonded to the helix wire. Ratings shall be as described for Low Pressure Duct above. Flexible ducts shall be not more than 2'-0" in length, used for alignment or sound/vibration purposes only, and may only be installed in straight runs. Medium pressure flexible duct shall NOT be used for changes of direction of air flow. Installation, clamps and sealing shall be the same as specified for rigid duct.

2.06 KITCHEN EXHAUST

- A. Minimum 16ga black iron or Stainless steel as indicated on drawings.
- B. Slope back to hood.
- C. Provide access doors at all changes in direction.
- D. Fire protect per NFPA and UMC.
- E. Manufactured duct systems with NFPA certification for grease systems may be used in lieu of above if approved by the authority having jurisdiction.

2.07 DUCT LINER: (SEE SECTION 23 07 19, FOR THE APPLICABLE INSULATION SPECIFICATION.)

- A. Only where indicated on the Drawings, ducts shall have lining equal to Fiberglass Aeroflex No. 150 duct liner. Duct liner shall be one inch (1") thick unless otherwise indicated. The liner shall be applied to the inside of the duct with heavy density side to the air stream and shall be secured in the duct with fireproof 3M #37 or St. Clair R41B adhesive, completely coating the clean sheet metal. All joints in the insulation shall be "buttered" and firmly butted tightly to the adjoining liner using fireproof adhesive. Where a cut is made for duct taps, etc., the raw edge shall be accurately and evenly cut and shall be thoroughly coated with fireproof adhesive. On ducts over twenty-four (24") in width or depth, the liner shall be further secured with mechanical fasteners. The fasteners shall be A. J. Gerrard Company pronged straps, or approved equal, secured to the ducts by fireproof adhesive. The clips shall be eighteen inch (18") maximum spacing and shall be pointed up with fireproof adhesive. Liner shall be accurately cut and ends thoroughly coated with fireproof adhesive so that when the duct section is installed, the liner shall make a firmly butted and tightly sealed joint. Where ducts are lined exterior insulation will not be needed unless otherwise noted, except that the two insulations shall not lap less than twenty-four inches (24"). Dimensions given on the Drawings are metal sizes. Refer to Section 23 00 00 for Flame-Spread Properties.
- B. Duct liner in medium pressure ducts shall be the same except a perforated metal liner shall be used over duct liner for securement in lieu of fasteners.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Refer also to requirements included in Part 2 of this specification.

- B. Obtain manufacturer's inspection and acceptance of fabrication and installation of fiberglass ductwork prior to beginning of installation.
- C. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- D. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- E. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
- F. Connect terminal units to medium pressure ducts directly or with two feet maximum length of flexible duct. Do not use flexible duct to change direction. Allow for a minimum of 4 diameters of straight duct to the entrance of all terminal units.
- G. Connect diffusers to low pressure ducts with 4 feet minimum, 10 feet maximum length of flexible duct. Hold in place with strap or clamp, and seal as specified.
- H. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Use stainless steel for ductwork exposed to view and stainless steel or galvanized steel for ducts where concealed.
- I. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Use stainless steel for ductwork exposed to view and stainless steel or galvanized steel for ducts where concealed.
- J. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- K. Wrap kitchen exhaust duct with 2-hour rated wrap as detailed or provide 2-hour duct system approved for use by CoH for grease duct applications.

3.02 LOW PRESSURE DUCT SUPPORTS:

- A. See Section 23 05 29.

3.03 MEDIUM PRESSURE DUCT SUPPORTS:

- A. See Section 23 05 29.

3.04 DUCTWORK APPLICATION SCHEDULE

THE MEN'S CENTER
3809 Main St.
Houston, Texas 77002

AIR SYSTEM

Low Pressure Supply
Medium Pressure Supply
Return and Exhaust
Kitchen Exhaust

MATERIAL

Galvanized
Galvanized
Galvanized
Stainless Steel, Schedule 40 Steel or Pre-manufactured 20hour duct approved for kitchen

grease
Outside Air Intake

Galvanized

3.05 **CLEANING OF SYSTEMS:**

- A. Before turning the installation over to the Owner, all ducts should be cleaned and blown free of all dust and dirt that has collected in the ducts.

END OF SECTION 23 31 00

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SECTION 23 33 00 - DUCTWORK ACCESSORIES

PART 1 0 GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 WORK INCLUDED

- A. Volume Control Dampers
- B. Fire and Fire/Smoke Dampers
- C. Backdraft Dampers
- D. Air Turning Devices
- E. Flexible Duct Connections
- F. Duct Access Doors
- G. Duct Test Holes

1.03 RELATED WORK

- A. Section 23 05 48 - Vibration Isolation
- B. Section 23 31 00 - Ductwork
- C. Section 23 36 00 - Air Terminal Units

1.04 REFERENCES

- A. NFPA 90A - Installation of Air Conditioning and Ventilating Systems
- B. SMACNA - Low Pressure Duct Construction Standards
- C. UL 33 - Heat Responsive Links for Fire-Protection Service
- D. UL 555 - Fire Dampers and Ceiling Dampers

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 00 00.
- B. Provide shop drawings for shop fabricated assemblies indicated, including volume control dampers duct access doors duct test holes. Provide product data for hardware used.

- C. Submit manufacturer's installation instructions under provisions of Section 23 00 00 for fire dampers and combination fire and smoke dampers.

PART 2 - PRODUCTS

2.01 DAMPERS:

- A. Furnish and install dampers where shown on the Drawings and wherever necessary for complete control of the air flow, including all supply, return and exhaust branches, "division" in main supply, return and exhaust ducts, each individual air supply outlet and fresh air ducts. Where access to dampers through a fixed suspended ceiling is necessary, the Contractor shall be responsible for the proper location of the access doors. Dampers located above solid ceilings shall be furnished with Young Regulators and extension rods (no cables shall be used).
- B. Dampers larger than three (3) square feet in area shall be controlled by means of rods hinged near the leading edge of the damper with provisions for firmly anchoring the rod and with end bearings supporting the axle.
- C. Fully-modulating control dampers larger than 10 square feet shall be provided with one actuator per 10 square feet minimum.
- D. Volume dampers shall be equal to those of American Foundry. Blades shall not exceed 48 inches (48") in length or twelve inches (12") in width and shall be of the opposed interlocking type. The blades shall be of not less than No. 16-gauge galvanized steel supported on one-half inch (1/2") diameter rust-proofed axles. Axle bearings shall be the self-lubricating ferrule type.
- E. Install all dampers furnished by the Temperature Control Manufacturer in strict accordance with the manufacturer's recommendations and requirements of these Specifications.
- F. All adjustable dampers installed in externally insulated ductwork shall be installed with Ventlok No. 639, or equal, elevated dial operators. Insulation shall extend under the elevated dial. All adjustable dampers installed in internally insulated ductwork shall be installed with Ventlok No. 635, or equal, dial operators. All damper shaft penetrations in the ductwork shall be installed with Ventlok #609 end bearings.

2.02 FIRE DAMPERS:

- A. General: Provide fire dampers at duct penetrations of rated floors, fire walls, elsewhere as shown in the Drawings and where required by the 2006 International Building Code. Fire dampers shall comply with Uniform Building Code Standard No. 43-7, be inspected and approved by an approved inspection agency and be labeled at the factory in accordance with Uniform Building Code Standard 43, Section 43.714. Dampers shall be UL-labeled and shall meet all of the requirements of NFPA 90A and UL Standard 555.
 - 1. Provide 1 hour rated dampers where penetrations are in required 1 hour fire rated assemblies.
 - 2. Provide 1-1/2 hour rated dampers where penetrations are in required 2 hour fire rated assemblies.
 - 3. Provide 3 hour rated dampers where penetrations are in required 4 hour fire rated assemblies. 4 hour occupancy separating walls are excepted and shall not be penetrated by ductwork..

4. Dampers shall be activated by a UL-approved fusible link which shall automatically close the damper upon operation. Fusible links shall operate at approximately 50°F above the maximum temperature in the duct system in normal operation, but not less than 165°F. All dampers associated with Life Safety Systems shall have minimum 212°F fusible links. Hinged dampers shall have stainless or cadmium-plated spring steel catches. All dampers shall be dynamic rated and shall have spring closure to ensure positive shutoff at velocities up to 5000 fpm and pressures up to 10" wg.
5. Dampers shall be UL-rated per UL Standard 555 and shall be Ruskin Type DIBD Series, Style A, B or C, or an approved equal by Greenheck, Pottoroff or Nailor.
6. Dampers shall be sized so that the free area space is not less than 100% of the connected duct free area space for low velocity, low pressure ductwork and 100% of the connected duct free area space for high velocity, high pressure ductwork. Dampers shall be installed so as to provide a positive barrier to the passage of air when in the closed position. Dampers shall be installed with angle iron frames and slip joint connections per manufacturer's installation requirements and SMACNA Standards such that they are self-supporting in the case of duct destruction due to heat. The installing contractor shall be responsible for coordinating locations which require special sleeves.
7. Provide access doors as specified under ductwork for all internally actuated dampers. Where duct access doors are installed in non-accessible locations, provide ceiling or wall access doors. Label duct access doors "FIRE DAMPER ACCESS" with 1/2" high black stencil letters.

2.03 FIRE/SMOKE DAMPERS:

- A. General: Provide low leakage fire/smoke dampers at all locations shown on the Drawings or required. Dampers shall be multi-blade type combination fire/smoke dampers and shall possess a 1-1/2 hour UL label in accordance with UL 555S and shall meet all requirements of the latest edition of NFPA 90A and 101. Dampers shall be tested and certified in accordance with AMCA Standard 500-75 and shall leakage Class II per UL Standard 555S.
 1. Fire/smoke dampers and operators shall be UL-listed and labeled in the sizes used on the project and all dampers on the project shall be by the same manufacturer. UL-labeling of damper sizes used on the project shall be clearly indicated on shop drawing submittals.
 2. Dampers shall be suitable for opening and closing at static pressure up to 6" wg and at air velocities up to 3500 fpm. Damper leakage shall not exceed 10 cfm/sf at one inch wg or 200 cfm/sf at 4" wg.
 3. All combination fire/smoke dampers shall include an operating shaft which, when rotated, causes the damper to operate between open and closed. Operating shaft and damper combination shall be suitable for linking to and operation by any standard electric damper operator having sufficient torque characteristics. Combination fire/smoke dampers shall be Ruskin Type FSD-60 or an approved equal by Greenheck, Pottoroff or Nailor, with 212°F thermal links and rectangular, round or oval duct connections as required.
 4. Each combination fire/smoke damper shall be furnished complete with factory sleeve, damper operator, and thermal link factory-installed. The installing contractor shall be responsible for coordinating locations which require a special sleeve. Actuators shall be electric type as specified or required and shall be of the spring fail closed type that will close upon loss of power. Damper operators shall be UL-listed as fire damper operators, shall bear the appropriate UL fire damper operator label and shall be rated for continuous operation at 250°F.

5. All controls to operate damper motors shall be furnished under Section 23 09 23, "Building Controls". All wiring and materials to interface the controls with the fire detection and alarm systems shall be furnished and installed under Division 26. Dampers shall be installed with angle iron frames and slip joint connections per manufacturer's recommendations and SMACNA Standards such that they are self-supporting in the case of duct destruction due to heat. Provide access doors as specified under Ductwork for all internally actuated dampers and for maintenance inspection of all externally actuated dampers. Where duct access doors are installed in non-accessible locations, provide ceiling or wall access doors. Label duct access doors "FIRE/SMOKE DAMPER ACCESS" with 1/2" high black stencil letters.
6. A double pole double throw (DPDT) limit switch shall be provided factory-installed on each fire/smoke damper. The switch shall change position when the fire damper closes. Refer to Section 23 09 23 for wiring of limit switches.

2.04 SMOKE DAMPERS:

- A. General: Provide smoke dampers at all locations shown on the Drawings or required. Dampers shall meet all requirements for fire/smoke dampers except that the dampers shall not incorporate a thermal link feature.

2.05 FLEXIBLE CONNECTIONS:

- A. Where ducts connect to fans, including roof exhausters, flexible connections shall be made using "Ventglas" fabric that is fire-resistant, waterproof, mildew resistant and practically air tight, and shall weigh approximately thirty ounces (30 oz.) per square yard. There shall be a minimum of one-half inch (1/2") slack in the connections, and a minimum of two and one-half inches (2-1/2") distance between the edges of the ducts except that there shall also be a minimum of one inch (1") of slack for each inch of static pressure on the fan system. This does not apply to Air Handling Units with internal isolation.

2.06 ACCESS DOORS:

- A. Furnish and install in the ductwork, hinged rectangular or round "spin-in" access doors to provide access to all fire dampers mixed air plenums, upstream of steam reheat coils, automatic dampers, etc. Where the ducts are insulated, the access doors shall be double skin doors with one inch (1") of insulation in the door. Where the size of the duct permits, the doors shall be eighteen inches (18") by sixteen inches (16"), or eighteen inches in diameter, and shall be provided with Ventlok No. 260 latches (latches are not required in round doors). Latches for rectangular doors smaller than 18" x 16" shall be Ventlok No. 100 or 140. Doors for zone heating coils shall be Ventlok, stamped, insulated access doors, minimum 10" x 12", complete with latch and two (2) hinges, or twelve inches (12") in diameter. Round access doors shall be "Inspector Series" spin-in type door as manufactured by Flexmaster USA, or approved equal. Doors for personnel access to ductwork shall be nominal twenty-four inches (24") in diameter.
- B. Where these access doors are above a suspended ceiling, this Contractor shall be responsible for the proper location of the ceiling access doors.

2.07 SCREENS:

- A. Furnish and install screens on all duct, fan, etc., openings furnished by this Contractor which lead to, or are, outdoors. Screens shall be No. 16-gauge, one-half inch (1/2") mesh in removable galvanized steel frame. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

2.08 TEST OPENINGS:

- A. Furnish and install in the return air duct and in the discharge duct of each fan unit Ventlok No. 699 instrument test holes. The test holes shall be installed in locations as required to measure pressure drops across each item in the system, e.g., O.A. louvers, filters, fans, coils, intermediate points in duct runs, etc.

2.09 LOW PRESSURE TAPS (CONICAL BELL MOUTH FITTINGS)

- A. Conical fittings may be used for duct taps and shall include quadrant dampers on all lines to air devices (diffusers and grilles), even though a volume damper is specified for the air device. (This does not apply to medium pressure duct.) Spin-in fittings shall be sealed at the duct tap with a gasket, or compression fit, or sealed with sealant specified for medium pressure ductwork. The location of spin-in fittings in the ducts shall be determined after dual or single duct terminal units are hung or the location of the light fixtures is known so as to minimize flexible duct lengths and sharp bends.
- B. The conical fitting shall be made of at least 26-gauge galvanized sheet metal. The construction to be a two-piece fitting with a minimum overall length of 6 inches and shall be factory sealed for high pressure requirements. Average loss coefficient for sizes 6, 8, and 10 shall be less than 0.055.
- C. Each to be provided with minimum 24-gauge damper plate with locking quadrant operator and sealed end bearings. Damper blade shall be securely attached to shaft to prevent damper from rotating around shaft.
- D. Provide flange and gasket with adhesive peel-back paper for ease of application. The fitting shall be further secured by sheet metal screws spaced evenly at no more than 4 inches on-center with a minimum of four screws per fitting.
- E. The conical bellmouth fitting shall be Series 3000G as manufactured by Flexmaster U.S.A., Inc., or Buckley Air Products, Inc., 'AIR-TITE'.
- F. Conical fittings shall be used at each tap off of the medium pressure duct to serve terminal units.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions.
- B. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Use splitter dampers only where indicated.

- C. Provide balancing dampers on medium and high pressure systems where indicated. Refer to Section 23 36 00 - Air Terminal Units.
- D. Provide fire, smoke and fire/smoke dampers at locations indicated, where ducts and outlets pass through fire rated components. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- E. Demonstrate re-setting of fire dampers to Owner's representative.
- F. Provide backdraft dampers on exhaust fans or exhaust ducts where indicated.
- G. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Cover connections to medium and high pressure fans with leaded vinyl sheet, held in place with metal straps.
- H. Provide duct access doors for inspection and cleaning before and after duct mounted filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated. Provide minimum 8 x 8 inch (200 x 200 mm) size for hand access, 18 x 18 inch (450 x 450 mm) size for shoulder access, and as indicated.
- I. Provide duct test holes where indicated and where required for testing and balancing purposes. Refer also to Section 23 05 93.

END OF SECTION 23 33 00

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SECTION 23 34 00 - FANS

PART 1 GENERAL

1.1 The following sections are to be included as if written herein:

- A. Section 23 0000 – Basic Mechanical Requirements
- B. Section 23 0529 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 0553 – Mechanical Identification

1.2 SECTION INCLUDES

- A. Backward inclined centrifugal fans.
- B. Airfoil centrifugal fans.
- C. Radial centrifugal fans.
- D. Tubular centrifugal fans.
- E. Inline centrifugal fans.
- F. Utility/vent sets.
- G. Motors and drives
- H. Fan Accessories.

1.3 RELATED WORK

- A. Section 23 0000 - Basic Mechanical Requirements.
- B. Section 23 0513 - Motors.
- C. Section 23 0548 - Vibration Isolation.
- D. Section 23 0713 - Ductwork Insulation.
- E. Section 23 2923 – Variable Speed Drives
- F. Section 23 3100 - Ductwork.
- G. Section 23 3300 - Ductwork Accessories: Backdraft dampers.
- H. Section 26 0519 - Cable, Wire and Connectors, 600 Volt.

Fans

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- I. Section 26 2726 - Wiring Devices and Floor Boxes.

1.4 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- C. AMCA 99 - Standards Handbook.
- D. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes
- E. AMCA 301 - Method of Calculating Fan Sound Ratings from Laboratory Test Data.
- F. NEMA MG1 - Motors and Generators.
- G. NFPA 70 - National Electrical Code.
- H. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

1.5 SUBMITTALS

- A. Submit under provisions of Section 23 0000.
- B. Shop Drawings: Indicate assembly of centrifugal fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
- C. Product Data: Submittal data for approval for all fans of every description furnished under this section of these Specifications driven by 5 (five) HP and larger motors shall include the following:
 - 1. Fan curves with specified operating point clearly plotted. The recommended range of operation shall be stable.
 - 2. Fans shall be capable of operating stably at reduced loads imposed by means of variable speed drives.
 - 3. Data on sound power levels for both fan inlet and outlet at rated capacity.
 - 4. Electrical characteristics and connection requirements.
 - 5. All data on fan accessories.
- D. Manufacturer's Installation Instructions.

1.6 OPERATION AND MAINTENANCE DATA

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- A. Submit under provisions of Section 23 0000.
- B. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 0000.
- B. Protect motors, shafts, and bearings from weather and construction dust.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate fans for any purpose until ductwork is clean, filters in place, bearings lubricated, and fan has been test run under observation.

1.9 EXTRA MATERIALS

1.10 Furnish under provisions of Section 23 0000.

- A. Provide two sets of belts for each fan, not including the set installed on the fans. Tag sets to identify fan.

PART 2 PRODUCTS

2.1 GENERAL

- A. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.
- B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.
- C. Fabrication: Conform to AMCA 99.
- D. Performance Base: Sea level conditions.
- E. Temperature Limit: Maximum 300 degrees F.
- F. Static and Dynamic Balance: Eliminate vibration or noise transmission to occupied areas.

2.2 EXHAUST FANS:

- A. Inline exhaust and supply fans shall be Cook, Acme, Greenheck, Penn Barry, in line centrifugal or vane axial as approved. Capacity ratings shall be based upon tests performed in accordance with AMCA Standard 210. Each fan shall carry near the unit nameplate the AMCA seal indicating that capacity ratings are certified. Housings for all inline fans shall be of 14 gauge steel minimum and shall have square mounting frame of heavy steel angle to provide for mounting of fan. The fan housing will provide for slip joint duct connection. Fan wheels shall be

axial flow type with cast aluminum blades or tubular centrifugal type constructed of welded steel and have airfoil shaped blades. The fan shall be dynamically balanced for smooth operation. The fan shaft shall be solid be solid steel AISI-C1040 keyed to the fan wheel. Grease lubricated bearings shall be selected for a minimum average life in excess of B-10, minimum life 40,000 hours at maximum catalogued operating conditions. Fans shall be provided with factory mounted inlet and outlet sound attenuators when required to meet the scheduled sound power levels. The increased pressure drop due to attenuation must not cause an increase in power requirements from those specified. If oversized slow speed units are required, the Contractor shall be responsible for any related extra costs, not coming under his contract.

- B. Propeller or centrifugal roof exhaust air and supply air fans shall be Cook, Acme, Greenheck, Penn Barry or approved equal. The fans shall be complete with fans and motors, propeller, motorized shutters factory wired to open when fans are in operation and close when fans are not in operation, nonfused disconnect switches, bird screens, and round spun aluminum weatherproof protection covers. Fans shall be all aluminum. The fans shall be firmly bolted to the curb on which they rest. Fans shall be AMCA rated. Wing nuts of nonferrous construction shall be provided to remove covers. Kitchen exhaust fans shall be provided with grease interceptor.
- C. Propeller wall fans shall be Cook, Acme, Greenheck, Penn Barry or approved equal, belt or direct driven as scheduled on the Drawings. The fans shall be complete with guards over motor side, heavy duty gravity shutters, etc. Furnish with a factory applied prime coat of paint. Fans shall be AMCA rated.

2.3 V-BELT DRIVES:

- A. All v-belt drives shall be designed for a minimum of 50% overload. Where more than one belt is required, matched sets shall be used. All belt drives shall be furnished with belt guards.

2.4 RELIEFS:

- A. The relief shall be as manufactured by the supplier of the roof exhausters and shall match, as closely as possible, their silhouette. Furnish complete with bird screen.

2.5 MOTORS:

- A. Refer to Section 23 0513 for requirements.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install fans with resilient mountings and flexible electrical leads. Refer to Section 23 0548.

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- C. Install flexible connections specified in Section 23 3300 between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.
- D. Install fan restraining snubbers as required. Refer to Section 23 0548. Adjust snubbers to prevent tension in flexible connectors when fan is operating.
- E. Provide fixed sheaves required for final air balance.
- F. Provide safety screen or cage where inlet or outlet is exposed. Plug fans inside walk-in casings shall be provided with hinged safety cage.
- G. Pipe scroll drains over to nearest floor or roof drain.
- H. Provide backdraft or motorized dampers on discharge of exhaust fans where indicated. Refer to Section 23 3300.
- I. Provide two fan belts for each belt-driven fan.
- J. Secure roof fans with cadmium plated steel lag screws to roof curb structure. Install dampers in roof curb damper tray when noted on the drawings
- K. Provide hinged curb adapter to permit access to dampers and duct connection.
- L. Install safety screen when inlet or outlet is exposed.
- M. Fan Balancing. Provide proper fan design and balance fans and drives to limit vibration (displacement in mils) at operating speed to the values in the following table unless specified elsewhere. Measure vibration at each fan bearing, in all three planes.

End of Section 23 3400

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SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 SECTION INCLUDES

- A. Variable Volume Boxes
- B. Integral Sound Attenuator
- C. Integral Controls

1.03 RELATED SECTIONS

- A. Section 23 05 13 - Motors
- B. Section 23 31 00 - Ductwork
- C. Section 23 33 00 - Ductwork Accessories
- D. Section 23 37 00 - Air Outlets and Inlets
- E. Section 23 09 23 - Direct Digital Control Systems
- F. Section 23 05 93.A - Testing, Adjusting and Balancing
- G. Section 26 05 19 - Cable, Wire and Connectors, 600-Volt
- H. Section 26 27 26 - Wiring Devices and Floor Boxes

1.04 REFERENCES

- A. NFPA 90A - Installation of Air Conditioning and Ventilation Systems
- B. UL 181 - Factory-Made Air Ducts and Connectors
- C. ADC 1062 - Air Distribution and Control Device Test Code

1.05 SUBMITTALS

- A. Submit shop drawings under provisions of Section 23 00 00.
- B. Submit shop drawings indicating configuration, general assembly, and materials used in fabrication.

- C. Submit product data under provisions of Section 23 00 00.
- D. Submit product data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate air flow, static pressure, and NC designation.
- E. Include schedules listing discharge and radiated sound power level for each of second through seventh octave bands at inlet static pressures of one inch wg.
- F. Submit manufacturer's installation instructions under provisions of Section 23 00 00.
- G. Submit product data indicating materials, finishes and options provided that clearly indicate compliance with Part 2 of this specification. For all types of terminal boxes, provide documents proving that the box performance as submitted has been certified by an independent laboratory. Submit independent laboratory test data showing that the terminal units will meet the leakage rate as specified. The test will be conducted with the discharge and recirculation openings of the terminal sealed leak tight. The box will then be pressurized via the inlet connection to the specified pressure. Note that the access door shall not be sealed to prevent operation of the door. Tapes and sealants on the exterior of the casing are not acceptable; all sealants shall be applied internally to the casing at joints and seams to achieve leakage at acceptable rates as specified.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00. Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years' documented experience.

1.08 WARRANTY

- A. Provide one-year manufacturer's warranty under provisions of Section 23 00 00.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Units shall have no external sealant used. All sealant shall be internal of the boxes.
- B. Base acoustic performance of terminal units upon units tested according to ARI 880 and ASHRAE Standard 130.
- C. Provide units with single point connections.
- D. Electric actuators shall be sized appropriately with specified control type and manufacture red by Belimo.

- E. The damper shafts shall be round and operate in Sintered Bronze self-lubricating bearings. The end of the shaft at the operator end shall be scored in line with the damper blade to reference the damper blade position.
- F. Dampers shall be Arrow Model 70-UTA.

2.02 VAV (TERMINAL) BOX CROSS-FLOW AVERAGING SENSOR (APPLIES TO ALL TYPES OF VAV BOXES)

- A. Units shall be provided with a grid of multipoint velocity sensors. Each flow cross shall include a minimum of 8 pickup points of amplified sensing for each 16 inches of duct diameter. The pickup points shall be divided evenly in each of the four quadrants of the duct. Ducts larger than 16 inches in diameter shall be divided into sections which are each averaged to its respective center and then cascaded so that the entire cross-sectional area is traversed.
- B. Center tapped averaging sensors shall provide a differential pressure signal that represents actual airflow within an accuracy of +3 percent. This accuracy shall be maintained when inlet duct varies from straight to 90 degrees entrance approach angle.

2.03 VARIABLE AIR VOLUME (TERMINAL) BOXES (TYPE VAV)

- A. Furnish boxes with performance certified as per ARI Standard 880, for installation above the ceiling with capacities as scheduled. Boxes shall be listed in the latest ARI directory. Provide boxes supplied by the manufacturer fully assembled with air dampers and self-contained volume regulator. Select boxes with maximum scheduled CFM within mid to 80 percent of box cataloged capacity range (max 2,000 fpm, min 400 fpm inlet velocity). Provide supply air connection not less than the size as scheduled. All controls components including controller shall be supplied by the Owner to box manufacturer for factory installation. Provide factory installed hanger brackets, control transformer (refer to electrical drawings for primary electrical voltage) 2 by 2 junction box for unit electrical service. Controls shall be electronic for DDC application by controls vendor.
- B. Units shall have internal air resistance, including heating coil, not to exceed 0.4" w.g. at maximum flow.
- C. Provide external differential pressure taps separate from the control pressure taps for airflow measurement with a 0"-1" w.g. range.
- D. The damper actuator must be factory installed by box manufacturer. All required linkages must be furnished and factory-installed and performance tested by the box manufacturer. Provide control transformer, disconnect switch, etc., as required.
- E. Box maximum volumes shall be adjustable through DDC over the entire range of operation. Contractor shall verify all maximum and minimum volumes in the field.
- F. Provide a self-contained pressure-independent volume regulator to vary discharge CFM up to 3 inches W.G. duct static pressure. The box controls will be factory installed to satisfy specified control sequence.

- G. Set the damper linkages so that primary air delivered to the box varies from 100 percent to scheduled minimum, depending upon the cooling load.
- H. Housing: Shall be constructed of 22 gauge minimum galvanized sheet metal with mechanical seals and gaskets to minimize housing leakage. Housing shall be insulated with one inch (1"), dual density coated fiberglass sterilock insulation with foil facing to prevent fibers from entering the airstream and meeting the requirements of NFPA 90A and UL 181. Housing shall be provided with a round or oval inlet for use with hard duct as shown on the drawings (2000 fpm maximum velocity) and a rectangular outlet for slip and drive connection to sheet metal ductwork (1600 fpm maximum velocity).
- I. Casing Leakage: Assembled unit shall be so constructed and sealed to limit air leakage to the following listed quantities at 3" static pressure. If sealing is required to obtain the leakage performance seal as for medium pressure ductwork Hardcast 1602 or FOIL-GRIP 1402 tape may be used to seal lap joints and flat seams only. Leakage curves or tables will be required as part of the submittal data. The following is the maximum allowable casing leakage including all components:

Diameter	Maximum Allowed CFM (Area x 2000 fpm)	Maximum Allowable CFM Casing Leakage
4"-5"-6"	393	8.0
7"-8"	698	14.0
9"-10"	1091	22.0
11"-12"	1571	30.0
13'-14"	2138	40.0

- J. The following is the maximum damper leakage allowable for the various size diameter inlets. The damper leakage shall not exceed the values listed in the table below at 6" w.g. differential pressure, following ARI 880 Testing Procedures.

Maximum Allowed CFM Diameter	Maximum Allowable (Area x 2000 fpm)	CFM Casing Leakage
4"-5"-6"	393	6.0
7"-8"	698	10.5
9"-10"	1091	16.5
11"-12"	1571	20.0
13'-14"	2138	30.0

- K. Provide factory installed hanging brackets for supporting units from above.
- L. Limit installed unit discharge sound levels to NC-25 and radiated to NC-30, measured 8 feet in front of the box with a unlined duct attached and the box operating at 1-1/2 inch inlet static pressure. Refer to Schedules for units which are located above or adjacent to non-critical areas and may exceed only the limit on radiated sound levels.
- M. Provide electric heating coils as indicated on schedule. Coils shall have the maximum number of stages allowed by the heater size for the manufacturer. The air pressure drop across the coil shall not 0.10" w.g. Provide a separate coil for duct mounting if necessary to meet this requirement.

- N. Room temperature sensors BAS Contractor and installed under Section "Direct Digital Control System" 23 09 23.
- O. The BAS Contractor shall furnish a DDC Controller and an electronic inlet damper actuator for installation on each fan-powered box by the fan-powered box manufacturer. These DDC (Direct Digital Control) devices shall be delivered to the fan-powered box manufacturer's factory in sufficient time for the manufacturer to meet its scheduled delivery obligations. The fan-powered box manufacturer shall factory mount and connect these devices as required for proper operation as required under Division 23, Section 23 09 23 and 23 09 93. The cost of factory-mounting these devices shall be included in the cost of the fan-powered boxes.
- P. CONTROL PERFORMANCE: Assemblies shall be able to reset the primary air to any airflow between zero and the maximum CFM shown on Drawings. To allow for maximum flexibility and future changes, it shall be necessary to make only keyboard adjustments to arrange each unit for any maximum air flow within the ranges for each inlet size as scheduled on the Drawings. The control devices shall be designed to maintain the desired flow regardless of inlet flow deflection. All terminal units shall be installed with a minimum of two diameters of straight duct directly prior to the entry into each terminal unit connection. Units shall be capable of controlling air volume to within +/- 5% of air volume setpoint as determined by the zone temperature sensor demand with variations in inlet pressures from 0.10" to 6" w.g.
- Q. Unit air volume shall be set at the factory and provided such that special tools are not required for field adjustment.
- R. Power to and within the terminal unit shall be as noted on the schedule for a single-point connection. Provide necessary transformer for controls low-voltage power.
- S. CONTROL SEQUENCE: The control sequence arrangements shall be as described in the Sequence of Operation 23 09 93.
- T. DDC SYSTEMS:
- U. Electronic operators and controllers shall be installed by the terminal unit manufacturer. The Direct Digital Control System Trades and the Automation Contractor shall be responsible for the operational performance of the entire system. The terminal unit manufacturer shall be responsible for the performance of the mechanical components of the unit.
- V. MANUFACTURER: All Terminal Units shall be as manufactured by Titus, Nailor, Krueger, Metalaire or Price. No other manufacturers or models are acceptable. Even though specific manufacturers may be named herein, the material supplied by any approved manufacturer shall meet all of the provisions of this specification without exception.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Refer also to requirements included in Part 2 of this specification.
- B. Install in accordance with manufacturer's instructions. Provide manufacturer's recommended minimum straight duct inlet requirements.

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- C. Provide clearance for inspection, repair, replacement, and service. The mechanical contractor shall ensure all fan-powered VAV terminal unit controllers and operators are located with a minimum of 30" clear in the direction of maintenance from all obstructions (walls, pipes, etc.).
- D. Provide ceiling access doors or locate units above easily removable ceiling components.
- E. Support units individually from structure. Do not support from adjacent ductwork.
- F. Connect to ductwork in accordance with Section 23 31 00.
- G. Install heating coils in accordance with Section 23 82 16.

END OF SECTION 23 36 00

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SECTION 23 37 00 - AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 WORK INCLUDED

- A. Grilles, Registers and Diffusers

1.03 RELATED SECTIONS

- A. Section 09 91 00 - Painting: Painting of Ductwork Visible behind Outlets and Inlets
- B. Section 23 31 00 - Ductwork
- C. Section 23 33 00 - Ductwork Accessories

1.04 REFERENCES

- A. ADC 1062 - Certification, Rating and Test Manual
- B. AMCA 500 - Test Method for Louvers, Dampers and Shutters
- C. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilating Systems
- D. ARI 650 - Air Outlets and Inlets
- E. ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Outlets and Inlets
- F. SMACNA - Low Pressure Duct Construction Standard.

1.05 QUALITY ASSURANCE

- A. Test and rate performance of air outlets and inlets in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.
- B. Test and rate performance of louvers in accordance with AMCA 500.

C. REGULATORY REQUIREMENTS

- D. Conform to ANSI/NFPA 90A.

1.06 SUBMITTALS

- A. Submit product data under provisions of Section 23 00 00.

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- B. Provide product data for items required for this project.
- C. Submit schedule of outlets and inlets indicating type, size, location, application, airflow pattern and noise level.
- D. Review requirements of outlets and inlets as to size, finish, and type of mounting prior to submitting product data and schedules of outlets and inlets.
- E. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

PART 2 - PRODUCTS

2.01 AIR SUPPLIES AND RETURNS:

- A. Grilles, registers and ceiling outlets shall be as scheduled on the Drawings and shall be provided with sponge rubber or soft felt gaskets. If a manufacturer other than the one scheduled is used, the sizes shown on the Drawings shall be checked for performance, noise level, face velocity, throw, pressure drop, etc., before the submittal is made. Selections shall meet the manufacturer's own published data for the above performance criteria. The throw shall be such that the velocity at the end of the throw in the five foot occupancy zone will be not more than 50 FPM nor less than 25 FPM. Noise levels shall not exceed those published in the ASHRAE Guide for the type of space being served (NC level). Grilles, registers and ceiling outlets shall be Krueger, Titus, Nailor, Metalaire or Price.
- B. Locations of outlets on Drawings are approximate and shall be coordinated with other trades to make symmetrical patterns and shall be governed by the established pattern of the lighting fixtures or architectural reflected ceiling plan. Where called for on the schedules, the grilles, registers and ceiling outlets shall be provided with deflecting devices and manual damper. These shall be the standard product of the manufacturer, subject to review by the Architect, and equal to brand scheduled.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install items in accordance with manufacturers' instructions.
- B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement. Refer to Section 09 91 00.
- C. Install diffusers to ductwork with air tight connection.
- D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, regardless of whether dampers are specified as part of the diffuser, or grille and register assembly. Do not provide dampers at diffuser neck unless specifically called for on the drawings or in the schedules.
- E. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 91 00.

END OF SECTION 23 37 00

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SECTION 23 41 00 - FILTERS

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 SECTION INCLUDES

- A. Filters
- B. Housings and Frames
- C. Filter Gauges

1.03 RELATED SECTIONS

- A. Section 23 05 13 - Motors
- B. Section 23 07 13 - Ductwork Insulation
- C. Section 23 31 00 - Ductwork
- D. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- E. Section 26 27 26 - Wiring Devices and Floor Boxes

1.04 REFERENCES

- A. AMCA 99 - Standards Handbook
- B. AMCA 500 - Test Methods for Louver, Dampers, and Shutters
- C. NFPA 70 - National Electrical Code
- D. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
- E. ANST/UL-900 - Test Performance of Air Filter Units
- F. ASHRAE 52 - Method of Testing Air Cleaning Devices

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.

- B. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- C. Product Data:
 - 1. Provide literature which indicates dimensions, weights, capacities, ratings, performance, gauges and finishes of materials, and electrical characteristics and connection requirements.
 - 2. Provide data of media, performance data, assembly, and frames.
 - 3. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- D. Manufacturer's Installation Instructions.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience, who issues complete catalog data on total product.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.09 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation. During construction, if the air units operate at any time, minimum MERV 13 filters shall be installed and kept clean.
- B. Provide two sets of belts and three sets of filters for each unit. One set of filters to be installed when unit is started up and shall be protected from construction debris with additional media either at the first bank of filters, or covering each air intake (outside air and return air). Second set of filters to be installed when test and balance activities begin. At substantial completion,

TAMU shall inspect filters to determine if the third set should be installed or delivered to campus operations personnel. Tag to identify associated unit.

1.10 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide two sets for each unit of filters. Tag to identify associated unit.

1.11 SCHEDULES ON DRAWINGS:

- A. In general, all capacities and characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the owner. All equipment shall be shipped to the job with not less than a prime coat of paint or as specified hereinafter. Where installation instructions are not included in these Specifications or on the Drawings, the manufacturer's instructions shall be followed. All equipment affected by altitude shall be rated to operate at the altitude where it is installed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Type "A": Replaceable Dry type, Moderate Efficiency
 - 1. Farr 30/30 – Class I
- B. Type "B": Replaceable Dry Type Medium and/or High Efficiency (MERV 11 or 13)
 - 1. American Air Filter
 - 2. Cambridge
 - 3. Farr RIGA-FLO
- C. Side Access Housings
 - 1. Farr (4P) (3P) Universal Glide Pack
 - 2. American Air Filter
- D. Frames
 - 1. American Air Filter
 - 2. Farr Type 8
- E. Filter Gauges
 - 1. Dwyer "Magnehelic"
 - 2. Dwyer #25 Manometer
- F. Substitutions: Under provisions of Section 23 00 00. The equipment or material supplied by any of these acceptable manufacturers or an approved equal shall comply with all of the provisions of this specification.

2.02 GENERAL DESCRIPTION

- A. Configuration: Fabricate with fan(s), coils, etc. plus accessories, including:
 - 1. Filters
 - 2. Filter Housings and Frames
 - 3. Filter Gauges
- B. Performance Base: Sea level conditions.
- C. Fabrication: Conform to AMCA 99 and ARI 430.
- D. Performance: Refer to schedules.

2.03 FILTERS:

- A. All air filters shall be listed as (Class 1, Class 2) in accordance with Underwriters Laboratories, Inc., Building Materials Director requirements. All filters are to be rated in accordance with ASHRAE Test Standard 52-76 and performance characteristics are to be published in the manufacturer's literature. When specified performance characteristics are not published in the manufacturer's literature, the submittal data shall include certified documentation of performance by an approved independent test laboratory.
- B. Type "A": Replaceable, Dry Type, Moderate Efficiency: Filters shall be of the pleated media, disposable type, 1" (one inch), or 2" (two inches) deep in direction of airflow, Class 1 MERV 8. Each filter cell shall utilize a nonwoven, lofted cotton media with a net effective area of not less than 7.0 square feet of media per 1.0 square feet of filter face area, a media support grid, and enclosing high wet strength cell sides. The 96% free area welded wire support grid shall be continuously bonded to the leaving air face of the media to properly support the radially tapered, pleated media in the air stream through the life span of the filter. The media itself shall be cemented to the inside perimeter of the cell sides to prevent bypass of unfiltered air. Filter efficiency shall average not less than 25 to 30% when tested in accordance with ASHRAE Test Standard 52-76. Initial clean resistance to air flow shall not exceed 0.30" w.g. at 500 fpm filter face velocity. The 24" x 24" size shall be certified to have a dust holding capacity of not less than 265 grams of ASHRAE Test Dust when operated at 500 fpm to a final resistance of 1.0" w.g.
- C. Type "B": Replaceable, Dry Type, Medium and/or High Efficiency (minimum MERV 11 or 13): Filters shall be 12" deep of the extended surface, supported pleat type. Each filter shall consist of high density, microfine glass fiber media, media support grid, contour stabilizers, and enclosing galvanized steel frame. Media shall be laminated to a nonwoven synthetic backing to form a lofted surface for maximum dust holding capacity. The edges of the media shall be continuously bonded to the internal surfaces of the galvanized steel frame to prevent bypass of unfiltered air. Filter efficiency shall average not less than 60 to 65% when tested in accordance with ASHRAE Test Standard 52-76. Filters shall be 24" x 24" x 12" deep with an initial clean resistance not to exceed 0.50 inches w.g. at 500 fpm face velocity. The filters shall be certified to have a dust holding capacity of not less than 235 grams of ASHRAE Test Dust when operated at 500 fpm face velocity to a final resistance of 1" w.g.

2.04 HOUSINGS AND FRAMES

- D. Side access housings shall be fabricated of not less than 16 gauge galvanized steel. Housings shall each be equipped with hinged access doors at both ends, provision for receiving filters of

any manufacturer without alteration to the housings, and extruded aluminum channels capable of receiving both the after filters and 2" deep panel type prefilters. The housings shall incorporate a permanent provision for sealing the filters against leakage around the entire perimeter of each filter, eliminating the need to purchase replacement filters with factory applied gasket strips. Replaceable woven pile seals shall be an integral component of the downstream flange of each extrusion so that the seals are compressed by the pressure drop across the filters, preventing bypass of unfiltered air. Side access housing shall not exceed 12 inches in direction of air flow and shall be of all welded construction with factory prepunched standing flanges for ease of attachment to adjacent equipment and/or ductwork. Doors are to be fitted with positive sealing, heavy duty multiple latches and with sponge neoprene gaskets.

- E. Unitary front access holding frames shall be fabricated of not less than 16-gauge galvanized steel with holes pre-punched for convenient assembly into banks. Frames shall be a minimum of 2-5/8" deep for maximum structural strength and resistance to racking. All joints in the field-assembled banks of frames shall be thoroughly caulked to prevent bypass of unfiltered air between frames and surrounding ductwork or plenum chambers. Frames shall each be fitted with polyurethane foam gaskets, held in place by long lasting adhesive, and with a minimum of four heavy-duty spring type fasteners. Fasteners shall attach to the frames without requiring tools and shall be capable of withstanding 25 pounds of pressure without deflection.

2.05 FILTER GAUGES

- A. Each individual filter or filter bank handling 2,000 cfm or more shall be equipped with a diaphragm actuated dial and pointer type gauge with zero adjustment capability. The range of the scale shall be no greater than 1" w.g. above the filter manufacturer's recommended final resistance for the type of filter to which the gauge is being applied. Each gauge shall be provided with an adjustable signal flag, two static pressure tips with compression fittings, two three-way vent valves with compression fittings, two lengths of aluminum tubing, and a mounting plate with screws.
- B. Provide dry contact switch to indicate high-pressure limit (adjustable) for connection by others to BAS system.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
 - 1. Type "A" - Replaceable, Dry Type, Moderate Efficiency: Install 1" or 2" deep fiberglass throwaway filters at startup. Replace throwaway filters as required prior to final acceptance. At final acceptance, remove and discard the partially used throwaway filters and install a set of moderate efficiency filters. Furnish Owner with an additional set of unused moderate efficiency filters.
 - 2. Types "B" - Replaceable, Dry Type, Medium and/or High Efficiency: Install 2" (two inch) deep fiberglass throwaway filters at startup. Replace throwaway filters as required prior to final acceptance. At final acceptance, remove and dispose of the used throwaway filters. Install first set of medium and/or high efficiency filters and, where called for, required prefilters. Furnish Owner with an additional set of unused medium and/or high efficiency filters.

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- B. Install in conformance with UL 900.
- C. Assemble high-pressure units by bolting sections together.

END OF SECTION 23 41 00

SECTION 23 62 13 - PACKAGED AND SPLIT AIR COOLED DX AIR CONDITIONING UNITS

PART 1: GENERAL

1.01 Section Includes:

- A. Packaged rooftop air conditioners

1.02 REFERENCES

- A. AFBMA 9—Load Ratings and Fatigue Life for Ball Bearings.
- B. AMCA 99—Standards Handbook
- C. AMCA 210—Laboratory Methods of Testing Fans for Rating Purposes
- D. AMCA 300—Test Code for Sound Rating Air Moving Devices
- E. AMCA 500—Test Methods for Louver, Dampers, and Shutters.
- F. ARI 340/360 - Unitary Large Equipment
- G. ARI 430—Central-Station Air-Handling Units.
- H. ARI 435—Application of Central-Station Air-Handling Units.
- I. IBC 2000 – International Building Code
- J. NEMA MG1—Motors and Generators
- K. National Electrical Code.
- L. NFPA 70—National Fire Protection Agency.
- M. SMACNA—HVAC Duct Construction Standards—Metal and Flexible.
- N. UL 900—Test Performance of Air Filter Units.

1.03 SUBMITTALS

- A. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics and connection requirements.
- B. Product Data:
 - 1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, and electrical characteristics and connection requirements.
 - 2. Provide computer generated fan curves with specified operating point clearly plotted.
 - 3. Manufacturer's Installation Instructions.

1.04 OPERATION AND MAINTANENCE DATA

- A. Maintenance Data: Provide instructions for installation, maintenance and service

1.05 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience, who issues complete catalog data on total product.
- B. Startup must be done by trained personnel experienced with rooftop equipment.
- C. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters and remote controls are in place, bearings lubricated, and manufacturers' installation instructions have been followed.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site.
- B. Accept products on site and inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. VAV Rooftop Unit Basis of Design: McQuay International
 - 1. Trane
 - 2. Carrier
 - 3. York
 - 4. AAON

2.02 GENERAL DESCRIPTION

- A. Furnish as shown on plans, McQuay Maverick Singlezone Heating and Cooling Unit(s) model MPS. Unit performance and electrical characteristics shall be per the job schedule.
- B. Configuration: Fabricate as detailed on prints and drawings:
 - 1. Return plenum / economizer section
 - 2. Filter section
 - 3. Cooling coil section
 - 4. Supply fan section
 - 5. Electric heating section.
 - 6. Condensing unit section
- C. The complete unit shall be ETL/CETL listed
- D. Each unit shall be specifically designed for outdoor rooftop application and include a weatherproof cabinet. Each unit shall be completely factory assembled and shipped in one piece. Packaged units shall be shipped fully charged with Refrigerant 410A and oil.
- E. The unit shall undergo a complete factory run test prior to shipment. The factory test shall include final balancing of the supply fan assemblies, a refrigeration circuit run test, a unit control system operations checkout, a unit refrigerant leak test and a final unit inspection.
- F. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.
- G. Performance: All scheduled capacities and face areas are minimum accepted values. All scheduled amps, kW, and HP are maximum accepted values that allow scheduled capacity to be met.
- H. Warranty: The manufacturer shall provide 12-month parts only warranty. Defective parts shall be repaired or replaced during the warranty period at no charge. The warranty period shall commence at startup or six months after shipment, whichever occurs first.
- I. The manufacturer shall provide extended 48-month, parts only, warranty on the compressor.

2.03 CABINET, CASING, AND FRAME

- A. Panel construction shall be double-wall construction for all panels. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to protect insulation during service and maintenance. Insulation shall be a minimum of 1" thick with an R-value of 4.0, and shall be neoprene coated glass fiber. Panel design shall include no exposed insulation edges. Unit cabinet shall be designed to operate at total static pressures up to 5.0 inches w.g.
- B. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long term durability. Paint finish to include a base primer with a high quality, polyester resin topcoat of a neutral beige color. Finished panel surfaces to withstand a minimum 750-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance.
- C. Service doors shall be provided on the fan section and the filter section in order to provide user access to unit components. All service access doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system. Removable service panels secured by multiple mechanical fasteners are not acceptable.
- D. The unit base shall overhang the roof curb for positive water runoff and shall seat on the roof curb gasket to provide a positive, weathertight seal. Lifting brackets shall be provided on the unit base to accept cable or chain hooks for rigging the equipment.

2.04 SUPPLY FAN

- A. Supply fan shall be a single width, single inlet (SWSI) airfoil centrifugal fan. The fan blade design shall be a double blade with the airfoil geometry, a backward inclined blade fan wheel design will not be acceptable. The fan wheel shall be Class II construction with aluminum fan blades welded to the back plate and end rim. The supply fan shall be mounted using solid-steel shafts and wheel hubs with mating keyways
- B. The fan assembly shall have fixed pitched drives with a minimum of two belts. The drives shall be selected with a minimum diameter of 4 inches and a 1.2 service factor. The belts shall be of the grip-notch design.
- C. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment. All fan assemblies shall employ solid steel fan shafts. Heavy-duty pillow block type, self-aligning, grease lubricated ball bearings shall be used. Bearings shall be sized to provide a L-50 life at 250,000 hours. The entire fan assembly shall be isolated from the fan bulkhead and mounted on 1" spring isolators.
- D. Fan motors shall be heavy-duty 1800 rpm open drip-proof (ODP) type with grease lubricated ball bearings. Motors shall be premium efficiency. Motors shall be mounted on an adjustable base that provides for proper alignment and belt tension adjustment. Motors shall be suitable for use with a variable frequency drive.
- E. The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled designed airflow. The fan shall not operate in a state of surge at any point within the modulation range.

2.05 VARIABLE AIR VOLUME CONTROL

- A. An electronic variable frequency drive shall be provided for the supply air fan. Each drive shall be factory installed out of the air stream in a conditioned cabinet. Drives shall meet UL Standard 95-5V. The completed unit assembly shall be listed by a recognized safety agency, such as ETL. Drives are

to be accessible through a hinged door assembly. Mounting arrangements that expose drives to high temperature unfiltered ambient air are not acceptable.

- B. The unit manufacturer shall install all power and control wiring.
- C. The supply air fan drive output shall be controlled by the factory installed main unit control system and drive status and operating speed shall be monitored and displayed at the main unit control panel.

2.06 ELECTRICAL

- A. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with the unit shall be number and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance. A GFI receptacle shall be unit mounted. The receptacle shall require a field power connection independent from the unit's main power block and / or disconnect.
- B. A single non-fused disconnect switch shall be provided for disconnecting electrical power at the unit. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle.

2.07 HEATING AND COOLING SECTIONS

- A. The direct expansion (DX) coil section shall be installed in a draw through configuration, upstream of the supply air fan. The coil section shall be complete with a factory piped cooling coil and an ASHRAE 62.1 compliant double sloped drain pan.
- B. Direct expansion (DX) cooling coils shall be fabricated of seamless high efficiency copper tubing that is mechanically expanded into high efficiency aluminum plate fins. Coils shall be a multi-row, staggered tube design with a minimum of 6 rows for maximum dehumidification effect. All units shall have two independent refrigerant circuits and shall use an interlaced coil circuiting that keeps the full coil face active at all load conditions. All coils shall be factory leak tested with high pressure air under water.
- C. A positively sloped drain pan shall be provided with the cooling coil. The slope of the drain pan shall be in two directions and comply with ASHRAE Standard 62.1. The drain pan shall have a minimum slope of 1/8" per foot to provide positive draining. The drain pan shall extend beyond the leaving side of the coil. The drain pan construction shall be a stainless steel design. The drain pan shall be connected to a threaded drain connection extending through the unit base. Drain pan shall be removable from the side of the unit without the removal of the cooling coil.
- D. The rooftop unit shall include an electrical resistance heating coil section. Staged electric heating coil modules shall be factory installed downstream of the supply air fan in the heating section of the rooftop unit. Heating coils shall be constructed of a low watt density, nickel - chromium alloy

resistance wire with intermediate supports that include ceramic bushings. The electrical contactors shall be of the full line-breaking type with all the electrical power legs being disconnected when the contactors are not energized. All electrical circuit wiring shall be designed with copper conductors, aluminum wires are not acceptable. Heating element branch circuits shall be individually fused to a maximum of 48 Amps per NEC requirements. The power supply for the electric heater shall be factory wired into the units main power block or disconnect switch.

- E. The heating modules shall have an automatic reset, high temperature limit safety protection. A secondary high limit protection shall also be provided that requires a manual reset. An airflow switch shall be provided with the heating module to prevent the electric heater from operating in the event of no airflow.
- F. The electric heat elements shall be controlled by the factory installed DDC unit control system. Field installed heating modules shall require a field ETL certification. Duct heaters mounted within the rooftop unit in the field shall not be acceptable. The manufacturer's rooftop unit ETL certification shall cover the complete unit including the electric heating modules

2.08 FILTERS

- A. Unit shall be provided with a draw-through filter section. The filter rack shall be designed to accept a 2" prefilter and a 4" final filter (60-65%). The unit design shall have a hinged access door for the filter section. The manufacturer shall ship the rooftop unit with 2" construction filters. The contractor shall furnish and install, at building occupancy, the final set of filters per the contract documents.

2.09 OUTDOOR / RETURN AIR SECTION

- A. A return air plenum shall be provided with a 0 to 30% outdoor air hood. The hood shall allow outdoor air to enter at the back of the return air plenum. The outdoor air hood shall be factory installed and constructed from galvanized steel finished with the same durable paint finish as the main unit. The hood shall include moisture eliminator filters to drain water away from the entering air stream. The return air plenum shall allow return air to enter from the bottom of the unit. The outdoor air damper shall be controlled by a factory installed direct coupled actuator. The unit controller shall control the actuator to an outdoor air position setpoint that is adjustable from 0 to 30%. Upon unit shut down during unoccupied periods the outdoor air damper shall be power driven closed.
- B. Damper blades shall be gasketed with side seals to provide an air leakage rate of no more than 4 cfm / square foot of damper area at 1" differential pressure per ASHRAE 90.1 Energy Standard. Leakage rate to be tested in accordance with AMCA Standard 500. Damper blades shall be operated from multiple sets of linkages mounted on the leaving face of the dampers.

2.10 CONDENSING SECTION

- A. Condenser coils shall be an all aluminum design. The aluminum tube shall be a micro channel design with high efficiency aluminum fins. Fins shall be brazed to the tubing for a direct bond. Each condenser coil shall be factory leak tested with high-pressure air under water. Condenser coils shall be protected from incidental contact to coil fins by a coil guard. Coil guard shall be constructed of cross wire welded steel with PVC coating

- B. Condenser fans shall be direct drive, axial type designed for low tip speed and vertical air discharge. Condenser fan rpm shall be 1140 rpm maximum. Fan blades shall be constructed of steel and riveted to a steel center hub. Condenser fan motors shall be heavy-duty, inherently protected, three-phase, non-reversing type with permanently lubricated ball bearing and integral rain shield.
- C. Each circuit shall have fan cycling of at least one condenser fan to maintain positive head pressure. An ambient thermostat shall prevent the refrigeration system from operating below 0° F.
- D. Condenser coils shall be protected from hail damage as an integral part of the unit design. Hail guards shall be provided on all units with vertical mounted condenser coils.
- E. Each unit shall have multiple, heavy-duty scroll compressors. Each compressor shall be complete with gauge ports, crankcase heater, sight-glass, anti-slug protection, motor overload protection and a time delay to prevent short cycling and simultaneous starting of compressors following a power failure. Compressors shall be isolated with resilient rubber isolators to decrease noise transmission
- F. Each unit shall have two independent refrigeration circuits. Each circuit shall be complete with a low pressure control, filter-drier, liquid moisture indicator/sight-glass, thermal expansion valve, and a manual reset high pressure safety switch. The thermal expansion valve shall be capable of modulation from 100% to 25% of its rated capacity. Sight-glasses shall be accessible for viewing without disrupting unit operation. Each circuit shall be dehydrated and factory charged with Refrigerant 410A and oil
- G. Each refrigeration circuit shall have isolation ball valves on the suction and discharge sides of the compressor.

2.11 ROOF CURB

- A. A prefabricated 14-gauge galvanized steel, mounting curb shall be provided for field assembly on the roof decking prior to unit shipment. The roof curb shall be a full perimeter type with complete perimeter support of the air handling section and condensing section. The curb shall be a minimum of 14" high and include a nominal 2" x 4" wood nailing strip. Gasket shall be provided for field mounting between the unit base and roof curb. Roof slope shall be considered in the construction of the curb to ensure proper leveling of the unit.

2.12 CONTROLS

- A. The Controls shall be integratable with the building automation system.
- B. Provide a complete integrated microprocessor based Direct Digital Control (DDC) system to control all unit functions including temperature control, scheduling, monitoring, unit safety protection, including compressor minimum run and minimum off times, and diagnostics. This system shall consist of all required temperature sensors, pressure sensors, controller and keypad/display operator interface. All MCBs and sensors shall be factory mounted, wired and tested.
- C. The stand-alone DDC controllers shall not be dependent on communications with any on-site or remote PC or master control panel for proper unit operation. The microprocessor shall maintain existing set points and operate stand alone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures. All factory and user set schedules and control points shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.

- D. The DDC control system shall permit starting and stopping of the unit locally or remotely. The control system shall be capable of providing a remote alarm indication. The unit control system shall provide for outside air damper actuation, emergency shutdown, remote heat enable/disable, remote cool enable/disable, heat indication, cool indication, and fan operation.
- E. All digital inputs and outputs shall be protected against damage from transients or incorrect voltages. All field wiring shall be terminated at a separate, clearly marked terminal strip.
- F. The DDC controller shall have a built-in time schedule. The schedule shall be programmable from the unit keypad interface. The schedule shall be maintained in nonvolatile memory to insure that it is not lost during a power failure. There shall be one start/stop per day and a separate holiday schedule. The controller shall accept up to sixteen holidays each with up to a 5-day duration. Each unit shall also have the ability to accept a time schedule via BAS network communications.
- G. The keypad interface shall allow convenient navigation and access to all control functions. The unit keypad/display character format shall be 4 lines x 20 characters. All control settings shall be password protected against unauthorized changes. For ease of service, the display format shall be English language readout. Coded formats with look-up tables will not be accepted. The user interaction with the display shall provide the following information as a minimum:
 - 1. Return air temperature
 - 2. Discharge air temperature
 - 3. Outdoor air temperature
 - 4. Space air temp
 - 5. Dirty filter indication
 - 6. Airflow verification
 - 7. Cooling status
 - 8. Control temperature (Changeover)
 - 9. VAV box output status
 - 10. Cooling status/capacity
 - 11. Unit status
 - 12. All time schedules
 - 13. Active alarms w/time and date
 - 14. Previous alarms with time and date
 - 15. Optimal start
 - 16. System operating hours
 - a. Fan
 - b. Exhaust fan
 - c. Cooling
 - d. Individual compressor
 - e. Heating
 - f. Economizer
 - g. Tenant override
- H. The user interaction with the keypad shall provide the following setpoints as a minimum:
 - 1. Controls mode
 - a. Off manual

- b. Auto
- c. Heat/cool
- d. Cool only
- e. Heat only
- f. Fan only
2. Occupancy mode
 - a. Auto
 - b. Occupied
 - c. Unoccupied
 - d. Tenant override
3. Unit operation changeover control
 - a. Return air temperature
 - b. Space temperature
 - c. Network signal
4. Cooling and heating change-over temperature with deadband
5. Cooling discharge air temperature (DAT)
6. Supply reset options
 - a. Return air temperature
 - b. Outdoor air temperature
 - c. Space temperature
 - d. Airflow (VAV)
 - e. Network signal
 - f. External (0-10 vdc)
 - g. External (0-20mA)
7. Temperature alarm limits
 - a. High supply air temperature
 - b. Low supply air temperature
 - c. High return air temperature
8. Lockout control for compressors
9. Compressor interstage timers
10. Night setback and setup space temperature
11. Building static pressure
12. Economizer changeover
 - a. Enthalpy
 - b. Drybulb temperature
13. Current time and date
14. Tenant override time
15. Occupied/unoccupied time schedule
16. One event schedule
17. Holiday dates and duration
18. Service mode
 - a. Timers normal (all time delays normal)

- b. Timers fast (all time delays 20 sec)
 - I. If the unit is to be programmed with a night setback or setup function, an optional space sensor shall be provided. Space sensors shall be available to support field selectable features. Sensor options shall include:
 - 1. Zone sensor with tenant override switch
 - 2. Zone sensor with tenant override switch plus heating and cooling set point adjustment. (Space Comfort Control systems only)
 - J. To increase the efficiency of the cooling system the DDC controller shall include a discharge air temperature reset program for part load operating conditions. The discharge air temperature shall be controlled between a minimum and a maximum discharge air temperature (DAT) based on one of the following inputs:
 - 1. Airflow
 - 2. Outside air temperature
 - 3. Space Temperature
 - 4. Return air temperature
 - 5. External signal of 1-5 VDC
 - 6. External signal of 0-20 mA
 - 7. Network signal
- 2.13 PTAC Unit
- A. Basis of Design: Frigidaire
 - 1. Trane
 - 2. Carrier
 - 3. York
 - 4. Others
 - B. Provide PTAC unit as noted with Wireless t-stat, architectural outdoor grille and insulated wall sleeve. Coordinate wall opening with Architect. Unit shall be BAS compatible so that it can be turned on and off through the BAS.

END OF SECTION 23 62 13

SECTION 23 63 13 – VARIABLE REFRIGERANT VOLUME DX SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes split-system air-conditioning and heat pump units consisting of multiple evaporator-fan and variable capacity compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

1.2 SUBMITTALS

- A. Product Data: For each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics including:
 - 1. Piping schematics with intended piping line lengths indicated on the drawings (piping plan to be coordinated between manufacturer and contractor prior to submittal. Generic piping schematics are not acceptable). The manufacturer shall include notes on the piping schematics indicating locations where expansion loops shall be installed.
 - 2. Wiring schematics showing electrical connection requirements, and field control wiring terminations.
 - 3. Field refrigerant charge volume shall be noted along with factory charge. Note schedule limitations.
 - 4. Manufacturer's performance data shall reflect specified conditions. Nominal capacities are not acceptable. Ratings shall allow for piping lengths, scheduled ambient temperatures, etc.
- B. Operation and maintenance data.
- C. Contractor must have completed the manufacturer's installation training. The contractor shall submit a copy of the training completion certificate for the project manager and at least 2 pipe installers with this submittal.

1.3 QUALITY ASSURANCE

- A. The units shall be listed by the Electrical Laboratories (ETL) and bear the cETL label.
- B. All wiring shall be in accordance with the National Electric Code (NEC).
- C. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings." Provide certified efficiency ratings per AHRI-1230 standard. (DOE Waiver is not acceptable) Scheduled EER and IEER ratings scheduled shall be considered minimum efficiency allowed.

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- D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings." Provide certified efficiency ratings per AHRI-1230 standard. (DOE Waiver is not acceptable) Scheduled COP ratings scheduled shall be considered minimum efficiency allowed.
- E. Units shall be designed to operate with HCFC-free refrigerants.

1.4 WARRANTY

- A. All VRF equipment and controls shall be warranted by the manufacturer for a period of 5 years from the date of startup. (Startup not to exceed 6 months from delivery). The warranty shall include both parts and labor and refrigerant. The condensing units shall include an additional 5 years (total of 10 years) of parts only warranty covering the entire condensing unit.
- B. All warranty shall be executed by the manufacturer's authorized representative. Contractor warranty shall not be allowed.
- C. Copies of the warranty paperwork and startup documentation shall be submitted upon close out of the installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Daikin AC
 - 2. Mitsubishi

2.2 GENERAL DESCRIPTION

- A. The variable capacity, heat recovery and/or heat pump air conditioning system shall be a Variable Refrigerant Volume (heat and cool model) split system as specified. The system shall consist of multiple evaporators, branch selector boxes, manufacturer supplied refrigerant joints and headers, a two or three pipe refrigeration distribution system using PID control, and matched variable speed outdoor condensing units. The outdoor unit is a direct expansion (DX), air-cooled heat recovery/heat pump, multi-zone air-conditioning system with variable speed driven compressors using R-410A refrigerant. All zones are each capable of operating separately with individual temperature control.
- B. Where heat recovery is specified, operation of the system shall permit either individual cooling or heating of each fan coil simultaneously or all of the fan coil units associated with one branch cool/heat selector box. See drawings for Branch Selector locations and associated fan coil units.

- C. Branch selector (BS) boxes shall be located as shown on the drawing. The branch selector boxes shall have the capacity to control up to 96 MBH (cooling) down stream of the BS box. The BS box shall consist of five electronic expansion valves, refrigerant control piping and electronics to facilitate communications between the BS box and main processor and between the BS box and fan coils. The BS box shall control the operational mode of the subordinate fan coils. The use of five EXV's ensures continuous heating during defrost, no heating impact during changeover and reduced sound levels. If solenoid valves in the selector box cause a "clicking" sound upon changeover, then the contractor shall be required to provide additional acoustic wrapping of the box until sound levels are acceptable to the owner and engineer.
- D. The indoor units shall be connected to the condensing unit utilizing manufacturer specified piping joints and headers to ensure correct refrigerant flow and balancing. T style joints are not acceptable. All joints shall be installed per manufacturer's instructions.
- E. Equipment capacities to meet leaving air temperatures (LAT) and Total and Sensible capacities as scheduled.

2.3 EVAPORATOR-FAN UNIT – HORIZONTAL DUCTED

- A. Concealed Horizontal Ducted Unit Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
- B. Indoor unit shall be a built-in ceiling concealed fan coil unit, operable with refrigerant R-410A, equipped with an electronic expansion valve, direct-drive DC (ECM) type fan with auto CFM adjustment at commissioning, for installation into the ceiling cavity. It is constructed of a galvanized steel casing. It shall be available in capacities scheduled. It shall be a horizontal discharge air with horizontal return air configuration. All models feature a low height cabinet making them applicable to ceiling pockets that tend to be shallow. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. Included as standard equipment, a condensate drain pan and drain pump kit that pumps to 18-3/8" from the drain pipe opening.
- C. INDOOR UNIT:
 - 1. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall be equipment with automatically adjusting external static pressure logic that is selectable during commissioning. This adjusts the airflow based on the installed external static pressure.
 - 2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
 - 3. All refrigerant lines shall be insulated from the outdoor unit.
 - 4. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 18-3/8" of lift from the center of the drain outlet.
 - 5. The indoor units shall be equipped with a return air thermistor.

6. The indoor unit will be powered with 208~230V/1-phase/60Hz. (single point)
7. The voltage range will be 253 volts maximum and 187 volts minimum.

D. UNIT CABINET:

1. The cabinet shall be located into the ceiling and ducted to the supply and return openings.
2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

E. FAN:

1. The fan shall be direct-drive DC (ECM) type fan, statically and dynamically balanced impeller with three fan speeds available.
2. The unit shall be equipped with an automatically adjusting external static pressure logic selectable during commissioning.
3. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range of 0.12 to 0.47 HP respectively.
4. The airflow rate shall be available in three settings.
5. The fan motor shall be thermally protected.
6. The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings.

F. COIL:

1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
3. The coil shall be a 3 row cross fin copper evaporator coil with 13 fpi design completely factory tested.
4. The refrigerant connections shall be flare connections and the condensate will be 1-1/4" outside diameter PVC.
5. A condensate pan shall be located under the coil.
6. A condensate pump with a 18-3/8" lift shall be located below the coil in the condensate pan with a built in safety alarm.
7. A thermistor will be located on the liquid and gas line.

G. ELECTRICAL:

1. A separate single point power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
2. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
3. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.

H. FILTERS:

1. The units shall be provided with an accessory rear return filter housing (field installed). If filter return grills are indicated on the drawing then this accessory is not required.
2. Provide minimum MERV 8 filter during construction. Contractor to install clean MERV 8 filters just prior to owner acceptance.

2.4 EVAPORATOR-FAN UNIT – VERTICAL DUCTED

- A. General: Indoor unit shall be a floor mounted vertical or horizontal right air handling unit, operable with refrigerant R-410A, equipped with an electronic expansion valve and direct-drive ECM type fan with auto CFM adjustment, for installation within a conditioned space. When installed in a vertical configuration it shall have top discharge air and bottom return air. When installed in a horizontal right configuration it shall have a horizontal discharge air and horizontal return air. The unit shall have a remote mounted temperature sensor or be installed with a thermostat equipped with a thermister in the controller. Return air sensor is not adequate for this unit. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition.
- B. INDOOR UNITS – VERTICAL CABINET:
1. The indoor unit components shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, brazed connections, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
 2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
 3. Both refrigerant lines shall be insulated from the outdoor unit.
 4. Return air shall be through an optional field supplied filter housing or via filter return grills as detailed on the drawings. Contractor to install a minimum of MERV 8 filter during construction and replace with a clean MERV 8 filter immediately prior to owner acceptance.
 5. Condensate draining shall be made via gravity or external condensate pump.
 6. The indoor unit will require a single point 208-230V/1/60 power connection.
 7. Voltage range will be 253 Volt max and 187 volt minimum.
- C. UNIT CABINET:
1. The cabinet shall be constructed with sound absorbing, foil-faced insulation to control air leakage.
 2. Select an installation location with adequate structural support, space for service access and clearance for air return and supply duct connections
- D. FAN:
1. The fan shall be a direct-drive Sirocco type fan, statically and dynamically balanced impeller with high and low fan speeds available.
 2. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range 0.2 to 0.5 HP
 3. The airflow rate shall be available in high setting.
 4. The fan motor shall be thermally protected.
- G. COIL:
1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
 2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.

1. The coil shall be a 4-row cross fin copper evaporator coil with 15 fpi design completely factory tested.
2. The refrigerant connections shall be brazed connections and the condensate will be 3/4 inch outside diameter PVC.
3. A thermistor will be located on the liquid and gas line

H. ELECTRICAL:

1. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
2. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
3. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet

I. CONTROL:

1. The unit shall have controls provided by manufacturer to perform input functions necessary to operate the system.
2. The unit shall be compatible with the manufacturer's central controller detailed further in this specification.

2.5 EVAPORATOR-FAN UNIT – DUCTLESS CASSETTE

- A. Ceiling cassette fan coil units shall be equipped with an electronic expansion valve for installation into the ceiling cavity. It shall be a round flow air distribution type. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition.
- B. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, condensate safety shutoff and alarm, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
- C. Return air shall be through the concentric panel, which includes a resin net, mold resistant, antibacterial filter.
- D. The indoor units shall be equipped with a condensate pan with antibacterial treatment and condensate pump. The condensate pump provides up to 20" of lift and has a built in safety shutoff and alarm.
- E. Units shall be equipped with a return air thermistor.
- F. Units shall utilize a factory mounted occupancy sensor. The occupancy sensor shall enable a setpoint reset function for energy savings by allowing the school district to change the setpoint based on both occupied and unoccupied times. This requirement shall be by the VRF equipment provider and not by BAS.

2.6 WALL MOUNTED FAN COIL UNIT

- A. General: indoor unit shall be a wall mounted fan coil unit, operable with refrigerant R-410A, equipped with an electronic expansion valve, for installation onto a wall within a conditioned space. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. A mildew-proof, polystyrene condensate drain pan and resin net mold resistant filter shall be included as standard equipment. The indoor units sound pressure shall range from 31 dB(A) to 41 dB(A) at low speed measured at 3.3 feet below and from the unit.
- B. Performance: Each unit's performance is per the scheduled capacities.
- C. Indoor Unit:
1. The indoor unit shall be factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart. The drain pipe can be fitted to from either left or right sides.
 2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
 3. Both refrigerant lines shall be insulated from the outdoor unit.
 4. Return air shall be through a resin net mold resistant filter.
 5. The indoor units shall be equipped with a condensate pan.
 6. The indoor units shall be equipped with a return air thermistor.
 7. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.
 8. The voltage range will be 253 volts maximum and 187 volts minimum.
- D. Unit Cabinet:
1. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.
 2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
- E. Fan:
1. The fan shall be a direct-drive cross-flow fan, statically and dynamically balanced impeller with high and low fan speeds available.
 2. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range 0.054 to 0.058 HP.
 3. The airflow rate shall be available in high and low settings.
 4. The fan motor shall be thermally protected.
- F. Coil:
1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
 2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.

3. The refrigerant connections shall be flare connections and the condensate will be 1 1/16 inch outside diameter PVC.
4. A thermistor will be located on the liquid and gas line.
5. A condensate pan shall be located in the unit.

2.6 AIR-COOLED VARIABLE REFRIGERANT VOLUME CONDENSING UNIT

- A. Outdoor units shall be provided for either 460/3/60 or 230/3/60 as scheduled.
- B. VFD Inverter Control – Each condensing unit shall use a high efficiency, variable speed “inverter” compressor coupled with inverter fan motors for superior part load performance. Compressor capacity shall be modulated automatically to maintain constant suction and condensing pressures while varying the refrigerant volume for the needs of the cooling or heating loads.
- C. Systems shall use a field installed 16 or 18 AWG, 2-wire, stranded, non-shielded and non-polarized daisy chain control wiring to interconnect the condensing units, branch selectors, and fan coil units.
- D. Systems shall include a self diagnostic, auto-check function to detect a malfunction and display the type and location.
- E. Condensing unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, and refrigerant regulator.
- F. Units shall be capable of operating down to zero degree F ambient air.
- G. The following safety devices shall be included on the condensing unit; high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
- H. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.
- I. The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed milled steel panels coated with a baked enamel finish.
- J. Condenser fan shall be direct drive motors that have multiple speed operation via a DC (digitally commutating) inverter.
- K. CONDENSER COIL:
 1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.

2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
 3. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.
 4. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film type E1.
 5. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.
- L. COMPRESSOR:
1. The inverter scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency or STD ON/OFF) shall be controlled to eliminate deviation from target value.
 2. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll "G2-type" with a maximum speed of 7,980 rpm.
 3. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
 4. The capacity control range shall be as low as 4% to 100%.
 5. Each non-inverter compressor shall also be of the hermetically sealed scroll type.
 6. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
 7. Oil separators shall be standard with the equipment together with an intelligent oil management system.
 8. The compressor shall be spring mounted to avoid the transmission of vibration.
 9. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours.

2.7 BRANCH SELECTOR BOXES (HEAT RECOVERY SYSTEMS)

- A. ISOLATION VALVES - Full port, bi-directional flow isolation valves shall be installed upstream of all Branch Selector boxes. Where multi-port boxes are used, provide isolation valves both upstream and downstream of the box to facilitate isolation of individual fan coil units. Ensure Schrader fitting is positioned on the downstream side of the valve.
- B. Where heat pump systems are used, provide isolation valves at the fan coils.
- C. During simultaneous heating and cooling, the units in heating mode shall energize their subcooling electronic expansion valve.

D. CONSTRUCTION:

1. The Branch Selector boxes shall have a galvanized sheet plate casing.
2. Each Branch Selector shall house 5 electronic expansion valves for refrigerant control. (Multi-port boxes shall maintain independent EEV construction. Sharing of valves between zones is not allowed)
3. Where multiple boxes are installed on the same system, the piping shall be such that isolation of one box shall not disrupt refrigerant flow to other boxes. "Pass through" of refrigerant should not be used where isolation for service will prevent usage of other zones.
4. The cabinet shall contain a subcooling heat exchanger.
5. The unit shall have a sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.
6. All pipe connections shall be brazed type.
7. Branch Selectors shall not require condensate drains.

E. ELECTRICAL:

1. The unit electrical power shall be 208-230 Volt, 1 phase, 60 Hz.
2. The control voltage between the indoor and condensing unit shall be 16 Volt DC.

2.8 CONTROLS

A. ZONE CONTROLLER – Each zone/FCU shall include a 7-Day Programmable controller with the following features:

1. Backlit LCD display. Day of the week as well as time of day configurable for 12/24 hour clock shall be displayed. Display of temperature information shall be Fahrenheit. The controller shall be able to display and adjust room temperature in one degree increments.
2. The controller shall have COOL, HEAT, FAN ONLY, DRY (dehumidification), and AUTO-CHANGE-OVER modes.
3. For AUTO change over mode, the controller shall allow independent setpoints for heating and cooling to eliminate wide swings in temperature and unnecessary change over. Independent setpoint control shall be available at both local controller and the central controller
4. Setback function shall be included with adjustable setback temperature override.
5. The programmable controller shall have the capability of individually disabling the following buttons:
 - a. Menu/OK
 - b. ON/OFF
 - c. Mode
 - d. Fan Speed
 - e. Setpoint Adjustment (Up/Down Keys) (Set point adjustment shall be in 1 deg F increments)
6. The controller shall allow for a local (controller-level) adjustable limitation of user setpoint range.
7. SCHEDULING: (Schedules shall be controlled via the BAS Interface - See control sequence.)

8. The Remote Controller shall display error codes on the screen in the event of a system error.
9. The following Fan Coil Unit sensor values shall be available at the wall mounted remote controller:
 - a. Controller thermistor temp
 - b. (Refrigerant) Liquid line temperature
 - c. (Refrigerant) Gas line temperature
10. 48 Hour battery back up of clock/date. All other settings shall be stored in non-volatile memory to ensure that settings are not lost upon power failure.

B. CENTRAL CONTROLLER

1. The building shall be installed with a web-enabled factory native central controller. The manufacturer native controller shall provide web users to manipulate the following functions:
 - a. On/Off Control
 - b. Schedule-Adjustment
 - c. Mode Selection – See control sequence for heat/cool changeover control
 - d. Setpoint Control (Independent heating and cooling setpoints available)
 - e. Operational Status and Alarm Notifications
 - f. Provide with battery backup and USB port for software updates
 - g. User and Administrator Levels with password protection.
 - h. Customize groups and zones

C. CONTROL SEQUENCE:

1. The VRF system shall be provided with required hardware and software to perform the core operational sequences detailed in this section.
2. The VRF manufacturer shall be responsible for all low voltage communication wiring between their components and central controller to facilitate these sequences. If the wiring is done by the installing mechanical contractor and/or the building automation contractor, the VRF manufacturer shall coordinate all wiring requirements.
3. The VRF central controller shall be provided onsite as a touch screen panel located in the administration office (or as directed by the client). It shall additionally be capable of being accessed on the internet via an owner provided IP address and Ethernet connection. All functions detailed below shall be available via touch screen interface and internet access.
4. Display interface: The controller shall provide a floor plan layout of the building with the fan coil icons and temperature information visible on the screen. At commissioning, the fan coil units shall have the tagging updated to provide the applicable room numbers for the as-built installation. The visual interface shall provide clear indication of what fan coil units are connected to which particular condensing unit system.
5. The controller shall combine all indoor units onto a single central controller interface. The central controller shall provide these basic functions per zone:
 - a. Alarm Identification per fan coil unit.
 - b. Min/Max set point limiting

- 1) Heating set point and cooling set points shall be controlled individually
- 2) Set points shall be adjustable at the zone level with adjustable limits controlled by the VRF central controller (initial programming shall limit cooling setpoint control to between 73 – 76 deg. Heating initial range to be 69 – 72 deg)

Timed override for after-hours air conditioning: During periods where the building is not in use (determined by the system schedule) the fan coil units shall be capable of being turned on at the wall mounted controller. The VRF system shall automatically turn off after 60 minutes (adj) of operation.

- c. When the system is off according to the schedule, the VRF controller shall cycle the cooling/heating if the temperatures exceed the unoccupied threshold temperatures. (85 cooling & 60 heating)
6. Heat/Cool Automatic Changeover Sequence:
- a. The VRF manufacturer's controller shall manage the heat/cool changeover automatically. The local thermostat MODE button shall be disabled by VRF central controller.
 - b. Requirement of manual change-over of heat/cool mode is not acceptable.
 - c. Each zone/fan coil unit shall have minor set point adjustment per the zone controller detail above. The central VRF controller shall monitor each fan coil unit connected to the heat pump condensing unit and compare the current temperature to the unit's set point. The central controller shall make the heat/cool mode changes for the group of fan coils based on the weighted average of their demand.
 - 1) Example – All zones are satisfied (system idle) and the system has heating mode enabled. Any fan coil on the system that has a space temperature rise above the active set point will result in a central enabling of the cooling mode.
 - 2) Individual fan coil units (or groups) should be capable of being assigned a higher priority if directed. This would allow heating/cooling needs of these units to drive the heat/cool mode changes.

PART 3 - C

3.1 INSTALLATION

- A. Mechanical contractor must complete an accredited installation training class prior to starting the installation. The contractors PM and piping foreman must each have certification.
- B. Installation shall be per manufacturer's recommendations. Extra care shall be provided to allow for expansion and contraction of piping. Contractor shall install expansion joints on gas lines per the manufacturer's recommendations.

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- C. UNDER NO CIRCUMSTANCE SHALL THE FAN COIL UNITS BE OPERATED BEFORE STARTUP OR WITHOUT SPECIFIED FILTERS IN PLACE.

3.2 FIELD QUALITY CONTROL

- A. The installing contractor shall complete the installation and complete a total system pressure test of 550 psi for 24 hours prior to startup.
- B. THE MANUFACTURER OR MANUFACTURER'S AGENT SHALL BE RESPONSIBLE FOR ALL EVACUATION AND CHARGING OF REFRIGERANT FOR EACH SYSTEM AT STARTUP. CONTRACTOR STARTUP IS NOT ALLOWED.
- C. The manufacturer's agent shall provide the following startup services:
1. Evacuation of the piping system to a 400 micron vacuum (hold 3 hours)
 2. Proper charging of the system with R-410A **Refrigerant provided and installed by the installing contractor**
 3. Execution of all standard diagnostics.
 4. Connection to the system with the manufacturer's Service Checker software and creating an operational log of the following information for verification:
 - a. Each system operates with proper temperatures, delta T and superheat conditions in both cooling and heating modes.
 - b. Each fan coil unit is heating/cooling properly (verification that piping work has been installed properly).
 5. A digital copy of these operational logs shall be stored by the manufacturer's agent as well as delivered to the owner with warranty documentation.

END OF SECTION 23XXXX

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SECTION 23 73 25 - HEAT RECOVERY UNITS

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 SECTION INCLUDES

- A. Packaged Heat Recovery Units
- B. DX Condensing Units
- C. Factory Installed Fans
- D. Dampers
- E. Filters
- F. Coils
- G. Drives
- H. Heat Recovery Wheels

1.03 RELATED SECTIONS

- A. Section 21 05 48 - Vibration Isolation
- B. Section 22 13 16 - Plumbing Piping: Equipment Drains
- C. Section 23 05 13.- Motors
- D. Section 23 05 16 - Expansion Compensation
- E. Section 23 07 13 - Ductwork Insulation
- F. Section 23 29 23 – Variable Speed Drives
- G. Section 23 31 00 - Ductwork
- H. Section 23 33 00 - Ductwork Accessories: Flexible Duct Connections
- I. Section 23 34 16 - Centrifugal Fans
- J. Section 23 41 00 - Filters
- K. Section 23 82 16 - Air Coils
- L. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- M. Section 26 27 26 - Wiring Devices and Floor Boxes

1.04 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings
- C. AMCA 99 - Standards Handbook
- D. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes
- E. AMCA 300 - Test Code for Sound Rating Air Moving Devices
- F. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices
- G. AMCA 500 - Test Methods for Louver, Dampers, and Shutters
- H. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
- I. ARI 430 - Central-Station Air-Handling Units
- J. ARI 435 - Application of Central-Station Air-Handling Units
- K. NEMA MG1 - Motors and Generators
- L. NFPA 70 - National Electrical Code
- M. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
- N. UL 900 - Test Performance of Air Filter Units

1.05 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Include with the initial submittal a letter signed by the manufacturer's national sales manager (or any corporate officer) and the production manager, acknowledging that this equipment is intended for a University of Texas facility and that all specification requirements shall be complied with. Submit copy of letter to OFPC engineer.
- C. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, electrical characteristics, connection requirements, and.
- D. Product Data:
 - 1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gauges and finishes of materials, electrical characteristics and connection requirements.
 - 2. Provide data of filter media, filter performance data, filter assembly, and filter frames as tested and certified per ASHRAE standards.
 - 3. Provide fan curves with specified operating point clearly plotted, as tested and certified per AMCA standards. Ratings to include system effects.

Bare fan ratings will not satisfy this requirement, but shall be submitted for comparison purposes.

4. Submit sound power level data for both fan outlet and casing radiation at rated capacity, as tested and certified per AMCA standards.
5. Provide data on all coils as tested and certified per ARI standards.
6. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
7. All materials shall have NFPA-90 rating of 25/50 or better.

E. Manufacturer's Installation Instructions.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.07 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience, who issues complete catalog data on total product.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.09 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation of the Owner's RCM.

1.10 EXTRA MATERIALS

- A. Furnish under provisions of Section 23 00 00.
- B. Provide two sets of belts and three sets of filters for each unit. - One set of filters is to be installed when unit is started up, and shall be protected from construction debris with additional media either at the first bank of filters, or covering each air

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intake (outside air and return air). The second set of filters is to be installed when test and balance activities begin. At substantial completion, OFPC RCM shall inspect filters to determine if the third set should be installed or delivered to campus operations personnel. Tag to identify associated unit.

1.11 SCHEDULES ON DRAWINGS:

- A. In general, all capacities of equipment, and motor and starter characteristics are shown in schedules on the Drawings. Reference shall be made to the schedules for such information. The capacities shown are minimum capacities. Variations in the capacities of the scheduled equipment supplied under this contract will be permitted only with the written direction of the owner. All equipment shall be shipped to the job with not less than a prime coat of paint or as specified hereinafter. Insofar as is possible, all items of the same type (i.e., pumps, fans, etc.) shall be by the same manufacturer. Where installation instructions are not included in these Specifications or on the Drawings, the manufacturer's instructions shall be followed. All equipment affected by altitude shall be rated to operate at the altitude where it is installed.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Munters
- B. Substitutions: Under provisions of Section 23 00 00. The equipment as supplied by any of the acceptable manufacturers or an approved equal shall comply with all of the provisions of this specification.

2.02 GENERAL DESCRIPTION

- A. Configuration: Fabricate with fan and coil sections as scheduled plus accessories, including:
 - 1. Intake section
 - 2. Filter section
 - 3. Condensing Unit
 - 4. Total Energy Wheel Section
 - 5. Preheat Section
 - 6. Cooling coil section
 - 7. Sensible Energy Wheel Section
 - 8. Supply Fan
 - 9. Bypass damper section
 - 10. Relief Filter Section

11. Relief Fan
 12. Motors and control
- B. Performance Base: Sea level conditions
 - C. Fabrication: Conform to AMCA 99 and ARI 430 in the absence of direction in this specification.
 - D. Performance: Refer to schedule in drawings.

2.03 HEAT RECOVERY UNIT CASING AND GENERAL CONSTRUCTION:

- A. Unit casing exterior (walls and roof) shall be a minimum 18-gauge thickness galvanized steel insulated internally, throughout (double wall construction with no thru metal). Internal insulation shall have an R-value of at least 12, with foil facing, neoprene or anti-microbial hardcoat protected unless specifically noted otherwise, and shall be fire and fungus proof. Insulation shall conform to NFPA standard 90 requirements. All internal insulation shall be protected with solid ASTM A653 G90 galvanized sheet metal, of a minimum of 20-gauge thickness. All sheet metal joints throughout the air handler, and between panelized sections, shall be gasketed with closed cell, soft rubber gaskets, fabricated from neoprene, EPDM, or other approved material. Internal walls and roof outside shall be sealed such that there is no passage of air from inside the unit to the outer casing. Casing shall be designed for outdoor installation and use.
- B. Individual panels of the fan section shall be removable without compromising the integrity of the unit. Casing assembly shall be configured to eliminate all thru-metal in portions of the unit subject to below ambient temperatures. Where fasteners are used in the assembly of the unit components, they shall not extend from the outside of the unit into the air stream.
- C. Drain pan liners shall be double walled and constructed of No. 14-gauge 316-L stainless steel or heavier as standard with the manufacturer and shall be non-skid. Drain pan shall extend past the cooling coil (leaving airside) into the fan section on draw through units. Entire drain pan shall be insulated with R-8 minimum rigid insulation. Insulation thickness shall be no less than 2". Drain pans shall be sloped to the outside edge of the unit. On units over six feet wide, slope to each side of the unit. The insulation shall be installed and sealed as is appropriate for the equipment construction. Condensate connection shall be no smaller than 1".
- D. Unit shall have a complete perimeter channel base of at least 6" galvanized steel or 6" carbon steel with marine quality primer. All floors shall be insulated with R-12 insulation with 14-gauge non-skid galvanized floor (or equivalent aluminum). An 18-gauge galvanized sheet shall enclose and form a vapor barrier for the insulation on the bottom of the unit. If a foamed-in-place closed cell insulation is used, the lower metal enclosure may be eliminated. All points of contact between the floor, vapor barrier and structure shall be thermally isolated with gasketing of closed cell soft rubber or EPDM.

- E. Access doors shall be provided to allow access to both sides (upstream and downstream) of the filter racks, into the fan section, and both sides of all coils. Access doors shall be double wall, insulated the same as wall panels, and the opening framed with thermal break construction. Door size shall be at least 18" wide and full height of the panel up to 5' 0" tall. The construction of the access doors shall equal or exceed the quality and quantity of the air handler casing materials as specified herein. Each door shall have a minimum of an 8-inch by 6-inch double-glazed view window, capable of withstanding the total developed pressure of the unit. The doors shall be hinged using either heavy-duty stainless butt hinges, or a continuous stainless steel piano hinge, extending along the entire edge of the door, except for a maximum of two inches at each end. If butt hinges are used, provide two per door for up to 36" high doors and three per door for longer doors. There shall be a minimum of two latches on doors longer than 18," and three latches in doors over 36" long. Latches shall be Ventlok 310, heavy-duty latch, or approved equal. All access doors shall open against air pressure. All access doors shall be located on the outside air path side of the unit. The relief side of the unit and all components within shall be accessed through doors between the outside air path side and the relief air side.
- F. Coils in the air-handling units shall be individually removable from the inside of the unit and shall not be used to provide structural stability for the casing. All coils shall be arranged for and piped to provide counterflow operation. The coils shall be completely enclosed within the coil housing of the air unit casing. Coil penetrations of the housing shall have rubber grommets and be fully sealed for pressurization and insulated from the casing insulation. All other penetrations of the air handler casing shall be neatly sealed using a resilient sealant. Hinged gasketed quick access doors of adequate size for a man to enter shall be provided for each space between coils, filters and other components. Stacked coils shall have intermediate drain pans with at least 1" rigid drain piping and pipe supports to main drain pan.
- G. Panels shall be reinforced with sufficient internal bracing to prevent excessive deflection of the panels. Maximum deflection at joint on the unit casing shall be limited to L /250th of the overall panel width or height.
- H. Unit manufacturer shall submit full sound performance data. Unit shall be finally configured to not exceed the room NC values in Section 13 48 00.
- I. Provide a unit housing, including joints, seams, and access doors, that will not condense moisture on the external surfaces of this housing when subjected to a surrounding ambient environment of 82°F dry-bulb/71°F dew-point temperature air.
- J. Equivalent aluminum material may be used where galvanized steel panel components are called for.

- K. Provide sealable test ports on either side of each filter bank and each coil section, in inlet plenum and discharge plenum, and suction and discharge side of all fans. Ports shall be equal to Ventfabrics test port Model 699-2.

2.04 FANS: (See also Section 23 34 16)

- A. Shall be both dynamically and statically balanced. Housed fans shall be equipped with quick opening access doors in the fan scroll. Motors shall be high efficiency type per Section 23 05 13. The motor mounting for each unit shall be an integral part of the fan support frame. The fan/motor unit shall be mounted on spring isolators within the air handler casing. Housed fans shall have an appropriately designed fabric duct vibration isolator installed within the air handler casing. The unit shall be supplied with a factory installed and sealed flange for connection to ductwork. For belt drive units, manufacturer shall provide fixed sheave on units of 10 HP and larger. Contractor shall provide one additional sheave set, size to be determined after job-operating conditions are known. The additional sheave set shall be of equivalent quality to that originally installed by the manufacturer.
- B. The fan unit bearings shall be of the antifriction type, either ball or roller, lubricated at the factory, and shall be equipped with means for lubrication with a grease fitting on the outside of the bearing housing. Both inboard and outboard bearings shall be the same, identical size. The bearings shall be a catalogued type as manufactured by Fafnir, SKF, Sealmaster, or approved equal, and stocked locally. Bearings shall have an L-10 minimum life of 200,000 hours. Intermediate bearings will not be acceptable. Grease fittings for bearings shall be remotely mounted within line of sight of the bearing, where possible. Where it is not possible, then the fitting shall be mounted where it is most easily accessible for service. The tubing used for remoting the fitting shall be stainless steel, installed with a strain relief pigtail approximately 4 inches in diameter and located on the drive side of the assembly.
- C. After assembly, the unit manufacturer shall balance the fan (per ANSI/AMCA 204-96 fan application category BV-3) at design fan speed with belts and drives in place to a vibration velocity less than or equal to 0.157 inches (0.100 inches for direct-drive applications) per second measured on horizontal, vertical, and axial planes at each bearing pad. Vibration amplitudes are in inches/second peak velocity. All values recorded are to be filter-in at the fan speed.
- D. Plug fans installed in walk-in units shall be provided with a safety cage around the wheel or with a fan shut down switch in the access door. Cage shall be large enough to allow working room for wheel and bearing service and shall have removable sections to allow wheel removal.

2.05 DAMPERS

- A. Mixing Boxes: Section with factory built, factory mounted outside and return air dampers of galvanized steel and edge seals in galvanized frame, with galvanized steel axles in self-lubricating nylon bearings, in opposed blade arrangement with

damper blades positioned across short air opening dimension. Provide removable, full width rack for supporting freeze protection thermostat, with removable end panel to permit rack removal.

- B. Damper Leakage: Maximum 4 CFM/Sq. Ft. at 4 inch WG differential pressure. Dampers shall be sized for 2000 fpm maximum face velocity.
- C. Refer to Section 23 33 00-2.01 for additional requirements.

2.06 DRIVES:

- A. V-belt drives: Shall be designed for a minimum of 50% overload. Where more than one belt is required, matched sets shall be used. All belt drives shall be furnished with belt guards.
- B. Variable speed drives: See Section 23 29 23. Drive supplied shall be tested at the AHU factory with motor provided and balanced. This testing shall be witnessed by a representative of the Owner's Test and Balance Consultant.

2.07 COILS:

- A. Refer to Section 23 82 16 - Air Coils, and Unit Schedules for requirements.

2.08 ENERGY RECOVERY WHEEL:

- A. General: Wheel shall have capacities and ratings as scheduled and shall be rated by the manufacturer.
- B. Rotor Assembly: Rotor shall consist of hub and bearing assembly, spokes and rim. Wheels built larger than 10' diameter shall be built in no less than 8 sections. Each set of media shall be supported by spokes and tensioned in place by the rim.
- C. Rim tensioning: Each section of the wheel shall be tensioned independently.
- D. Spoke System: Spokes shall provide the structural integrity to limit deflection of the wheel and to eliminate mechanical fatigue of the media. Spokes shall be made of aluminum fashioned in the form of an "I" beam for added strength. Each spoke shall have grooves which correspond to matching grooves machined into the media.
- E. Rim System: The rim shall hold each section of media in place and provide an area for the belts that drive the wheel to ride. Rims shall be made of extruded aluminum and have "V" shaped grooves for the drive belts and corresponding ridges on the inside diameter that fit into grooves machined in the media.
- F. Hub & Bearing System: The hub and bearing system shall support the wheel in the frame. Hubs shall be machined from steel or aluminum. The roller bearings shall be oversized and externally tapered with easily accessible grease fittings.

- G. Casing Frame Structure: The structural frame shall be designed in two or more sections to provide a rigid structure capable of supporting the rotor. It shall be capable of being supported at each end without any additional support in the center.
- H. Seal System: Seals shall be strong, flexible and not move once set in place. There shall be an extruded aluminum strip that is secured to the wheel frame and an extruded rubber seal which shall be permanently attached to the aluminum strip. Seals shall be bolted in place.
- I. Motor Drive System: The motor drive system shall use gravity to hold belts in place. The motors shall be variable speed drive with "V" belts. The motor shall be monitored through the BAS for current to alarm if the motor fails or if the belt breaks.
- J. Control System: The control system shall be provided with the wheel and shall be compatible with the Seimans system that the University currently is using. The system shall measure the temperatures of the two air streams and control wheel speed for maximum efficiency.
- K. Media: The media shall be able to transfer both heat and moisture between the air streams. The media shall be a balanced sieve media with a 4A desiccant for high performance and contaminant control performance tested with ASHRAE Standard 84-91 and ARI Standards 1060-2000. Media shall be supplied with an Anti-corrosion/anti-mold coating.

2.09 FILTERS:

- A. Refer to Section 23 41 00 - Filters, and Unit Schedules for requirements.

2.10 ELECTRICAL

- A. Fan motors shall be factory-mounted and wired to an external disconnect switch adjacent to the motor access door. Fan motors shall be interlocked with fan access door to shut down when door is opened.
- B. Vapor proof lights (ceiling or wall mounted so that fixture shall be no higher than 88" above floor) shall be provided in each compartment with access doors for units with fan motor horsepower totaling over 10HP. Lights shall have a switch at each door into the compartment. Provide two GFI convenience outlets evenly spaced on the long dimension of the unit. Wire lights and outlets to two external 120v, 20a power connections (one for each service) for connection by Division 26.
- C. All wiring shall be 600v rated type MTW/THWN stranded copper in EMT or LiquidTite conduit (max 3 feet). All junction boxes shall be UL approved and gasketed.
- D. Motors – see Section 23 05 13 for additional requirements.

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2.11 FINISH

- A. All external parts of the unit shall be Brite G-90 galvanized. No painting will be required.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Field assembly of the unit shall be the responsibility of the manufacturer.
- B. Install in conformance with ARI 435.

3.02 TESTING

- A. Units with cabinet mounted fans shall be tested and certified at rated conditions using AMCA 210 and AMCA 300 test procedures with fan mounted in the cabinet.
- B. Fan/Motor Vibration Test. With the unit set in place, leveled, and ductwork attached, the manufacturer shall perform a final dynamic vibration trim balance to verify the fan/motor vibration velocity limit over the following operating speed range: Fans with VFDs shall be checked from 40 to 110% of the rated fan speed. Constant speed fans shall be checked at 100% of rated fan speed. 'Lock-out' ranges may be used to correct up to two ranges of excess vibration. The span of each 'lock-out' range shall be limited to an effective fan speed of 50 RPM. Any 'lock-out' range used shall be clearly identified in the test report and shall be prominently displayed on a typed, laminated legend mounted inside the VFD controller cabinet. This testing shall be witnessed by a representative of the Owner's Test and Balance firm.
- C. Failure of the trim balance to confirm vibration limit shall require rebalancing and re-testing until criteria is met. Contractor shall bear all costs involved in the modifications, balancing, and re-testing, including travel and hourly costs associated with the representatives of the Owner's Test and Balance firm.

END OF SECTION 23 73 25

SECTION 23 82 16 - AIR COILS

PART 1 - GENERAL

1.01 THE FOLLOWING SECTIONS ARE TO BE INCLUDED AS IF WRITTEN HEREIN:

- A. Section 23 00 00 – Basic Mechanical Requirements
- B. Section 23 05 29 – Sleeves, Flashings, Supports and Anchors
- C. Section 23 05 53 – Mechanical Identification

1.02 SECTION INCLUDES

- A. DX coils
- B. Electric coils
- C. This section does not include coils to be provided with the room vertical fan coil units. Vertical fan coil unit coils shall be specified within the fan coil unit specifications. This section applies only to the coils within the first floor air handling unit and the penthouse outside air handling unit.

1.03 RELATED SECTIONS

- A. Section 23 07 19 - Piping Insulation
- B. Section 23 06 20 - Hydronic Specialties
- C. Section 23 31 00 - Ductwork: Installation of duct coils
- D. Section 23 09 00 - Controls and Instrumentation
- E. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- F. Section 26 27 26 - Wiring Devices and Floor Boxes

1.04 REFERENCES

- A. ANSI/ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils
- B. ANSI/NFPA 70 - National Electrical Code
- C. ANSI/UL 1096 - Electric Central Air Heating Equipment
- D. SMACNA - HVAC Duct Construction Standards, Metal and Flexible

1.05 SUBMITTALS

- A. Submit shop drawings under provisions of Section 23 00 00.

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- B. Submit shop drawings indicating coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.
- C. Submit product data under provisions of Section 23 00 00.
- D. Submit product data indicating coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.
- E. Submit manufacturer's installation instructions under provisions of Section 23 00 00.
- F. Submit manufacturer's certificate under provisions of Section 23 00 00 that coils are tested and rated in accordance with ANSI/ARI 410.

1.06 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Section 23 00 00.
- B. Store and protect products under provisions of Section 23 00 00.
- C. Protect coil fins from crushing and bending by leaving in shipping cases until installation, and by storing indoors.
- D. Protect coils from entry of dirt and debris with pipe caps or plugs.

PART 2 -PRODUCTS

2.01 DX COILS:

- E. Provide DX coils as noted in the specifications.

2.02 ELECTRIC COIL:

- A. Furnish and install as indicated Electric duct heaters as manufactured by Brasch Manufacturing Company, Inc., St. Louis, Missouri or approved equal as manufactured by Chromalox, Indeeco or Nailor. Voltage, size, wattage, number of steps and accessories shall be provided as indicated herein and on the Drawings.
- B. Heaters shall be U.L. Listed for zero clearance and meet all the applicable requirements of the National Electrical Code.
- C. All resistance coil terminals and nuts shall be made of stainless steel, and terminal insulators and bracket bushings shall be made of high grade ceramic and securely positioned. Resistance wire shall be iron free, 80% nickel and 20% chromium. Bracket supports for the resistance wire shall be reinforced with stiffening ribs and gussets, and spaced no more than four inches apart. Heaters shall be tested dielectrically for 1000V plus twice the rated voltage or 2000V, whichever is higher.

- D. Electric heaters shall be of the slip-in flanged type and shall be suitable for mounting in a horizontal or vertical duct, and air flow through the heater in either direction. Heaters shall be made with galvanized steel frame. A terminal box shall be provided on the unit with solid cover.
- E. Heaters shall be furnished for volts and phases as scheduled. Three phase heaters shall be furnished with balanced three phase load. The control voltage shall be 120 volts or as scheduled and transformers with primary fuse protection shall be provided in the terminal box for each heater when the control voltage is not the same as the unit feeder voltage. Heaters shall be furnished for step control as scheduled using magnetic contactors on all steps not line switched by thermostats and air flow switches.
- F. Heaters shall be supplied with overcurrent protection per NEC. Overcurrent protection shall consist of one built in automatic circuit. A disc type automatic reset thermal cutout shall be furnished for primary overheating protection. Secondary protection fusible links shall be provided to de-energize the elements in case the primary cutout fails. Both devices shall be serviceable through the terminal box without having to remove the heater from the duct.
- G. All duct heaters shall be sized to fit the duct in which they are installed and located at least 48" (forty-eight inches) from any turn, transition, tap, damper, or other fittings in the duct run. Heaters installed in internally lined ductwork shall be provided with a recessed terminal box and extra wide flanges to have the heater face area fit the inside dimensions of the duct insulation. Terminal boxes shall not be insulated except as specifically noted.
- H. Provide factory mounted and wire pressure sensitive type air flow switch for each heater to allow the heater to be "on" only when sufficient air is blowing through the heater.
- I. Provide thermostats suitable for operating the heaters in accordance with the control requirements indicated herein and on the Drawings.
- J. Heaters and protection devices shall be arranged for single point connection.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in ducts and casings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- C. Support coil sections independent of piping on steel channel or double angle frames and secure to casings. Provide frames for maximum three coil sections. Arrange supports to avoid piercing drain pans. Provide airtight seal between coil and duct or casing.
- D. Protect coils to prevent damage to fins and flanges. Comb out bent fins.
- E. Make connections to coils with unions and flanges.

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- F. Wire electric duct coils in accordance with ANSI/NFPA 70. Refer to Electrical Specification Sections 26.
- G. Provide drain pan and drain connection for cooling coils. Fabricate drain pan from minimum 18-gauge 316L stainless steel. Extend 3 inches from face of coil entering air side, 18 inches from face of coil leaving air side. Pipe drain pans individually to floor drain with water seal trap.
- H. Insulate headers located outside air flow as specified for piping. Refer to Section 23 07 19.

END OF SECTION 23 82 16

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SECTION 23 82 19 - UNIT HEATERS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 GENERAL

- A. Perform all work required to provide and install unit heaters indicated by the Drawings with supplementary items necessary for proper installation.

1.03 REFERENCES

- A. NFPA 70 – National Electrical Code.
- B. ASHRAE 90.1 – 2001 – “Energy Standard for Buildings Except Low-Rise Residential Buildings”.
- C. ARI 440-98 – “Room Fan-Coils”.
- D. ANSI/UL-883 – “Safety Standards for Fan Coil Units and Room Fan Heater Units”.
- E. NFPA 90A – “Standard for the Installation of Air Conditioning and Ventilation Systems”.

1.04 SUBMITTALS

- A. Shop Drawings: Submit under provisions of Section 23 00 00. Indicate materials and methods of assembly, unit dimensions, weight loading, required clearances, field connection details, electrical characteristics and dimensional views as required to adequately describe the unit.
- B. Product Data: Submit under provisions of Section 23 00 00.
- C. Submit product data indicating typical catalog of information including dimensions, weights, capacities, ratings, fan performance, gages and finishes of materials, electrical characteristics and connection requirements.
- D. Submit fan curves with specified operating point clearly plotted. The fan curves shall clearly demonstrate that the fan coil unit will operate stably within the range of performance scheduled.
- E. Submit coil performance data as tested and certified per ARI standards.

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- F. Submit electrical requirements for power supply wiring, clearly indicating factory-installed and field-installed wiring.
- G. The submittal shall indicate that all materials meet NFPA 90 flame/smoke spread levels of 25/50 or better.
- H. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

1.05 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three years documented experience.

1.06 REGULATORY REQUIREMENTS

- A. Conform to ANSI/NFPA 70 code and Underwriter's Laboratories, Inc. for internal wiring of factory wired equipment.
- B. Conform to ANSI/UL-883 for safety standards.
- C. Unit heaters shall meet the efficiency requirements listed in ASHRAE Standard 90.1-2004.

1.07 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to site under provisions of Section 15010.
- B. Store and protect products under provisions of Section 15010.
- C. Protect units from physical damage by storing in protected areas and leaving factory covers in place.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Reznor
- B. Modine
- C. Trane
- D. Carrier
- E. Sterling
- F. Approved Equal.

2.02 GENERAL DESCRIPTION

- A. Coils:

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1. Provide electric heating coils.
 - B. Casing: 18-gauge steel with threaded pipe connections for hanger rods.
 - C. Finish: Factory applied baked enamel of a color as selected by the Architect on visible surfaces of enclosure or cabinet.
- 2.03 Fan:
- A. Direct drive propeller type, statically and dynamically balanced, with fan guard.
 - B. Horizontal models with permanently lubricated sleeve bearings.
 - C. Vertical models with grease lubricated ball bearings.
 - D. Air Outlet: Adjustable pattern diffuser on projection models and four way louvers on horizontal throw models.
- 2.04 Motor:
- A. Refer to Section 23 05 13.
 - B. Horizontal models with permanently lubricated sleeve bearings.
 - C. Vertical models with grease lubricated ball bearings.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that surfaces are ready to receive work and opening dimensions are as indicated on shop drawings.
- B. Verify that required utilities are available, in proper location and ready for use.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's written instructions.
- B. Hang unit heaters from building structure with pipe hangers anchored to the building, not from piping. Mount units as high as possible to maintain greatest headroom unless otherwise indicated. Refer to Section 23 05 48 for vibration isolation.
- C. Install unit heaters (equipment exposed to finished areas) after walls and ceiling are finished and painted. Avoid damage.
- D. Protect units with protective covers during balance of construction.
- E. Provide hydronic units with shut-off valve on supply and lockshield balancing valve on return piping. If not easily accessible, extend vent to exterior surface of cabinet for easy servicing. For cabinet unit heaters, and unit heaters, provide float operated automatic air vents with stop valve.

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F. Leave adequate room to access and service all components.

3.03 CLEANING

A. After construction and painting is completed, clean exposed surfaces of units.
Vacuum clean coils and inside of cabinets.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

C. Install new filters after Substantial Completion.

3.04 RECORD DRAWINGS

A. Submit Operation and Maintenance Drawings in accordance with the requirements of Section 23 00 00.

B. Submit Record Drawings in accordance with the requirements of Section 23 00 00.

END OF SECTION