

SECTION 23 00 00

BASIC MECHANICAL REQUIREMENTS

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 DOCUMENTS:

- A. THE UNIFORM GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS, and DIVISION 01 of the Specifications apply to the work specified in this Section.
- B. All work covered by this Section of these Specifications shall be accomplished in accordance with all applicable provisions of the Contract Documents and any addenda or directives which may be issued herewith, or otherwise.

1.03 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.

- 1.04 DEFINITIONS:** (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.)

- A. CONCEALED / EXPOSED: Concealed 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.
- B. 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.
- C. 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.
- D. 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.
- E. 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.
- F. 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.
- G. 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."
- H. 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."
- I. 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."

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

1.05 PERMITS, UTILITY CONNECTIONS AND INSPECTIONS:

- A. General: Refer to DIVISION 01 for construction phasing and time increments.
- B. Fees and Costs: Refer to Division 01 for payment requirements of fees and utility costs.
- 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, refer to Division 01 for responsibility.
- 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.

1.06 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.

1.07 FUTURE WORK

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

1.08 SUBMITTALS

- A. Refer to Uniform General Conditions.
- B. Proposed Products List: Include Products specified in the following Sections:
 - 1. Section 23 05 29 - Sleeves, Flashings, Supports and Anchors
 - 2. Section 21 12 00 – Fire Protection Systems
 - 3. Section 21 13 13 – Wet Pipe Fire Sprinkler System

- 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.

1.09 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 manufacturer's 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.
- 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.

1.10 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.

1.11 FLAME SPREAD PROPERTIES OF MATERIALS:

- A. Materials and adhesives incorporated in this project to be installed within return air plenums 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.

1.12 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. 13, Sprinkler System, Installation
 - 2. NFPA No. 14, Standpipes and Hose Systems
 - 3. NFPA No. 20, Centrifugal Fire Pumps
 - 4. NFPA No. 37, Stationary Combustion Engines & Gas Turbines
 - 5. NFPA No. 45, Fire Protection for Laboratories Using Chemicals
 - 6. NFPA No. 51, Welding & Cutting, Oxygen-Fuel Gas Systems
 - 7. NFPA No. 54, Gas Appliances, Piping, National Fuel Gas Code
 - 8. NFPA No. 70, National Electrical Code
 - 9. NFPA No. 72D, Proprietary Signaling Systems
 - 10. NFPA No. 78, Lightning Protection Code
 - 11. NFPA No. 90A, Air Conditioning Systems
 - 12. NFPA No. 91, Blower & Exhaust Systems
 - 13. NFPA No. 99, Health Care Facilities
 - 14. NFPA No. 101, Life Safety Code
 - 15. NFPA No. 200, Series, Building Construction
 - 16. NFPA No. 255, Method of Test of Surface Burning Characteristics of Building Materials

27. 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. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA): All current editions of applicable manuals and standards (See Sections 23 31 00.UT and 23 33 00.UT).
- H. Air Moving and Conditioning Association (AMCA): All current editions of applicable manuals and standards.
- I. American Society of Testing Materials (ASTM): All current editions of applicable manuals and standards.
- J. American Water Works Association (AWWA): All current editions of applicable manuals and standards.
- K. National Electrical Manufacturers' Association (NEMA): All current editions of applicable manuals and standards.
- L. City of Houston, Fire Department as may be applicable to construction on this site.
- M. International Building Code, (Includes the International Mechanical and International Plumbing Codes)
- N. Texas Occupational Safety Act: All applicable safety standards
- O. Occupational Safety and Health Act (OSHA)
- P. 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.
- Q. Texas State Fire Marshal Rules
- R. State Energy Code
- S. Refer to Specification Sections hereinafter bound for additional Codes and Standards.

- T. All materials and workmanship shall comply with all applicable state and national codes, Specifications, and industry standards. In all cases where Underwriters' Laboratories, Inc. have 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.
- U. 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.

1.13 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. Nameplates: Each major component of equipment shall have the manufacturer's name, address, and catalog number on a plate securely attached to the item of equipment. All data on nameplates shall be legible at the time of Final Inspection.
- E. 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.
- F. Protection from Moving Parts: Belts, pulleys, chains, gears, couplings, projecting set screws, keys, and other rotating parts shall be fully enclosed or properly guarded for personnel protection.

- G. 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.

1.14 WALL, FLOOR AND CEILING PLATES:

- A. See Section 23 05 29.

1.15 SLEEVES, INSERTS, AND FASTENINGS:

- A. See Section 23 05 29.

1.16 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 Architect/Engineer before proceeding.

1.17 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 manufacturers' 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 manufacturers' directions or such instructions from the Architect/Engineer, he shall bear all costs arising in connection with the deficiencies.

1.18 SPACE AND EQUIPMENT ARRANGEMENT:

- A. The size of mechanical and electrical equipment indicated on the Drawings is based on the dimensions of a particular manufacturer and a particular model. While other manufacturers and models may be acceptable, it is the responsibility of the Contractor to determine if the equipment he proposes to furnish will fit in the space with all adequate clearances. Fabrication Drawings shall be prepared when required by the Architect/Engineer or Owner to indicate a suitable arrangement.
- B. All equipment shall be installed in a manner to permit access to all surfaces. All valves, motors, drives, filters, and other accessory items shall be installed in a position to allow removal for service without disassembly of another part.

1.19 LARGE APPARATUS:

- A. Any large piece of apparatus which is to be installed in any space in the building, and which is too large to permit access through stairways, doorways, or shafts shall be brought to the job and placed in the space before the enclosing structure is completed. Following placement in the space, such apparatus shall be thoroughly, completely protected from damage as hereinafter specified.

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 (including Controls and Testing and Balancing), 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.

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 nor 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".

Building lines
Structural Members
Soil and Drain Piping
Condensate Drains
Vent Piping
Supply, Return, and Outside Air Ductwork
Exhaust Ductwork
HVAC Water and Steam Piping
Steam Condensate Piping
Fire Protection Piping
Natural Gas Piping
Domestic Water (Cold and Hot)
Refrigerant Piping
Electrical Conduit

1.26 CONNECTIONS FOR OTHERS:

- A. The Mechanical Contractor shall rough in for and make all gas, water, steam, sewer, etc. connections to all fixtures, equipment, machinery, etc., provided by others in accordance with detailed roughing-in Drawings provided by the equipment suppliers, by actual measurements of the equipment connections, or as detailed.
- B. After the equipment is set in place, this Contractor shall make all final connections and shall provide all required pipe, fittings, valves, traps, etc.

- C. Provide all air gap fittings required, using materials hereinbefore specified. In each service line connected to an item of equipment or piece of machinery, provide a shutoff valve. On each drain not provided with a trap, provide a suitable trap.
- D. All pipe fittings, valves, traps, etc., exposed in finished areas and connected to chrome plated lines provided by others shall be chrome plated to match.
- E. Provide all sheet metal ductwork, transition pieces, etc., required for a complete installation of vent hoods, fume hoods, etc., provided by others.

1.27 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.
 - 1. All piping not directly buried in the ground shall be considered as "interior piping".
 - 2. Prior to the installation of any ceiling material, gypsum, plaster, or acoustical board, the Contractor shall notify the construction inspector so that arrangement can be made for an inspection of the above-ceiling area about to be "sealed" off. The Contractor shall give as much advance notice as possible no less than 10 working days.
 - 3. All above-ceiling areas will be subject to a formal inspection before ceiling panels are installed, or installation is otherwise concealed from view. All mechanical and electrical work at and above the ceiling, including items supported by the ceiling grid, such as air inlets or outlets and lighting fixtures, shall be complete and installed in accordance with contract requirements, including power to lighting fixtures, fans, and other powered items. Adequate lighting shall be provided to permit thorough inspection of all above-ceiling items. The inspection will include representatives of the following: General Contractor and each Subcontractor having work above the ceiling, Architect/Engineer, Physical Plant, Resident Construction Manager's Construction Inspector(s), the Resident Construction Manager and Office of Facilities Planning and

Construction (OFPC). Areas to be included and time of inspection shall be coordinated with the Construction Inspector.

4. The purpose of this inspection is to verify the completeness and quality of the installation of the air conditioning systems, the electrical systems, the plumbing systems, and any other special above ceiling systems such as pneumatic tube, vacuum systems, fire sprinkler piping and cable tray systems. The ceiling supports (tee bar or lath) shall be in place so that access panel and light fixture locations are identifiable and so that clearances and access provisions may be evaluated.
5. No ceiling materials may be installed until the resulting deficiency list from this inspection is worked off and the Construction Inspector has given approval.

1.28 RECORDS FOR OWNER:

- A. The Contractor shall maintain a set of "blueline" 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 revised drawings per Division 01. The contractor shall transfer the information from the "blueline" 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. 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.

1.29 ACCESS DOORS:

- A. General: This Contractor shall provide wall or ceiling access doors for unrestricted access to all concealed items of mechanical equipment or devices.
- B. Doors: Access doors mounted in painted surfaces shall be of Milcor (Inland-Ryerson Construction Products Company) manufacture, Style K for plastered surfaces and Style M or DW for non-plastered surfaces. The Style K doors shall be set so that the finished surface of the door is even with the finished surface of the adjacent finishes. Access doors mounted on tile surfaces shall be of similar construction as noted above, except they shall be of stainless steel materials. Access doors shall be a minimum of 12" x 12" in size.

1.30 OPERATION PRIOR TO COMPLETION:

- A. When any piece of mechanical equipment is operable and it is to the advantage of the Contractor to operate the equipment, he may do so, providing that he properly supervises the operation, and has the Construction Inspector's written permission to do so. The warranty period shall, however, not commence until such time as the equipment is operated for the beneficial use of the Owner, or date of substantial completion, whichever occurs first.
- B. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media, properly adjust, and complete all deficiency list items before final acceptance by the Owner. The date of acceptance and performance certification will be the same date.

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 furnished and installed in exposed areas under Divisions 23 and 26 of these Specifications shall be cleaned, prepared, and painted according to the specification for the equipment.
- 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.

- D. Color of finish painting noted shall be painted using Pratt and Lambert, Inc.'s "Effector" enamel, or approved equal. Two coats shall be applied with a light tint first coat and deep color for final coat. Colors shall be as follows:

<u>ITEM</u>	<u>COLOR</u>	<u>"P and L" PAINT NUMBER</u>
Pump Couplings and Fuel Gas Piping	Safety Yellow	Y361M (Daisy Yellow)
Fire Protection Equipment and Piping	Safety Red	R131R (Vibrant Red)

Note that the paint specified above is included for purposes of establishing a quality which shall be used on this project. The proposed paint shall be submitted, and alternatives will be considered using the submittal procedures specified in this document.

- E. Jacketing on insulation shall not be painted.
- F. 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.
- G. Scope of painting for Division 23 and 26 work in areas other than those defined as "exposed" is as follows:
1. All canvas finishes including those underfloor and 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.
 2. All fuel piping (natural gas, LPG, etc.) and all fire protection piping shall be painted whether concealed or exposed, in all areas of the project without exception. Fuel piping shall be painted safety yellow, and fire protection piping shall be painted safety red. These "safety" colors shall be as defined by OSHA. Primer and first color coat may be omitted on piping above ceilings.
 3. 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.
- 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 "nonbleed" 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. 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

NOT USED

PART 3 EXECUTION

NOT USED

END OF SECTION

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SECTION 23 05 13

MOTORS

PART 1 GENERAL

1.00 **RELATED WORK** 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

1.01 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

1.02 RELATED WORK

- A. Section 23 20 00 - HVAC Pumps

1.03 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

1.04 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

1.05 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.

1.06 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.

1.07 REGULATORY REQUIREMENTS

- A. Conform to ANSI/NFPA 70.

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.
- 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.

1.09 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. Explosion-Proof Motors: UL approved and labeled for hazard classification, with over temperature protection.
- E. 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.
- F. Electrical Connection: Conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.
- G. 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.

- H. 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.
- I. 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.
- J. Dynamic Balance shall be no greater than the vibration limits of the driven equipment as defined in Section 23 34 16.UT-3.01I for fans and Section 23 20 00 -3.01J for pumps.
- K. 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 (motor shall not run in Service Factor under normal operating conditions), 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. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 26 24 19 - Motor Control Centers.
- L. 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 L-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.
- M. Sound Power Levels: Refer to ANSI/NEMA MG 1.
- N. Part Winding Start [Where Indicated:] [Above 254T Frame Size:] Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- O. Weatherproof Epoxy [Sealed] [Treated] Motors (Where Indicated): Epoxy [seal windings using vacuum and pressure] [coat windings] with rotor and starter surfaces protected with epoxy enamel. Bearings shall be double shielded with waterproof non-washing grease.
- P. Nominal Efficiency: Meet or exceed values per 23 05 13-3.03 at full load and rated voltage when tested in accordance with ANSI/IEEE 112.
- Q. Service Factor: Meet or exceed values per 23 05 13-3.02—at full load and rated voltage when tested in accordance with ANSI/IEEE 112.
- R. Motors 1 HP and larger shall be provided with a copper frame grounding lug of hydraulic compression design, for installation by the electrical subcontractor.
- S. 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 centrifugal pumps shall be split phase type.
- E. Single phase motors for shaft mounted fans or blowers shall be permanent split capacitor type.
- F. Single phase motors for pumps shall be capacitor start type.
- G. Single phase motors for pumps shall be capacitor start, capacitor run type.

3.02 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
1	1.25	1.15	1.15	1.15
1.5-150	1.15	1.15	1.15	1.15

3.03 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	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.8
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0
200	95.4	95.8	95.0	95.8	96.2	95.4

*Reference NEMA MG 1-2006 Table 12-12.

END OF SECTION

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SECTION 23 05 29

SLEEVES, FLASHINGS, SUPPORTS AND ANCHORS

PART 1 GENERAL

1.0 RELATED WORK 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

1.01 SECTION INCLUDES

- A. Pipe and equipment hangers and supports
- B. Sleeves and seals

1.02 RELATED SECTIONS

- A. Section 23 07 16 - Ductwork Insulation

1.03 REFERENCES

- A. ASME B31.9 - Building Services Piping
- B. ASTM F708 - Design and Installation of Rigid Pipe Hangers
- C. MSS SP69 - Pipe Hangers and Supports - Materials, Design and Manufacturer
- D. MSS SP89 - Pipe Hangers and Supports - Selection and Application
- E. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices
- F. NFPA 13 - Installation of Sprinkler Systems
- G. UL 203 - Pipe Hanger Equipment for Fire Protection Service

1.04 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.

1.05 REGULATORY REQUIREMENTS

- A. Conform to applicable code for support of plumbing, hydronic, steam and steam condensate 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. Anvil International
- 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 above covered walk 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. 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.
- L. 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. 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.
- M. Vertical conduits shall be supported as often as necessary for rigidity by clamps resting on adjacent beams or floor slabs, using a minimum of one support per floor.
- N. Perforated strap iron or wire will not, under any circumstances, be acceptable as hanger material.
- O. Where specifically noted on the drawings that one material is to be hung from the support of another material due to space restrictions, the hangers shall be sized to properly carry the weight of all items to be supported by such.
- P. 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.
- Q. 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) **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."
 - e) 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.

Power-actuated fasteners (shooting) will not be acceptable under any circumstances.

Note: Under no circumstances will the use of plastic anchors or plastic expansion shields be permitted for any purpose whatsoever.

5. Power-actuated fasteners (shooting) will not be acceptable under any circumstances.

- R. 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.
- S. 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.
- T. 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.
- U. 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.
- V. Ductwork supported from the floor: Ductwork supported from the floor shall be done by the same means as that supported from above, but shall include a neoprene vibration isolation spacer to restrict vibration transmission to the structure below.

2.03 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.

2.04 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.

2.05 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.
- 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. 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.
- F. 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.
- G. Air Plenums: The space around piping, ductwork, etc., passing through air plenums shall be made airtight in a manner acceptable to the Architect/Engineer.
- H. 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 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.

3.04 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:

<u>Angle Length</u>	<u>Angle</u>	<u>Rod Diameter</u>
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.

<u>Angle Length</u>	<u>Angle</u>	<u>Rod Dia.</u>
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"

- D. 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.

3.05 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

E&C Engineers & Consultants Inc.
TX Firm Registration No. F-003068

SECTION 23 05 48

VIBRATION ISOLATION

PART 1 GENERAL

1.00 RELATED WORK 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

1.01 WORK INCLUDED

- A. Inertia bases
- B. Vibration isolation

1.02 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.

1.03 REFERENCES

- A. ASHRAE - Guide to Average Noise Criteria Curves

1.04 QUALITY ASSURANCE

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

1.05 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.

1.06 CERTIFICATES

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

1.07 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: 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:

- A. 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.
- B. Type 6 - A spring hanger, as described in Type 5, with the addition of an elastomeric element at the top of the box for acoustic isolation. The design shall be such to prevent metal - to metal contact between the hanger rod and the top of the hanger box. The elastomeric element shall meet the design requirements for Type 3 mountings.
- C. 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.
- D. Type 8 - 1/4" thick closed cell Neoprene ASTM Grade S.E.C. 44 in sheets cut to fit penetrations,

as required.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS:

- A. Install vibration isolators for motor driven equipment.
- B. 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 in-line centrifugal pump and its driving motor shall be isolated with the piping system they serve.
- 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.

END OF SECTION

E&C Engineers & Consultants Inc.
TX Firm Registration No. F-003068

SECTION 23 05 53

MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.00 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

1.01 SECTION INCLUDES

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

1.02 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section 22 63 13 - Medical Gas Systems: Supply of pipe labels for placement by this Section

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. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch (40 mm) diameter.
- B. 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 CEILING TACKS

- A. Description: Steel with 3/4 inch (20 mm) diameter color coded head.
- DC. Color code as follows:
 - 1. Yellow - HVAC equipment
 - 2. Red - Fire dampers/smoke dampers
 - 3. Green - Plumbing valves
 - 4. Blue - Heating/cooling valves

- 2.05 General: The Contractor shall make it possible for the personnel operating and maintaining the equipment and systems in this project to readily identify the various pieces of equipment, valves,

piping, etc., by marking them. All items of equipment such as fans, pumps, etc., shall be clearly marked using engraved nameplates as hereinafter specified. The item of equipment shall indicate the same number as shown on the Drawings. For example, pumps will be identified as 3A, 3B, 3C, etc.; exhaust fans will be E-1, E-2, etc.; supply fans will be S-1, S-2, etc.

- 2.06 Mechanical: All items of mechanical equipment shall be identified by the attachment of engraved nameplates constructed from laminated phenolic plastic, at least 1/16" thick, 3-ply, with black surfaces and white core. Engraving shall be condensed Gothic, at least 1/2" high, appropriately spaced. Nomenclature on the label shall include the name of the item, its mark number, area, space, or equipment served, and other pertinent information. Equipment to be labeled shall include but not be limited to the following:

Pumps

HVAC Terminal Units

Air Conditioning Control Panels and Switches

Miscellaneous – similar and/or related items

- 2.07 Piping: Pipe markers and arrow markers also shall be provided on but not limited to the piping of the following systems:

Building Chilled Water Supply

Building Chilled Water Return

Equipment Chilled Water Supply

Equipment Chilled Water Supply

Laboratory Air

Domestic Hot Water Supply

Domestic Hot Water Return

Domestic Cold Water Supply

Domestic Cold Water Return

- 2.08 Electrical: 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.

- A. Electrical equipment to be identified includes: All switchgear, distribution panels, transformers, motor control centers, panel boards, disconnect switches, starters, contactors and time switches.
- B. 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 .

- C. Individual circuit breakers in distribution panels, individual units in motor control centers, disconnecting means, and motor starters, shall have nameplates showing the load served.
- D. 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.
- 2.09 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:
- | | |
|------------------------------|-------------------------|
| HPS-1-3 High Pressure Steam | 1st Level - Valve No. 3 |
| CHS-2-4 Chilled Water Supply | 2nd Level - Valve No. 4 |
- 2.10 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 steam PRV stations, valves associated with condensate, gas, water meters, 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.
- 2.11 In addition, pipe runs throughout the building including those above lift out ceilings, under floor, and those exposed to view when access doors or access panels are opened shall be identified by means of Seton Setmark or Brady Mechanical Pipe Markers. Concealed areas, for purposes of this identification section, are those areas which cannot be seen except by demolition of the building elements. In addition to the pipe markers, arrow markers shall be used to indicate direction of flow. The following specific instructions shall apply to the application of these markers:
- A. Provide a pipe marker at each valve to indicate proper identification of pipe contents. Where several valves exist on one header, it is necessary to mark only the header.
- B. Provide an arrow marker with each pipe marker pointing away from the pipe marker to indicate direction of flow.

- C. Provide a double ended arrow marker when flow can be in either or both directions.
 - D. Provide a pipe marker and an arrow marker at every point of pipe entry or exit where line goes through a wall or service column.
 - E. Provide pipe markers and arrow markers at intervals not exceeding 50 feet.
 - F. Markers shall be located on the two lower quarters of the pipe where view is unobstructed.
 - G. Use Seton Setmark Type SNA or Brady snap-on type identification for all piping systems, 3/4" thru 6". For piping systems larger than 6", use Seton or Brady strap on markers.
 - H. Pipe Markers shall conform to ANSI A 13.1-1981 "Scheme for the Identification of Piping Systems." Arrow markers must have same ANSI background colors as their companion pipe markers, or be incorporated into the pipe identification marker.
 - I. Locate markers to be visible from floor.
- 2.12 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.
- 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 air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with [plastic nameplates.] [stencil painting.] Small devices, such as in-line pumps, may be identified with tags.
- H. Identify control panels and major control components outside panels with plastic nameplates.

- I. Identify thermostats relating to terminal boxes or valves with nameplates.
- J. Identify valves in main and branch piping with tags.
- K. Identify air terminal units and radiator valves with numbered tags.
- L. Tag automatic controls, instruments, and relays. Key to control schematic.
- M. Provide ceiling tacks to locate valves, dampers or other concealed equipment above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION

E&C Engineers & Consultants Inc.
TX Firm Registration No. F-003068

SECTION 23 05 93

SYSTEM TESTING, ADJUSTING AND BALANCING

PART 1 GENERAL

1.00 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
- D. 23 36 00 -- Air Terminal Units (VAV)

1.01 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 Owner, separate and apart from the construction contract.
- 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.

1.02 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.

1.03 REFERENCES

- A. AABC - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems, Sixth Edition, 2002.
- B. ASHRAE - 2007 HVAC Applications Chapter 34: 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.

1.04 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.

1.05 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. 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. During the design stage, before the documents are finalized, review the mechanical drawings and specifications for balanceability and provide commentary.
 - b. During construction, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to commissioning work and balanceability.
 - c. 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 RCM of each observation.

- d. Test one (1) 8" single duct terminal box for performance capability and leakage as described in Section 23 36 00. The shipment of the box to the TAB Agency's lab will be at the manufacturer's cost and the test period will be for three (3) weeks from receipt of the box. Submittal data will not be approved until box testing passes. If the sample box is rejected for any reason the second test will be at the Contractor's cost and the time allowed will restart when the box is received at the TAB Agency.
- e. Test one (1) 8" dual duct box for performance capability and leakage as described in Section 23 36 00. The shipment of the box to the TAB Agency's lab will be at the manufacturer's cost and the test period will be for three (3) weeks from receipt of the box. Submittal data will not be approved until box testing passes. If the sample box is rejected for any reason the second test will be at the Contractor's cost and the time allowed will restart when the box is received by the TAB agency.
- f. Test 10% of the single and dual duct boxes for casing and damper leakage when the shipment arrives at the project site. All testing (except for the initial boxes) shall be performed on site.

Boxes requiring re-testing will be charged to the Contractor at the unit price provided to the Owner.

- g. 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.

- 2. 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.

1.06 FINAL AIR BALANCE

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 $\pm 5\%$ 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. At the time of reading record water flow and entering and leaving water temperatures (In variable flow systems adjust the water flow to design for all the above readings).
7. Zone Air Flow: Adjust each zone of multizone units, 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 $\pm 5\%$ of design air CFM. Include all terminal points of air supply and all points of exhaust. Note: For Labs and 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.

1.07 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 water circulating pumps, 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.

1.08 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 multizone units, 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 and humidistats 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.

1.09 REPORTS

- A. The activities described in this section shall culminate in a report to be provided in quadruplicate (4) individually bound to the RCM. 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, water, 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
 - f) Return air temperature
 - g) Outside air temperature
 - h) Required mixed air temperature
 - i) 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 Distribution Test Sheet
 - 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

9. Pump Data
 - a) Identification/number
 - b) Manufacturer
 - c) Size/model
 - d) Impeller
 - e) Service
 - f) Design flow rate, pressure drop, BHP
 - g) Actual flow rate, pressure drop, BHP
 - h) Discharge pressure
 - i) Suction pressure
 - j) Total operating head pressure
 - k) Shut off, discharge and suction pressure
 - l) Shut off, total head pressure
 - m) Pressure differential settings

10. Control verification indicating date performed and any abnormalities identified.
 - a) Point Location/Description
 - b) EMS Readout (Setpoint and Actual)
 - c) Actual Readout
 - d) Interlocks
 - e) Safeties
 - 1) VSD Normal Operation
 - 2) VSD Bypass Operation
 - f) Alarms
 - g) Sequences of Operation

END OF SECTION

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TX Firm Registration No. F-003068

SECTION 23 05 93.A

SYSTEM PREPARATION FOR TESTING, ADJUSTING AND BALANCING

PART 1 GENERAL

1.00 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

1.01 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 not have a contractual relationship with any Contractor referred to herein, but will be responsible to the Construction Inspector and the Owner for the satisfactory execution of the TAB work. 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.

1.02 RELATED SECTIONS

- A. Section 23 05 48 - Vibration Isolation
- B. Section 23 05 93 – System Testing, Adjusting and Balancing
- C. Section 23 06 20.13 - Hydronic Specialties
- D. Section 23 09 23 - Direct Digital Control Systems
- E. Section 23 20 00 - HVAC Pumps
- F. Section 23 31 00 - Ductwork
- G. Section 23 33 00 - Ductwork Accessories
- H. Section 23 34 16 - Fans
- I. Section 23 36 00 - Air Terminal Units (VAV)

1.03 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.

1.04 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 RCM'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 RCM and TAB Agency.

Note: The hot water and chilled water systems must be 100% complete to balance. 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.

3. Promptly correct deficiencies of materials and workmanship identified as delaying completion of TAB work.
 4. 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.
- B. 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.
- C. 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 and/or double duct variable and constant volume terminal units ("mixing boxes") shall be installed and functional (i.e. controls functioning).
 2. Water Circulating Systems:
 - a. Check and verify pump alignment and rotation.
 - b. Open all valves to their full open position, close bypass stop valves. Set mixing valves to full-flow through systems components. After the system is

flushed and checked for proper operation, remove and clean all strainers. The Contractor shall repeat the operation until circulating water is clean.

- c. Record each pump motor amperage on each phase and voltage after reaching rated speed. Readings shall not exceed nameplate rating.
- d. Verify that the electrical heater elements are of the proper size and rating.
- e. In preparation of TAB all water circulating systems shall be full and free of air, expansion tanks shall be set for proper water level, and all air vents shall be installed at high points of systems and operating freely. Systems shall be cleaned and flushed. Chemicals shall be added to closed systems to treat piping and inhibit corrosion.
- f. Check and set operating parameters of the heat exchangers and control devices to the design requirements.

3. 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 and water 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.

4. 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.

D. 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.

1.05 RESPONSIBILITIES OF THE TAB FIRM

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

END OF SECTION

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SECTION 23 06 20.13
HYDRONIC SPECIALTIES

PART 1 GENERAL

1.00 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

1.01 WORK INCLUDED

- A. Automatic Air Vents
- B. Air Separators
- C. Strainers
- D. Gauges and Gauge Connections
- E. Thermometer and Thermometer Wells
- F. Pump Suction Fittings
- G. Water Relief Valves

1.02 RELATED WORK

- A. Section 22 13 16 - Plumbing Piping
- B. Section 23 21 00 - Hydronic Piping

1.03 REFERENCES

- A. ANSI/ASME - Boilers and Pressure Vessels Code

1.04 REGULATORY REQUIREMENTS

- A. Conform to ANSI/ASME Boilers and Pressure Vessels Code Section 8D for manufacture of tanks.

1.05 QUALITY ASSURANCE

- A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.06 SUBMITTALS

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

- B. Submit shop drawings and product data for manufactured products and assemblies required for this project.
- C. Include component sizes, rough in requirements, service sizes, and finishes. Include product description, model number and dimensions.
- E. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

1.07 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00.
- B. Include installation instruction, assembly views, lubrication instructions, and replacement parts list.

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 AUTOMATIC AIR VENTS

- A. Provide at the highest points of the chilled water system and on the chilled water coils as shown on the Drawings, an automatic air vent, Armstrong No. 21AR or approved equal, with a pressure rating of 250 psig. Provide shut-off valve to facilitate maintenance of air vent. Locate all air vents and their discharge lines in accessible locations, preferably clustered.

2.02 AIR SEPARATORS

- A. Dip Tube Fitting: For 125 psig operating pressure; to prevent free air collected in boiler from rising into system.
- B. In-line Air Separators: Cast iron for sizes 1-1/2 inches and smaller, or steel for sizes 2 inches and larger; tested and stamped in accordance with Section 8D of ANSI/ASME Code; for 125 psig operating pressure.
- C. Air Elimination Valve: Bronze, float operated, for 125 psig operating pressure.
- D. Combination Air Separators/Strainers: Steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code, for 125 psig operating pressure, with galvanized steel integral strainer with 3/16 inch perforations, tangential inlet and outlet connections, and internal stainless steel air collector tube.

2.03 STRAINERS

- A. Each control valve for chilled water and heating water, and each pressure reducing valve assembly regardless of its size shall be preceded by a sediment strainer. The arrangement of these sediment strainers shall be such that the screens may be removed for cleaning with ease through a gasketed plug. Monel or stainless steel shall be used to fabricate the noncollapsible lapped screens, which shall contain no soldered joints.

- B. Sediment strainers shall be placed in piping systems wherever shown on the Drawings and at such other points as may be required for the removal of foreign material from the piping systems.
- C. Strainers for water piping 2-1/2" and larger shall be Crane No. 989-1/2 Sediment Separators or approved equal. In piping two inches (2") and smaller, they shall be Crane No. 988-1/2, or approved equal.
- D. Strainers, 2" and smaller, bronze body, screwed ends, No. 10 mesh strainer, screwed cap with bronze blow off valve (size to be determined by standard tap size in cap). Cast iron body, 2 1/2" and larger, isolating type flanged ends where installed in copper lines, No. 7 perforated monel strainer, flanged cap with bronze ball blow off valve (size of blow off valve shall be determined by standard tap size in cap). Special Note: All strainers 6" and larger shall have studs mounted in the body flange in lieu of bolts for removal of cap. Baskets for strainers 6" and larger shall have stainless steel reinforcing bands at ends to prevent collapsing.
- E. Full sized blow off valves shall be installed on all strainers in steam, condensate, chilled and hot water lines and a drain shall be installed from each valve to the nearest floor drain.

2.04 GAUGES AND GAUGE CONNECTIONS

- A. Furnish and install Ashcroft No. 1279A Duragauges on both suction and discharge sides of pumps, complete with Ashcroft No. 1095 lever handle shut-off cocks, and Ashcroft No. 1106B pulsation piston type dampeners, or approved equal. Porous type will not be accepted. See pump Specifications. Gauges shall have stainless steel movement and 1/2 of 1% accuracy. Gauges shall have back connection when used on a panel; otherwise they shall have bottom connections. The graduation of the dials and the arrangement of the mechanisms shall conform to the pressure range details shown on the Drawings.
- B. Combination pressure or vacuum gauges shall be Ashcroft Duragauges Number 1279AC, or approved equal. The accessories for these gauges shall conform to those prescribed for pressure gauges.
- C. Furnish and install, where noted or indicated on the accompanying Drawings or called for elsewhere in these Specifications, gauge connections complete with Ashcroft No. 1095 lever handle union shutoff cocks, or approved equal. All gauge connections shall be made up with brass pipe, nipples and brass screw fittings.

2.05 THERMOMETER AND THERMOMETER WELLS

- A. Furnish and install thermometers of not less than 9" scale complete with brass separable sockets with extension neck to allow for insulation of piping. These thermometers shall be mercury red reading type in one piece glass tubes extending from top of scale to sensor, and shall be located so that they may be easily read. Field adjustable angle thermometers are acceptable. Thermometers shall in all cases be installed upright or at the proper angle to be read while standing on the floor. The wells for thermometers shall be located in vertical pipes where possible and when necessary in horizontal pipes they shall be installed in the side and not on the top of the pipe. They shall be Weksler Industrial Thermometers, or approved equal, with range of 0 to 100 degrees F. for chilled water, and 0 to 220 degrees F for hot water.
- B. Thermometer wells and thermometers shall be located where noted on the accompanying Drawings and where called for in other sections of the Specifications. Thermometer test

wells only shall be installed in a vertical position in horizontal lines and at 45 degrees, in vertical lines to hold a fluid in the well.

- C. Thermometer test wells shall be 3/4" Weksler Thermal Wells, brass with stem of minimum length to extend beyond the mid-diameter of the pipe, 2-1/2" extension neck, and brass screw plug. Wells shall be suitable for use of industrial type thermometers.
- D. Indicating thermometers shall be placed in lines wherever shown on the Drawings. These thermometers shall be Weksler Industrial Thermometers having stainless steel separable sockets and scales of the range shown on the Drawings.
- E. Provide thermometer and thermowell assemblies, as described above, with one assembly each for the chilled water supply and return main pipes. Install the assemblies in close proximity to the RTDs that are provided for the chilled water BTU meter.

2.06 PUMP SUCTION FITTINGS

- A. Fitting: Angle pattern, cast iron body, threaded for 2 inch and smaller, flanged for 2-1/2 inch and larger, rated for 175 psig working pressure, with inlet vanes, cylinder strainer with 3/16 inch diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning.
- B. Suction diffusers shall be Paco or approved equal, cast iron body and cover, steel diffuser, and stainless steel strainer, 125 pound ASA (flat face) flange for a working pressure of 175 psi and temperature of 300°F.
- C. Accessories: Adjustable foot support, blow down tapping in bottom, gauge tapping in side.

2.07 WATER RELIEF VALVES

- A. The pressure relief valves installed for the protection of the water circulating circuits shall be McAlear No. 307 single seated diaphragm and spring type valves with screwed connections or approved equal. They shall be 3/4" size of bronze construction with bronze seat, composition shut-off disc and rubber diaphragm.

PART 3 EXECUTION

3.01 INSTALLATION AND APPLICATION

- A. Install specialties in accordance with manufacturer's instructions to permit intended performance.
- B. Support tanks inside building from building structure in accordance with manufacturer's instructions.
- C. Provide manual air vents at system high points and as indicated.
- D. Provide manual air vents at entrance to all heating hot water coils, with a "cane" shaped discharge tube, positioned to permit draining to a portable receptacle.
- E. For automatic air vents in ceiling spaces or other concealed locations, extend vent tubing to nearest drain.

- F. Provide air separator on suction side of system circulation pump and connect to expansion tank.
- G. Provide valved drain and hose connection on strainer blow down connection.
- H. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems. Clean all permanent strainers after circulating systems for a minimum of 48 hours at full capacity.
- I. Support pump fittings with floor mounted pipe and flange supports.
- J. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.
- K. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
- L. Pipe relief valve outlet to nearest floor drain.
- M. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

END OF SECTION

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TX Firm Registration No. F-003068

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SECTION 23 07 13

DUCTWORK INSULATION

PART 1 GENERAL

1.00 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

1.01 SECTION INCLUDES

- A. Ductwork insulation
- B. Insulation jackets

1.02 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

1.03 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

1.04 SUBMITTALS

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

1.05 QUALITY ASSURANCE

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

1.06 QUALIFICATIONS

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

1.07 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.

1.08 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 A:

- A. Three pound per cubic foot minimum density glass fiber semi-rigid board insulation with fiber perpendicular to the surface and with factory applied white foil reinforced vapor barrier jacket (ASJ). Insulation shall be equal to E.O. Woods Company "Rigid-Wrap".
- B. The insulation shall be secured to the ducts with mechanical fasteners; "Stick-clips", Graham Pins or Speed Clips, and shall be spaced approximately 12" on center on bottom of duct and where required elsewhere to hold insulation securely against the duct as noted in the published recommendations of the Insulation Manufacturer.
- C. After insulation is in place, all joints and seams shall be sealed with Foster 30-35 white vapor barrier emulsion applied over a 3" wide strip of Duramesh Glass Fabric. All protrusions through the vapor barrier shall be thoroughly sealed.
- D. On ducts that are reinforced with standing seams or angle iron stiffeners 1" and over in height, the Contractor shall apply a strip of fiberglass board 1" thick by 6" wide, sealing same to the other insulation with mastic.
- E. Vapor sealing of joints and seams is not required on hot duct application where concealed.

2.02 Insulation B:

- A. Three pound per cubic foot minimum density glass fiber rigid board insulation with factory applied white foil reinforced All Service Jacket (ASJ).
- B. Insulation B shall be applied as specified for Insulation A.
- C. Contractor at his option may substitute Insulation A where Insulation B is called for.

2.03 Insulation C:

- 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 Foster 30-35 white vapor barrier Emulsion and covered with Foster 30-35 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.

2.04 All ductwork in the building and in the crawl spaces except toilet exhaust and fume hood exhaust ducts shall be insulated externally unless specifically excluded. Only sound attenuated return ducting may be insulated internally, if specifically designated as such.

2.05 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.

2.06 Low pressure supply duct taps to ceiling diffusers shall be externally insulated including top of ceiling diffuser with 2" Insulation C.

2.07 Flexible round ducts are specified in Section 23 31 00.UT as factory insulated.

2.08 All kitchen hood exhaust ductwork connected to both inlet and discharge sides of Fans shall be insulated. Insulation shall be 1" insulation A or B.

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. For ductwork exposed in mechanical equipment rooms or in finished spaces, finish with aluminum jacket.
- E. For exterior applications, provide insulation with vapor barrier jacket. Cover with caulked aluminum jacket with seams located on bottom side of horizontal duct section.
- F. External Duct 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.
- G. 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.
- 3.03 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.
- 3.04 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.

- 3.05 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.
- 3.06 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.
- 3.07 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.
- 3.08 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.
- 3.09 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.
- 3.10 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.
- 3.11 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.
- 3.12 The handling and installation of all insulation materials shall be performed in strict accordance with the manufacturer's recommendations.
- 3.13 TOLERANCE**
- A. Substituted insulation materials shall provide thermal resistance within 10 percent at normal conditions, as materials indicated.

3.14 DUCT INSULATION SCHEDULE:

<u>Duct Type</u>	<u>Insulation Type</u>
Cold Supply Round	1 1/2" Insulation A
Hot Supply Round	1" Insulation A
Cold Supply Flat Oval	1 1/2" Insulation A
Hot Supply Flat Oval	1" Insulation A
Cold/Hot/or Combination Rectangular	1 1/2" Insulation B
Hot and Cold Combination Supply Round	2" Insulation C
Outside Air	1" Insulation B

END OF SECTION

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TX Firm Registration No. F-003068

SECTION 23 07 16
EQUIPMENT INSULATION

PART 1 GENERAL

1.00 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

1.01 SECTION INCLUDES

- A. Equipment insulation
- B. Covering
- C. Breaching insulation

1.02 RELATED SECTIONS

- A. Section 09 91 00 - Painting: Painting insulation covering

1.03 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 Insulating and Finishing Cement
- 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 C552 - Cellular Glass Block and Pipe Thermal Insulation
- J. ASTM C553 - Mineral Fiber Blanket and Felt Insulation
- K. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation
- L. ASTM C640 - Corkboard and Cork Pipe Thermal Insulation

- M. ASTM C921 - Properties of Jacketing Materials for Thermal Insulation
- N. ASTM D1056 - Flexible Cellular Materials - Sponge or Expanded Rubber
- O. ASTM E84 - Surface Burning Characteristics of Building Materials
- P. ASTM E96 - Water Vapor Transmission of Materials
- Q. NFPA 255 - Surface Burning Characteristics of Building Materials
- R. UL 723 - Surface Burning Characteristics of Building Materials

1.04 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Product Data: Provide product description, list of materials and thickness for equipment scheduled.
- 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.

1.05 QUALITY ASSURANCE

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

1.06 QUALIFICATIONS

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

1.07 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.

1.08 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 PUMPS AND FILTER HOUSINGS:

- A. Each chilled water pump and filter housing shall be insulated as hereinafter specified.
- B. Contractor shall install dimensional standard cellular glass insulation, Pittsburgh Corning "FOAMGLAS". The "FOAMGLAS" "StrataFab System" may also be installed as appropriate. "FOAMGLAS" for higher than ambient temperature service shall be manufactured using Pittsburgh Corning Hydrocal B-11 as the joint adhesive between layers of material. Prior to application of any insulation, all metal surfaces shall be thoroughly cleaned. Regular "FOAMGLAS" insulation shall be applied to the piping with butt joints staggered and all joints tightly butted. The insulation shall be held in place using stainless steel bands. The bands shall be spaced at 12 inches on center. A jacket of aluminum or stainless steel shall be applied to the completed installation. The Longitudinal joint of the jacketing shall be placed with overlap directed to bottom of pipe. The jacketing shall be overlapped a minimum of 3 inches, and it shall be held in place using 3/4 inch bands applied at 12 inches on center. Note that the use of asphaltic compounds in higher-than-ambient temperature service is prohibited.
- C. Fitting insulation shall be applied in same manner as pipe application. Refer to piping insulation specification for proper guidance.
- D. The insulation thickness shall be as follows:

Temperature	<u>Thickness</u>
75°F to 150°F	2"
151°F to 300°F	2 1/2"
above 300°F	3"

- E. Securing of the jacket shall be made by the use of 1/2" x 0.016" aluminum or stainless steel bands and seals. The shields at support points shall be secured with 1/2" x 0.020" stainless steel bands and seals. Ferrous metal surfaces shall be primed with a red lead oxide primer. The metal jacketing and fitting covers shall be fabricated of 0.016" aluminum or stainless steel with a smooth finish.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that equipment 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. Do not insulate factory insulated equipment.
- C. On exposed equipment, locate insulation and cover seams in least visible locations.
- D. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Secure insulation to equipment with studs, pins, clips, adhesive, wires, or bands.

- E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.
- F. Insulated dual temperature equipment or cold equipment containing fluids below ambient temperature:
 - 1. Provide vapor barrier jackets, factory applied or field applied.
 - 2. Finish with glass cloth and vapor barrier adhesive.
 - 3. Insulate entire system.
- G. For insulated equipment containing fluids above ambient temperature:
 - 1. Provide standard jackets, with or without vapor barrier, factory applied or field applied.
 - 2. Finish with glass cloth and adhesive.
 - 3. For hot equipment containing fluids 140 degrees F or less, do not insulate flanges and unions, but bevel and seal ends of insulation.
 - 4. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions, including those at equipment, but label the insulation to indicate a concealed flange or union.
- H. Inserts and Shields:
 - 1. Application: Equipment 2 inches diameter or larger.
 - 2. Shields: Galvanized steel between hangers and inserts.
 - 3. Insert location: Between support shield and equipment and under the finish jacket.
 - 4. Insert configuration: Minimum 6 inches (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - 5. Insert material: Heavy density insulating material suitable for the planned temperature range.
- I. Finish insulation at supports, protrusions, and interruptions.
- J. For equipment in mechanical equipment rooms or in finished spaces, finish with aluminum jacket.
- K. For exterior applications, provide vapor barrier jacket or finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal equipment.
- L. Cover cellular glass and cellular foam insulation with aluminum jacket.
- M. Do not insulate over any nameplate or ASME stamps. Bevel and seal insulation around such.
- N. Install insulation for equipment requiring access for maintenance, repair, or cleaning, in such a manner that it can be easily removed and replaced without damage.

- O. 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.
- P. 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.
- Q. 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.
- R. 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.
- S. 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.
- T. 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.
- U. 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.
- V. 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.
- W. 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.

- X. The handling and installation of all insulation materials shall be performed in strict accordance with the manufacturer's recommendations.

END OF SECTION

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TX Firm Registration No. F-003068

SECTION 23 07 19

PIPING INSULATION

PART 1 GENERAL

1.00 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

1.01 SECTION INCLUDES

- A. Piping insulation
- B. Jackets and accessories

1.02 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.
- D. Section 23 22 00 - Steam Piping: Placement of hangers and hanger inserts.

1.03 RELATED SECTIONS

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

1.04 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.
- 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.

1.05 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.

1.06 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.

1.07 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.

1.08 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 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.

1.09 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.
- C. All insulation materials to be asbestos free.

PART 2 PRODUCTS

2.01 DOMESTIC HOT AND COLD WATER

- A. All domestic hot and cold water lines in buildings, including valves, strainers, unions, flanges, etc., except where specifically noted to the contrary, shall be insulated.
- B. All domestic cold water lines shall be insulated as scheduled with preformed fiberglass insulation with a factory applied All Service Jacket, vapor sealing all joints, and factory performed fittings with vapor seal, or a flexible, "25-50" rated, closed cell elastomeric thermal insulation such as "Self Seal Armaflex 2000". 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. Valves shall be insulated with mitered pipe covering with voids filled with glass fiber blanket insulation. Valves and fittings shall be vapor sealed with a water base asphaltic emulsion. Fittings on concealed insulation shall be built up to the thickness of adjacent insulation with glass fiber fitting wrap and shall be finished with Glasfab tape embedded in vapor barrier emulsion. Exposed fitting insulation shall be built up to same thickness as adjoining pipe insulation with one coat cement and after drying shall be finished with a white vapor seal and canvas jacket secured with "Arabol" adhesive and be suitable for painting. Seams in jacket shall be placed in the least noticeable locations. Where seams, joint or fittings are rough they shall be covered with an application of insulating cement troweled on smoothly before the canvas is applied with Arabol adhesive. The canvas must be free of wrinkles and have a smooth, neat appearance.
- C. All domestic hot water piping systems shall be insulated as specified above for cold water except the vapor barrier may be deleted and the lap and butt joints secured with staples and a field applied adhesive (self sealing lap and butt joints alone are not acceptable). The insulation thickness shall be as scheduled. Where service temperature exceeds 250°F, insulation shall contain high temp binders.
- D. The only domestic hot and cold water piping that will not require insulation are the exposed runouts under non-handicap plumbing fixtures. Where pipe chases are tight, adequate provision shall be made at the rough in stage utilizing offset fittings or other means (except springing the pipe) to insure that insulation can be applied throughout the length of the pipe.

2.02 CHILLED WATER PIPING - BUILDINGS

- A. Chilled Water Piping - "FOAMGLAS" as manufactured by the Pittsburgh Corning Corporation or "INSUL-PHEN" as manufactured by Resolco, Inc. and shall be installed on chilled water lines in tunnels and in buildings up to the building circulating pump. The "FOAMGLAS" "StrataFab System" may also be installed on larger pipe sizes as appropriate. Prior to application of any insulation, all metal surfaces shall be thoroughly cleaned. The metal shall then be primed with an asphaltic primer consisting of one (1) coat of Foster No. 60-26 Primer or Pittcote 300 Primer. Cleaning and priming specified in this paragraph is not included in requirements for "Cleaning and Painting" specified in other sections of the Specifications. Regular "FOAMGLAS" insulation shall be applied to the piping with butt joints staggered and all joints tightly butted and sealed with a ¼" bead of joint sealer ½" from outside edge. Hold in place with 14 gauge copper clad wire 9" o.c. After insulation has been wired in place, a 1/16" minimum thick, 3" wide band of asphaltic vapor seal mastic shall be brushed or troweled on the outside of the "FOAMGLAS" insulation at the approximate location of the aluminum bands. (Note that the asphaltic material specified in this paragraph is intended to be an exception to the flame spread and smoke generation limitations found elsewhere in this specification.) An aluminum jacketing 0.016" thickness equal to Premetco precast, pre rolled Z-lock Kraft paper lined pipe covering with zee type closure and ¾" wide snap straps with permanent sealant shall then be fitted to O.D. of

insulation and applied over the insulated pipe with 3" end and side caps secured with aluminum bands on 12" centers. Longitudinal joint of aluminum jacketing shall be placed with overlap directed to bottom of pipe. Any voids in the completed installation of the insulation shall not be filled with vapor seal coating but shall be eliminated by refitting or replacing insulation.

- B. "FOAMGLAS" or "INSUL-PHEN" insulation on flanges, valves and other fitting shall consist of prefabricated fitting covers of the same thickness as specified for adjoining pipe insulation.
- C. Fitting covers shall be applied in same manner as pipe application except that 16 gauge aluminum wire may be used to secure screwed fitting covers. Protruding metal parts (such as valve stems) shall be completely sealed off. Fitting cover jacketing shall be equal to Gasco, Papco or RPR Metals prefabricated fitting covers of 0.016" paper coated aluminum, secured as recommended by the manufacturer.
- D. The insulation thickness shall be as scheduled.
- E. "FOAMGLAS" or "INSUL-PHEN" installed inside the building downstream of the blending station shall be insulation with factory applied Class I, Fire Rated, Kraft-Aluminum, vapor barrier jacketing as manufactured by Pittsburgh Corning. It shall be applied in strict accordance with the manufacturer's recommendations after the pipe has been primed with one (1) coat of Foster No. 60-26 Primer or Pittcoat 300 Primer. (Note that the asphaltic material specified in this paragraph is intended to be an exception to the flame spread and smoke generation limitations found elsewhere in this specification.) It will be necessary to include expansion joints at regular intervals on dual temperature service. Thickness shall be as scheduled.
- F. Fitting covers shall be built up of shaped segments of "FOAMGLAS" or "INSUL-PHEN." These fitting covers shall be adhered in place using "Foster No. 30-35 80" water based vapor seals, then smoothly covered by a one-quarter inch (1/4") thick application of one coat white insulating cement. All this piping and fittings shall be finished with an eight ounce canvas jacket neatly applied using Arabol adhesive.
- G. 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, plus white vapor seal mastic, plus Manville No. 301 finishing cement to smooth surfaces, plus canvas applied and sized for painting with fire resistant adhesive. In addition, all manufactured vapor barrier jacketing in mechanical rooms and finished spaces shall be finished with canvas applied and sized for painting with fire resistant adhesive.
- H. No chilled water pipe supporting structures shall pierce the insulation except as anchor points as shown on the Drawings. At these points, the anchor member shall occur on the bottom of the piping to allow condensation to drain.
- I. 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.
- J. All insulation joints (longitudinal and butt) shall be buttered with vapor sealant mastic then pressed firmly together.

2.03 CONDENSATE DRAIN PIPING

- A. Condensate drain piping from fan and coil units, coil banks, drinking fountain refrigeration units, 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.

2.04 PROTECTIVE JACKETING

- A. Provide protective jacketing as described elsewhere.
- 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.) $\frac{3}{4}$ " 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.

2.05 EXPANSION JOINTS

- A. Where expansion bends occur in the lines, a two foot (2') double layer contraction joint shall be provided in the main line starting two feet from the end of the main line ells on both sides of the expansion loop. Contraction joints shall consist of two 1-1/2" thick x 24" long pipe covering cuts into 17-1/4" and 6" lengths to provide a $\frac{3}{4}$ " space by 10-1/4". A slip joint mastic (Pittseal III) shall be placed between layers from the $\frac{3}{4}$ " space provided on the inside layer to the $\frac{3}{4}$ " space on the outside layer.
- B. The $\frac{3}{4}$ " space on inside layer shall be filled with mineral wool loose fill and the $\frac{3}{4}$ " space on the outer layer shall also be filled with same loose fill and joint sealer pressed $\frac{1}{2}$ " deep into space for sealing (Pittseal III). Around the outside layer at the $\frac{3}{4}$ " space, there shall be wrapped a 4" wide piece of glass fabric and sealed down with vapor seal mastic. On pipe sizes smaller than aforementioned, the same contraction joint shall be provided using one inch (1") thick "FOAMGLAS" or "INSUL-PHEN" pipe covering for the inner layer. On two inch (2") IPS, both inner and outer layer shall be 1" thick "FOAMGLAS" or "INSUL-PHEN".
- C. The joint and vapor seal mastic shall be Pittsburgh Corning Corporation Pittcote 300. (Note that the asphaltic material specified in this paragraph is intended to be an exception to the flame spread and smoke generation limitations found elsewhere in this specification.
- D. The slip joint sealer shall be Pittsburgh Corning Corporation's Pittseal III.

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 dual temperature pipes or cold pipes conveying fluids below ambient temperature: 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:
 - 1. Provide standard jackets, with or without vapor barrier, factory applied or field applied.
 - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe.
- F. If PVC fitting covers are used they shall have 25/50 rating.
- G. For hot piping conveying fluids 140°F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- H. 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 3/4 inch 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 3/4" 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 INSUL-PHEN 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

- 1. 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 180° saddle bonded to the bottom section of the K Block, for all pipe sizes 1 1/2" and larger.
- 2. 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.
- 3. 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 products K Block. Ref:- Kooltherm sketch 106/2c for use with Roller or flat beam support.

4. 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.
- 3.04 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.
- 3.05 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.
- 3.06 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.
- 3.07 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.
- 3.08 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.
- 3.09 Special Protection: All insulated piping in the mechanical rooms within 8'-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.
- 3.10 All exposed outdoor piping shall have metal jacket.
- 3.11 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.
- 3.12 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.
- 3.13 No pipe supporting device (other than guides or anchors attached directly to the pipe) shall penetrate the insulation.
- 3.14 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.

Insulation 'R' Value Schedule (R = thickness / k)

Service °F	Oper Temp	'k' @ Mean Temp °F	& less	Min. R value for each Pipe Size				
				1" to 2"	1-1/4" to 4"	2-1/2" 6"	5" & over	8" &
Cold (6)40-55		.25 @ 75	2.0	3.0	4.0	4.0	4.0	

(6) Ch. Water; Dom. Cold Water; Storm; Cold condensate

Minimum 'R' does not consider water vapor transmission and condensation. Additional insulation and/or vapor retarders may be required to limit water vapor transmission and condensation under extreme conditions.

A minus 15 percent tolerance, on the insulation performance listed shall be permitted for manufacturers' standard insulation systems.

In non-conditioned mechanical rooms and all crawl spaces, insulation shall prevent formation of surface condensation under conditions of 95°F, 95%RH, and zero wind speed. Provide manufacturer's certification of this performance on submittal data.

END OF SECTION

E&C Engineers & Consultants Inc.
TX Firm Registration No. F-003068

SECTION 23 09 23

DIRECT DIGITAL CONTROL SYSTEMS

PART 1 GENERAL

1.00 RELATED WORK 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

1.01 SECTION INCLUDES

- A. Control Equipment
- B. Software

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 23 33 00 - Ductwork Accessories: Installation of automatic dampers, smoke detectors. Connection of damper end switches.

1.03 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

1.04 SYSTEM DESCRIPTION

- A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units with future communications to the existing JCI MetaSys BCAS.]
- B. Central and remote hardware, software, and interconnecting wire and conduit.
- C. Terminal unit controls for variable air volume terminals shall be DDC with electric actuators unless indicated otherwise.
- D. Damper Motors and Valve Operators: Electric.

1.06 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Shop Drawings:

1. Trunk cable schematic showing programmable control unit locations, and trunk data conductors.
 2. List of connected data points, including connected control unit and input device.
 3. System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.
 4. System configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
 5. Descriptive data and sequence of operation of operating, user, and application software.
- C. Product Data: Provide data for each system component and software module.
- D. Manufacturer's Installation Instructions: Include for all manufactured components.

1.07 PROJECT RECORD DOCUMENTS

- A. Accurately record actual location of control components, including panels, thermostats, and sensors.
- B. Revise shop drawings to reflect actual installation and operating sequences.
- C. Include data specified in "Submittals" in final "Record Documents" form.

1.08 OPERATION AND MAINTENANCE DATA

- A. Include interconnection wiring diagrams complete field installed system with identified and numbered, system components and devices.
- B. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
- C. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

1.09 QUALIFICATIONS

- A. Manufacturer: Johnson Controls MetaSys to match existing Campus Controls.
- B. Installer: Johnson Controls to match existing Campus Controls.

1.10 COORDINATION

- A. Ensure installation of components is complementary to installation of similar components in other systems.
- B. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.
- C. Ensure system is completed and commissioned.

1.11 WARRANTY

- A. Provide warranty as specified in Division 1.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturer: Johnson Controls MetaSys to match existing Campus Controls.

2.02 INPUT/OUTPUT SENSORS

- A. Temperature:
 - 1. Resistance temperature detectors with resistance tolerance of plus or minus 0.1 percent at 21 degrees C, interchangeability less than plus or minus 0.2 percent C, time constant of 13 seconds maximum for fluids and 200 seconds maximum for air. Sensors shall match the current sensors being installed in the building.
 - 2. Measuring current maximum 5 MA with maximum self-heat of 0.017 degrees C/MW in fluids and 0.008 degrees C/MW in fluids and 0.008 degrees C/MW in air.
 - 3. Provide 3 lead wires and shield for input bridge circuit.
 - 4. Use insertion elements in ducts not affected by temperature stratification or smaller than one square meter. Use averaging elements where larger or prone to stratification sensor length 2.5 m or 5 m as required.
 - 5. Insertion elements for liquids shall be with brass socket with minimum insertion length of 2-1/2 inches (60 mm).
 - 6. Supply room sensors with locking cover.]
 - 7. Provide outside air sensors with watertight inlet fitting, shielded from direct rays of sun.
- B. Humidity Sensors:
 - 1. Elements: Accurate within 5 percent full range with linear output.
 - 2. Room Sensors: With locking cover, span of 10 to 60 percent relative humidity. Sensors shall match the current sensors being installed in the building.
 - 3. Duct and Outside Air Sensors: With element guard and mounting plate, range of 0 - 100 percent relative humidity.
- C. Static Pressure Sensors:
 - 1. Unidirectional with ranges not exceeding 150 percent of maximum expected input.
 - 2. Temperature compensated with typical thermal error or 0.06 percent of full scale in temperature range of 40 to 100 degrees F (5 to 40 degrees C).
 - 3. Accuracy: One percent of full scale with repeatability 0.3 percent.

4. Output: 0 - 5 vdc with power at 12 to 28 vdc.
- D. Equipment Operation Sensors:
1. Status Inputs for Fans: Differential pressure switch with adjustable range of 0 to 5 inches wg (0 to 1250 Pa).
 2. Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 8 to 60 psi (50 to 400 kPa).
 3. Status Inputs Where Differential Pressure Sensing is Impractical: Current sensitive relay with current transformers, adjustable and set to 175 percent of rated motor current.
- E. Damper Position Indication: Potentiometer mounted in handbox enclosure with adjustable crank arm assembly connected to damper to transmit 0 - 100 percent damper travel.

2.03 OPERATING SYSTEM SOFTWARE

- A. Johnson Controls MetaSys.
1. Functionality and graphics shall match existing DDC/BCAS controls in the building.
 2. Identify points with unique, structured point identifier reflecting "specific area" or "specific system", and "specified point".
- B. Operator Access Control: Restrict any operator commands through use of software password.
- C. Information Access: Obtain point status information from any designated output device with access command. Point status consists of point identification, numerical value (analog points) and associated engineering units, and individual function label indicating that point is on or off or in Alarm Normal condition. Output includes date and time of execution.
- D. Point Display: Video display includes status of single point or group of points with high and low limits (if applicable). Refresh display at least every 20 seconds.
- E. Alarm summary includes status of points in Alarm condition.
- F. Off-normal summary includes status of points in Off-Normal condition.
- G. Alarm Reporting:
1. Alarm outputs contain descriptor, point identification, point data, engineering units, and date and time.
 2. Print on line changeable message for each alarm point specified, immediately.
 3. Display alarm reports on video. Display multiple alarms in order of occurrence.
 4. Inhibit reporting of associated analog and binary alarms upon HVAC system shutdown. Upon restart, inhibit alarm reporting for operator pre-determined time.
 5. Operator specifies if alarm required acknowledgement.
- H. Advisories:

1. Lockout summary which contains status of points in locked out condition.
 2. Continuously interrogate system hardware and programmable control units for failure or tampering and report if operational or not operational.
 3. Power failure detection, time and date.
 4. System communication failure with operator device, field interface unit, point, programmable control unit.
- I. Power Failure Motor Restart: Provide program to restore systems to normal operating conditions following power outage, and to enforce emergency operating conditions during power outage. Automatically restart loads to correct operating condition if normal or emergency power is available.

2.04 BASIC OPERATING FEATURES

A. Binary Capabilities:

1. Monitor binary sensors, continuously storing present contact condition in memory.
2. Indicate if point is off-normal, in alarm, or off-line.
3. Program output points for Open/Closed, Test/Reset, Start/Stop.
4. Feedback Start/Stop points. Employ point unique, feedback delay timer to temporarily suppress alarm reporting after input to allow time for response.
5. Output advisory message if response is not as commanded.
6. Hold points in present operating condition if controls power failure occurs.

B. Analog Capabilities:

1. Measure, transduce, transmit and display analog values.
2. Express analog point values in proper engineering units, displaying with up to six significant digits.
3. Have sensor to readout accuracy of plus or minus 0.5 degrees F (0.28 degrees C).
4. Use English system of measurement.
5. Provide for operator designated ranges either linear, series of linear approximations, split ranges, or square root extractions of exponential functions.
6. Compare analog read to high and low limits and annunciate Alarm or Off-Normal condition.
7. Output alarm, including point identification current value and associated engineering units, high or low value, and time and date.

8. Automatically disable alarm reporting upon associated system shutdown. Allow sufficient time to return to normal operating conditions before allowing alarm reporting.
 9. Provide limit and differential summary.
- C. Analog Point Adjust:
1. Remotely adjust controller set points or dampers. Automatically adjust points based upon preselected time or value.
 2. Employ feedback so that if point fails to respond, responds with wrong value, or drifts from set point value by plus or minus 2 percent, output alarm message. Employ feedback delay timer to temporarily suppress alarm reporting after input to allow time for response.
 3. Hold points in present operating condition if controls power failure occurs.
- D. Automatic Alarm Lockout: Automatically inhibit alarm reporting of analog and binary points upon associated system shutdown. Inhibit reporting for operator predetermined time, upon restart of HVAC systems.

2.05 HVAC CONTROL PROGRAMS

- A. General:
1. Support English units of measurement
 2. Identify each HVAC Control system

2.06 PROGRAMMING APPLICATION FEATURES

- A. Trend Point:
1. Provide to match existing BCAS in building.
- B. Alarm Messages:
1. Provide to match existing BCAS in building.
- C. Interlocking:
1. Permit events to occur, based on changing condition of one or more associated master points.
 2. Binary contact, high/low limit of analog point or computed point shall be capable of being utilized as master. Same master may monitor or command multiple slaves.
 3. Operator commands:
 - a. Define single master/multiple master interlock process.
 - b. Define logic interlock process.
 - c. Lock/unlock program.

- d. Enable/disable interlock process.
- e. Execute terminate interlock process.
- f. Request interlock type summary.

2.07 UNITARY CONTROLLERS

- A. Terminal Unit Controllers:
 - 1. Provide DDC controllers with integral electric damper operators to match current terminal unit DDC controllers being installed in the building.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install electrical work in accordance with Section 26 05 00. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.
- C. Provide with 120V AC, 15 amp control power circuit to each programmable control unit.

3.02 MANUFACTURER'S FIELD SERVICES

- A. Prepare and start systems under provisions of Division 1.
- B. Start-up and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

3.03 DEMONSTRATION

- A. Provide systems demonstration under provisions of Division 1.
- B. Demonstrate complete and operating system to Owner.

END OF SECTION

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SECTION 23 20 00

HVAC PUMPS

PART 1 GENERAL

1.00 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

1.01 WORK INCLUDED

- A. Base mounted pumps

1.02 RELATED WORK

- A. Section 23 05 13 - Motors
- B. Section 21 05 48 - Vibration Isolation
- C. Section 23 07 19 - Piping Insulation
- D. Section 23 07 16 - Equipment Insulation
- E. Section 23 21 00 - Hydronic Piping
- F. Section 23 06 20.13 - Hydronic Specialties

1.03 REFERENCES

- A. ANSI/UL 778 - Motor Operated Water Pumps

1.04 QUALITY ASSURANCE

- A. Manufacturer: Company specializing in manufacture, assembly, and field performance of pumps with minimum three years experience.
- B. Alignment: Base mounted pumps shall be aligned by qualified millwright and alignment certified.

1.05 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 23 00 00.
- B. Submit certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
- 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 installation instructions, assembly views, lubrication instructions, and replacement parts list.

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.

1.08 EXTRA PARTS

- A. Provide one extra set of mechanical seals for pumps under provisions of Section 23 00 00.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. ITT Allis-Chalmers
- B. ITT Bell & Gossett
- C. Buffalo Forge
- D. Aurora
- E. Taco
- F. Paco
- G. Substitutions: Under provisions of Section 23 00 00

2.02 IN-LINE CENTRIFUGAL PUMPS:

- A. Provide circulating pumps with all-bronze construction of the size, type, and capacity scheduled or shown on the Drawings. Pumps shall be fitted with a dynamically balanced brass enclosed type impeller with mechanical seal. Mechanical seal shall be Type 1 or Type 2 material, Code BP-1D1 as manufactured by John Crane Company or an approved equal, suitable for service specified. Motor shall have a maximum speed of 1750 rpm. Pumps, casings, flanges, and seals shall be suitable for operation with the working pressures and temperatures indicated. The scheduled working pressure applies to the entire pump assembly.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install pumps in accordance with manufacturer's instructions.
- B. Provide access space around pumps for service. Provide no less than a minimum of three feet, not including piping and piping appurtenances.

- C. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 15 percent of midpoint of published maximum efficiency curve.
- D. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches and over. Refer to Section 23 05 48.
- E. Provide line sized shut-off valve (ball or butterfly) and strainer on pump suction, and line sized soft seat check valve and balancing (ball or butterfly with memory stop) valve on pump discharge.
- F. Provide air cock and drain connection on horizontal pump casings.
- G. Provide drains for bases and seals, piped to and discharging into floor drains.
- H. Lubricate pumps before start-up.
- I. Alignment: A qualified millwright shall check, align and certify pumps. A reverse alignment procedure utilizing laser instruments shall be used. Alignment shall be performed in both hot and cold operating extremes. The maximum parallel and angular misalignment shall not exceed .002 inch. Record and deliver copies of the alignment report to the Owner's RCM and include copy of the report in the O&M Manual.
- J. Vibration Testing: Vibration velocity readings shall be taken at all bearing locations of all pumps. Pumps driven by variable speed drives shall be tested throughout their range of speeds. Vibration shall not exceed 0.15 inch/second (peak). Record and deliver copies of the test report to Owner's RCM and include report in the O&M Manual.

END OF SECTION

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SECTION 23 20 00.A
PIPING, VALVES AND FITTINGS

PART 1 GENERAL

1.00 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

1.01 SECTION INCLUDES

- A. Pipe and Pipe Fittings
- B. Valves

1.02 RELATED SECTIONS

- A. Section 23 05 16 - Expansion Compensation
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 07 19 - Piping Insulation

1.03 REFERENCES

- A. AGA - American Gas Association
- B. ANSI B31.1 - Power Piping
- C. ANSI B31.2 - Fuel Gas Piping
- D. ANSI B31.4 - Liquid Petroleum Transportation Piping Systems
- E. ANSI B31.9 - Building Service Piping
- F. ASME - Boiler and Pressure Vessel Code
- G. ASME Sec. 9 - Welding and Brazing Qualifications
- H. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250 and 800
- I. ASME B16.3 - Malleable Iron Threaded Fittings
- J. ASME B16.4 - Cast Iron Threaded Fittings Class 125 and 250
- K. ASME B16.18 - Cast Bronze Solder-Joint Pressure Fittings
- L. ASME B16.22 - Wrought Copper and Bronze Solder-Joint Pressure Fittings

- M. ASME B16.23 - Cast Copper Alloy Solder-Joint Drainage Fittings - DWV
- N. ASME B16.26 - Cast Bronze Fittings for Flared Copper Tubes
- O. ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV
- P. ASME B16.32 - Cast Copper Alloy Solder-Joint Fittings for Solvent Drainage Systems
- Q. ASTM A47 - Ferric Malleable Iron Castings
- R. ASTM A135 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless
- S. ASTM A74 - Cast Iron Soil Pipe and Fittings
- T. Not Used
- U. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
- V. ASTM B32 - Solder Metal
- W. ASTM B42 - Seamless Copper Pipe
- X. ASTM B43 - Seamless Red Brass Pipe
- Y. ASTM B75 - Seamless Copper Tube
- Z. ASTM B88 - Seamless Copper Water Tube
- AA. ASTM B251 - Wrought Seamless Copper and Copper-Alloy Tube
- BB. ASTM B302 - Threadless Copper Pipe (TP)
- CC. ASTM B306 - Copper Drainage Tube (DWV)
- DD. ASTM C14 - Concrete Sewer, Storm Drain, and Culvert Pipe
- EE. ASTM C425 - Compression Joints for Vitrified Clay Pipe and Fittings
- FF. ASTM C443 - Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
- GG. ASTM C564 - Rubber Gaskets for Cast Iron Soil Pipe and Fittings
- HH. ASTM C700 - Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
- II. ASTM D1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
- JJ. ASTM D2235 - Solvent Cement for Acrylonitrile - Butadiene - Styrene (ABS) Plastic Pipe and Fittings
- KK. ASTM D2241 - Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)

- LL. ASTM D2466 - Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
- MM. ASTM D2513 - Thermoplastic Gas Pressure Pipe, Tubing and Fittings
- NN. ASTM D2564 - Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
- OO. ASTM D2680 - Acrylonitrile-Butadiene-Styrene (ABS) Composite-Sewer Piping
- PP. ASTM D2683 - Socket-Type Polyethylene Fillings for Outside Diameter - Controlled Polyethylene Pipe
- QQ. ASTM D2729 - Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
- RR. ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings
- SS. ASTM D2846 - Chlorinated Polyvinyl Chloride (CPVC) Pipe, Fittings, Solvent Cements and Adhesives for Potable Hot Water Systems
- TT. ASTM D2855 - Making Solvent-Cemented Joints with Poly Vinyl Chloride (PVC) Pipe and Fittings
- UU. ASTM D3033 - Type PSP Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
- VV. ASTM D3034 - Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
- WW. ASTM D3309 - Polybutylene (PB) Plastic Hot Water Distribution System
- XX. ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe
- YY. ASTM F493 - Solvent Cements for Chlorinated Poly Vinyl Chloride (CPVC) Plastic Pipe and Fittings
- ZZ. ASTM F845 - Plastic Insert Fittings for Polybutylene (PB) Pipe
- AAA. AWS A5.8 - Brazing Filler Metal. BA. AWWA C105 - Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids
- BBB. AWWA C110 - Ductile - Iron and Gray - Iron Fittings 3 in. through 48 in., for Water and Other Liquids
- CCC. AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Gray-Iron Pressure Pipe and Fittings
- DDD. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids
- EEE. AWWA C651 - Disinfecting Water Mains
- FFF. CISPI 301 - Cast Iron Soil Pipe and Fittings for Hubless Cast Iron Sanitary Systems
- GGG. CISPI 310 - Joints for Hubless Cast Iron Sanitary Systems

HHH.CAN-3 B281 - Aluminum Drain, Waste, and Vent Pipe and Components

III. NCPWB - Procedure Specifications for Pipe Welding

JJJ. NFPA 54 - National Fuel Gas Code

KKK.NFPA 58 - Storage and Handling of Liquefied Petroleum Gases

LLL.TDH - Texas Department of Health, Water System Regulations

1.04 SUBMITTALS

- A. Submit under provisions of Section 23 00 00.
- B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.

1.05 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 23 00 00.
- B. Record actual locations of valves, etc. and prepare valve charts.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 23 00 00.
- B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.07 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.
- C. Welder's Certification: In accordance with ASME Sec. 9. Submit welder's certifications prior to any shop or field fabrication. Welder's certifications shall be current within six months of submission.
- D. Maintain one copy of each document on site.

1.08 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years' documented experience.
- B. Installer: Company specializing in performing the work of this section with minimum of three years' documented experience.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 23 00 00.

- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 STEEL PIPING:

- A. Scope: This section applies to all piping systems providing for welded piping, fittings, and other appurtenances. Specific systems requiring welded piping include, but are not limited to: chilled water, hot water, steam, steam condensate, and fire protection systems.
- B. Pipe: Unless otherwise indicated, chiller and boiler plants piping shall be Schedule 40, and underground and building piping shall be Standard weight, Grade A or B, seamless black steel pipe conforming in all details to Standard ASTM Designation A135, A106, and A53, latest revisions. Steam condensate shall be Schedule 80.
- C. Fittings:
 - 1. All weld fittings shall be domestic made wrought carbon steel butt-welding fittings conforming to ASTM A234 and ASME/ANSI B16.9, latest edition, as made by Weld Bend, Tube Turn, Hackney, or Ladish Company. Attach to only pipe with a hole for the entire length. Each fitting shall be stamped as specified by ASME/ANSI B16.9 and, in addition, shall have the laboratory control number metal stenciled on each fitting for ready reference as to physical properties required for any fittings selected at random. Fittings which have been machined, remarked, printed, or otherwise produced domestically from non-domestic forgings or materials will not be acceptable. Each fitting is to be marked in accordance with MSS SP-25. Markings shall be placed on the fittings at the farthest point from the edge to be welded to prevent disfiguring from the welding process. Submittal data for these fittings shall include a letter signed by an official of the manufacturing firm certifying compliance with these specifications.
 - 2. All screwed pattern fittings specifically called for shall be Class 150 malleable iron fittings of Grinnell Company, Crane Company or Walworth Company manufacture (300 lb. for unions).
- D. FABRICATION:
 - 1. Welded piping and fittings in chiller and boiler plants shall be fabricated in accordance with ASME/ANSI the latest editions of Standards B31.1 and B31.3 for Steam and Condensate systems, from the Code for Pressure Piping. Standard B31.9 –Building Services Piping may be used within buildings. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.

2. Ensure complete penetration of deposited metal with base metal. Contractor shall provide filler metal suitable for use with base metal. Contractor shall keep inside of fittings free from globules of weld metal. All welded pipe joints shall be made by the fusion welding process, employing a metallic arc or gas welding process. All pipe shall have the ends beveled 37-1/2 degrees and all joints shall be aligned true before welding. Except as specified otherwise, all changes in direction, intersection of lines, reduction in pipe size and the like shall be made with factory-fabricated welding fittings. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction will not be permitted.
3. Align piping and equipment so that no part is offset more than 1/16 inch. Set all fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.
4. Do not permit any weld to project within the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.
5. Do not split, bend, flatten or otherwise damage piping before, during or after installation.
6. Remove dirt, scale and other foreign matter from the inside of piping, by swabbing or flushing, prior to the connection of other piping sections, fittings, valves or equipment.
7. In no cases shall Schedule 40 pipe be welded with less than three passes including one stringer/root, one filler and one lacer. Schedule 80 pipe shall be welded with not less than four passes including one stringer/root, two filler and one lacer. In all cases, however, the weld must be filled before the cap weld is added.
8. Procedure of Assembling Screw Pipe Fittings: All screw joints shall be made with taper threads properly cut. Joints shall be made tight with Teflon applied to the pipe threads only and not to fittings. When threads are cut on pipes, the ends shall be carefully reamed to remove any burrs. Before installing pipe that has been cut and threaded, the lengths of pipe shall be upended and hammered to remove all shavings and foreign material.

E. WELD TESTING:

1. All welds are subject to inspection, visual and/or X-ray, for compliance with specifications. The owner will, at the owner's option, provide employees or employ a testing laboratory for the purposes of performing said inspections and/or X-ray testing. Initial visual and X-ray inspections will be provided by the owner. The contractor shall be responsible for all labor, material and travel expenses involved in the re-inspection and re-testing of any welds found to be unacceptable. In addition, the contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards B31.1, B31.9, and B31.3 due to the discovery of poor, unacceptable, or rejected welds.
2. Welds lacking penetration, containing excessive porosity or cracks, or are found to be unacceptable for any reason, must be removed and replaced with an original quality weld as specified herein. All qualifying tests, welding and stress

relieving procedures shall, moreover, be in accord with Standard Qualification for Welding Procedures, Welders and Welding Operators, Appendix A, Section 6 of the Code, current edition.

2.02 CAST IRON PIPING:

A. PIPE & FITTINGS:

1. Service weight cast iron soil pipe conforming to ASTM Specification A-74 and CISPI Standard 301, hub and spigot for pipe ten inch (10") and larger and hubless for eight inch (8") and smaller. Each piece of pipe and each fitting shall be coated at the factory with asphaltum or coal tar pitch and with the manufacturer's mark or name cast on it.
2. All joints in hub and spigot cast iron pipe shall be made water and gas tight with Tyseal neoprene gaskets. Lead and Oakum may be used only under special conditions, with prior written permission from the Resident Construction Manager. Joints in hubless cast iron soil pipe and fittings shall be made by the use of a neoprene sleeve and 24-gauge, Type 304 Stainless Steel shield made tight with a torque wrench and torqued to a minimum of 100 inch-pounds. Each clamp shall consist of a neoprene gasket with a stainless steel outer band which effectively captures the gasket material. Each clamp shall bear the FM and UPC stamp, shall be approved to Class I of Factory Mutual Standard #1680, and shall be Clamp-All or approved equal. All elbows and tees shall be braced against thrust loads which might result in joint separation due to static pressure or dynamic forces caused by sudden, heavy impulse loading (water hammer) conditions. Hubless piping systems shall not be used in a directly buried, underground application.

2.03 GALVANIZED STEEL PIPE

- A. Pipe: Schedule 40 and shall conform in every detail to ASTM Standard Specifications for BLACK AND HOT-DIPPED ZINC-COATED GALVANIZED WELDED AND SEAMLESS STEEL PIPE ASTM Designation A-135, latest revision. This threaded pipe shall be supplied with thread protectors on each end. All steel water pipe shall be hot-dipped galvanized pipe zinc coated both inside and outside.
- B. Fittings: All fittings for six inch (6") and larger water lines shall be 125 lb., cast iron, flanged pattern fittings. These fittings shall be hot-dipped galvanized, after all machining operations have been completed. These fittings shall be of Crane Company, or approved equal, manufacture and their flanges shall be dimensioned, faced drilled and spot faced to conform to the Class 150 American Standard for Steel Pipe Flanges and Flanged Fittings.

2.04 COPPER PIPE

- A. Copper Pipe: Piping four inches (4") and smaller shall be fabricated of Type K, hard drawn, copper pipe made of deoxidized copper (99.9% pure). This Type K copper pipe shall conform in every detail to ASTM Standard Specifications for COPPER WATER TUBE, Serial Designation B-88-66, and it shall be provided in 20-foot straight lengths. Copper pipe 4" and smaller may only be joined using non-lead-bearing solder, such as 95-5 silver or antimony solder (95 percent tin, and 5 percent silver or antimony). Copper pipe 4" and larger may be joined using roll grooved fittings.

(Note: For UT Austin, substitute the following sentence for the previous two sentences: "Copper pipe may only be joined using "Silvabrite" solder. No other solders may be used.")

- B. Fittings: All fittings for four inch (4") and smaller water lines shall be Streamline Solder Fittings manufactured by Streamline Pipe and Fittings Division, Mueller Brass Company, or approved equal. These wrought copper fittings shall be rigid and strong with openings machined to accurate capillary fit for the pipe.
- C. Lead: It is forbidden that lead in any form be used in any water system other than waste. If lead is used in the fabrication or installation of any water system other than waste, then ALL of the installed equipment and material, which may have come in contact with the lead, shall be marked with bright red or orange spray paint, and shall be removed from the project site. The system(s) shall then be restored and reinstalled using ALL NEW MATERIALS.

2.05 VALVES:

- A. All valves shall be located such that the removal of their bonnets is possible. All flanged valves shown in horizontal lines with the valve stem in a horizontal position shall be positioned so that the valve stem is inclined one bolt hole above the horizontal position. Screw pattern valves placed in horizontal lines shall be installed with their valve stems inclined at an angle of a minimum of 30 degrees above the horizontal position. All valves must be true and straight at the time the system is tested and inspected for final acceptance. Valves shall be installed as nearly as possible to the locations indicated in the Construction Drawings. Any change in valve location must be so indicated on the Record Drawings. All valves must be of threaded or flanged type. No solder connected or grooved fitting valves shall be used on this project. All bronze and iron body gate and globe valves shall be the product of one manufacture for each project. Manufacturers of other types may not be mixed on the same project; i.e., all butterfly valves shall be of the same manufacture, all ball valves shall be of the same manufacture, etc.
- B. All valves used in circulating systems, plumbing and steam systems (low and medium pressure) shall be Class 150 SWP. Class 300 valves shall be constructed of all ASTM B-61 composition. All gate, globe and angle valves shall be union bonnet design. Metal used in the stems of all bronze gate, globe and angle valves shall conform to ASTM B371 Alloy 694, ASTM B99 Alloy 651, or other corrosion resistant equivalents. Written approvals must be secured for the use of alternative materials. Alloys used in all bronze ball, gate, globe, check, or angle valves shall contain no more than 15% zinc. No yellow brass valves will be allowed.
- C. All iron body valves shall have the pressure containing parts constructed of ASTM designated of 126 class B iron. Stem material shall meet ASTM B16 Alloy 360 or ASTM 371 Alloy 876 silicon bronze or its equivalent. Gates and globes shall be bolted bonnet with OS&Y (outside screw and yoke) and rising stem design. A lubrication fitting is preferred on yoke cap for maintenance lubrication of the yoke bushing.
- D. All cast steel body valves shall have the pressure containing parts constructed of ASTM designation A-216-GR-WCB carbon steel. Gate and globe valves shall be bolted bonnet outside and screw and yoke design with pressure-temperature rating conforming to ANSI B16-34-1977. Stems shall meet ASTM designation A-186-F6 chromium stainless steel. Wedge (gate valves) may be solid or flexible type and shall meet ASTM A-182-F6 chromium stainless steel on valves from 2" to 6". Sizes 8" and larger may be A-216-WCB with forged rings or overlay equal to 182-F6. Seat ring shall be hard faced carbon steel or 13% chromium A-182-F6 stainless. Handwheels shall be A47 Grade 35018 malleable iron or Ductile Iron ASTM A536.
- E. All forged steel body valves shall have the pressure containing parts constructed of ASTM 105, Grade 2 forged carbon steel. Seat and wedges shall meet ASTM A-182-F6 chromium stainless steel. Seat rings shall be hard faced. Valves shall conform to ANSI B16-34 pressure-temperature rating.

- F. All valves shall be repackable, under pressure, with the valve in the full open position. All gate valves, globe valves, angle valves and shutoff valves of every character shall have malleable iron hand wheels, except iron body valves 2-1/2" and larger which may have either malleable iron or ASTM A-126 Class B, gray iron hand wheels.
- G. Packing for all valves shall be free of asbestos fibers and selected for the pressure-temperature service of the valve. It is incumbent upon the manufacturer to select the best quality, standard packing for the intended valve service. At the end of one year, period spot checks will be made, and should the packing show signs of hardening or causing stem corrosion then all valves supplied by the manufacturer shall be repacked by the Contractor, at no expense to the Owner, with a packing material selected by the Owner.
- H. Valves 12" and larger located with stem in horizontal position shall be drilled and tapped in accordance with MSS-SP-45 to accommodate a drain valve and equalizing by-pass valve assembly.
- I. Balancing and/or Shutoff Valves for Hot Water Systems: Two inches and smaller, three piece full port bronze body ball valve, stainless steel ball and stem. Teflon seats, packing and gasket, bronze gland follower, adjustable stuffing box, steel lever type handle, with plastic sheathed operating handle, adjustable memory stops, and shall be class 150 SWP/600 WOG, screwed pattern. Manufacturer shall certify ball valves for use in throttling service. Stem extensions shall be furnished for use in insulated lines. Cold water service valves shall be as above, except two piece construction. All valves 2 1/2" and larger shall be tapped full lug butterfly valves with aluminum bronze discs of ASTM B148 Alloy C955 and 316, 416, or 420 stainless steel shafts. Design must incorporate bushing between shafts and body of material suitable to provide a bearing surface to eliminate seizing or galling. Valve must be capable of providing a bubble tight seal at 200 psi for valves up to 12" (150 psi for larger valves) when used for end of line service without requiring the installation of a blind flange on the downstream side. Liners shall be resilient material suitable for 225 °F temperature and bodies of ductile iron. Butterfly valves 8" and larger and butterfly valves used for balancing service, regardless of size, shall have heavy duty weather proof encased gear operators, with malleable iron handwheel or crank. Valves 2 1/2" through 6" shall have lever handles which can be set in interim positions between full open and full closed. All butterfly valves shall be absolutely tight against a pressure differential of 150 psi.
- J. Check Valves for Water Systems: Bronze body, 2" and smaller, bronze body regrinding disc and seat with screw-in cap. Iron body, 2 1/2" and larger, bronze disc and seat or non slam wafer type with stainless pins and springs, and bronze plate. Forged steel lift check valves, 2" and smaller shall be bolted cap and body, screwed end connections and conform to ANSI B16.34 and pressure temperature rating.
- K. Valves for Fire Protection Service: 2" and smaller, bronze body ball valve as above, Underwriters' Laboratories Listed and Factory Mutual Approved, screw pattern 2 1/2" and larger, Underwriters Laboratories Listed and Factory Mutual Approved butterfly valves with tapped full lug body and gear operated with malleable iron hand-wheel and position indicator. All valves to be furnished with two factory mounted internal supervisory switches.

Gate valves 2 1/2" and larger shall have approved rating of 175 psi WWP or greater, iron body with resilient rubber encapsulated wedge, epoxy-coated interior, and pre-grooved stem for supervisory switch.
- L. Check Valves Fire Protection System: Iron body, swing-check, bronze disc, seat ring and hinge pin, 300 psi rated working pressure, Underwriters' Laboratories and Factory Mutual approved. Complete with ball drip assembly.

M. Standards of Quality for Valves:

Standard of Quality for Valves:

				<u>Class</u>	<u>Milwaukee</u>	<u>Nibco</u>	<u>Stockham or as noted</u>
*2" & smaller	Ball Valve "	Chilled Water	1	50 --		T-585-70	Apollo 77-100
Requires extended stems in insulated lines with adjustable memory stop.							
*2" & Smaller	Ball Valve	Domestic Hot & Cold Water Plumbing Systems		150	--	Nibco T-585-Y-66	Apollo 77-140
Requires extended stems in insulated lines with adjustable memory stop.							
2" & smaller	Check Valve	All Water Systems		150	510	T-433	B-345
2-1/2" & larger	Check Valve	All Water Systems		150	1400 Series	W-920-W	Stockham 'Duo-Check'

2.13 UNIONS:

- A. Provide and install unions at proper points to permit removal of pipe and various equipment and machinery items without injury to other parts of the system. No unions will be required in welded lines or lines assembled with solder joint fittings except at equipment items, machinery items and other special pieces of apparatus. Unions in 2" and smaller in ferrous lines shall be Class 300 AAR malleable iron unions with iron to brass seats, and 2 1/2" and larger shall be ground flange unions. Unions in copper lines shall be Class 125 ground joint brass unions or Class 150 brass flanges if required by the mating item of equipment. Companion flanges on lines at various items of equipment, machines and pieces of apparatus shall serve as unions to permit removal of the particular items. See particular Specifications for special fittings and pressure.
- B. Unions connecting ferrous pipe to copper or brass pipe shall be dielectric type equal to EpcO.
- C. In all water lines where the material of the pipe is changed from ferrous to copper or brass, a dielectric coupling shall be used at the transition.

2.14 FLANGES:

- A. All 150 lb. and 300 lb. ANSI flanges shall be weld neck and shall be domestically manufactured, forged carbon steel, conforming to ANSI B16.5 and ASTM A-181 Grade I or II or A-105-71 as made by Tube Turn, Hackney or Ladish Company. Slip on flanges shall not be used. Each fitting shall be stamped as specified by ANSI B16.9 and, in addition, shall have the laboratory control number stenciled on each fitting for ready reference as to physical properties and chemical composition of the material. Complete test reports may be required for any fitting selected at random. Flanges which have been machined, remarked, painted or otherwise produced domestically from imported forges will not be acceptable. Flanges shall have the manufacturer's

trademark permanently identified in accordance with MSS SP-25. Contractor shall submit data for firm certifying compliance with these Specifications. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard Heavy dimensions. Allthread rods will not be an acceptable for flange bolts. Steam system flange bolts shall have a tensile strength of 105,000 psi and an elastic limit of 81,000 psi and rated at least ANSI Grade V. Other bolts shall have a tensile strength of 80,000 psi and an elastic limit of 36,000 psi and rated at least ANSI Grade I.

- B. Flat faced flanges shall be furnished to match 125 lb cast iron flanges on pumps, check valves, strainers, etc. with full flange gaskets. Bolting of raised face flanges to flat faced flanges is not allowed.

C. FLANGE GASKETS

1. Gaskets shall be placed between the flanges of all flanged joints.
2. Gaskets for steam piping - All steam flange joints shall use Flexitallic Class 150 spiral wound for low pressure applications and Flexitallic Class 300 spiral wound gaskets for medium or high pressure applications. Raised and flat face flange gaskets shall be Flexitallic compression gauge (CG) style. External ring shall be Type 304 stainless steel and color coded yellow. Filler material shall be Flexite Super and color coded with pink stripe. Equivalentents may be submitted with all design data so that an evaluation of the gasket can be made.
3. Gaskets for all other applications: Gaskets shall be ring form gaskets fitting within the bolt circle of their respective flanges. Gaskets shall be 1/16" thick asbestos free material recommended for service by Anchor, Garlock, or John Crane. The inside diameter of such gaskets shall conform to the nominal pipe size and the outside diameter shall be such that the gasket extends outward to the studs or bolts employed in the flanged joint.
4. Spares - Contractor shall provide ten spares for every flange size and rating.

D. Flange Bolt Installation:

1. Bolt Lubrication: Bolts shall be well lubricated with a heavy graphite and oil mixture.
2. Torque Requirements - Bolts shall be stressed to 45,000 psi.

Nominal Bolt Dia. (Inch)	Torque (Ft-Lbs)
.25	6
.3125	12
.375	18
.4375	30
.5	45
.5625	68
.625	90
.75	150
.875	240
1.0	368
1.125	533
1.25	750
1.375	1020
1.5	1200

3. Torque shall be checked with a calibrated breaking action torque wrench on the final torque round. Bolts shall be cold and hot torqued.
4. Torque Pattern - Shall be a cross or star pattern with at least four passes. Limit each pass to 30% of full torque increases.
5. Hot Torque - Re-torque the flange bolts with system at normal operating pressure and temperature for at least four hours.
6. Inspection - Owner shall verify hot torquing of all medium and high pressure steam flange bolts.

PART 3 EXECUTION

Refer to other Sections for service specific requirements.

3.01 EXAMINATION

- A. Verify excavations under provisions of Section 23 00 00.
- B. Verify that excavations are to required grade, dry, and not over-excavated.

3.02 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.03 INSTALLATION

- A. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- B. Route piping in orderly manner and maintain gradient.
- C. Install piping to conserve building space and not interfere with use of space.
- D. Group piping whenever practical at common elevations.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Provide clearance for installation of insulation and access to valves and fittings.
- G. Provide access where valves and fittings are not exposed. Coordinate access door location with architectural features.
- HI. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- I. Provide support for utility meters in accordance with requirements of utility companies.
- J. Prepare pipe, fittings, supports, and accessories not pre-finished, ready for finish painting. Refer to Division 09.
- K. Install valves with stems upright or horizontal, not inverted.

3.04 ERECTION TOLERANCES

- A. Establish invert elevations, slopes for drainage to 1/8 inch per foot (one percent) minimum. Maintain gradients through each joint of pipe and throughout system.
- B. Slope water piping and arrange to drain at low points.

END OF SECTION

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TX Firm Registration No. F-003068

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SECTION 23 21 00

HYDRONIC PIPING

PART 1 GENERAL

1.00 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

1.01 WORK INCLUDED

- A. Pipe and Pipe Fittings
- B. Valves
- C. Chilled Water Piping System

1.02 SCOPE OF WORK: Furnish and install all labor, materials, equipment, tools and services and perform all operations required in connection with, or properly incidental to, the construction of complete HVAC piping and accessories systems as indicated on the Drawings, reasonably implied therefrom, or as specified herein unless specifically excluded.

1.03 RELATED WORK

- C. Section 23 20 00.A - Piping, Valves and Fittings
- E. Section 21 05 48 - Vibration Isolation
- G. Section 23 07 19 - Piping Insulation

1.04 REFERENCES

- A. ANSI/ASME - Boiler and Pressure Vessel Code
- B. ANSI/ASME Sec 9 - Welding and Brazing Qualifications
- C. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings Class 150 and 300
- D. ANSI/ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV
- E. ANSI/ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV

- F. ANSI/ASME B31.9 - Building Services Piping
- G. ANSI/ASTM D2466 - Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
- H. ANSI/AWS A5.8 - Brazing Filler Metal
- I. ANSI/AWS D1.1 - Structural Welding Code
- J. ANSI/AWWA C105 - Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids
- K. ANSI/AWWA C110 - Ductile - Iron and Gray - Iron Fittings 3 in. through 48 in., for Water and Other Liquids
- L. ANSI/AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Gray-Iron Pressure Pipe and Fittings
- M. ANSI/AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids
- N. ASTM A135 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless
- O. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
- P. ASTM B32 - Solder Metal
- Q. ASTM B88 - Seamless Copper Water Tube
- R. ASTM D1785 - Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
- S. ASTM D2235 - Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
- T. ASTM D2241 - Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR)
- U. ASTM D2310 - Machine-Made Reinforced Thermosetting Resin Pipe
- V. ASTM D2466 - Socket-Type PVC Plastic Type Fittings, Schedule 40
- W. ASTM D2467 - Socket-Type PVC Plastic Type Fittings, Schedule 80
- X. ASTM D2680 - Acrylonitrile-Butadiene-Styrene (ABS) Composite-Sewer Piping
- Y. ASTM D2683 - Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing

Z. ASTM D2751 - Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings

AA. ASTM D2855 - Making Solvent-Cemented Joints with PVC Pipe and Fittings

BB. ASTM F477 - Elastomeric Seals (Gaskets) for Joining Plastic Pipe

1.05 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME B31.9

1.06 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Welding Materials and Procedures: Conform to ANSI/ASME SEC. 9, and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/AWS D1.1.

1.07 SUBMITTALS

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

B. Include data on pipe materials, pipe fittings, valves, and accessories.

C. Include welder's certification of compliance with ANSI/AWS D1.1.

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.

C. Deliver and store valves in shipping containers with labeling in place.

PART 2 PRODUCTS

2.01 WALL, FLOOR AND CEILING PLATES:

A. See Section 23 05 29.

2.02 SLEEVES, INSERTS, AND FASTENINGS:

A. See Section 23 05 29.

2.05 CHILLED WATER PIPING - ABOVE GROUND:

A. See Section 23 20 00.A and 23 06 20.13.

1. Building chilled water piping shall be hard drawn Type K copper with wrought copper sweat fittings and dielectric unions where connected to dissimilar materials.
2. EM chilled water piping shall be hard drawn Type K copper with wrought copper sweat fittings
3. Low Zone (0' to 150' elevation)
 - a. Fittings on piping 2-1/2" and larger shall be standard weight butt welding type. Flanges shall be 150# welding neck type. Standard weight Weld-O-Lets, Thread-O-Lets, and shaped nipples may be used only when take-off is 1/3 or less nominal size of main. Bushings shall not be used.
 - b. Fittings on piping 2" and smaller shall be Class 150 black malleable iron screw fittings. (Class 300 for unions.)
 - c. Valves and strainers: Class 150.

2.08 EQUIPMENT DRAIN PIPING:

- A. All factory fabricated or field erected air conditioning units with drain pans, all centrifugal water pumps and all other items or equipment or apparatus that require drains shall be connected with drain line run with adequate slope to a floor drain or other point of discharge as shown on the Drawings. On A.C. units the drain line shall include a properly sized water-sealed trap.
- B. All drain piping shall be one inch (1") size minimum or larger as may be indicated on the Drawings. Such piping shall be Type L hard copper tube. The drain piping shall be assembled with adapter tees at each change in direction. Install screw plugs in unused openings for access to rod and clean.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. After completion, fill, clean, and treat systems. Refer to Section 22 13 16.UT

3.02 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.

- B. Install piping to conserve building space, and not interfere with use of space and other work.
- C. Group piping whenever practical at common elevations.
- D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 23 05 16.
- E. Provide clearance for installation of insulation, and access to valves and fittings.
- F. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
- G. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to weld area.
- H. Prepare pipe, fittings, supports, and accessories for finish painting. Refer to Section 09 91 00.
- I. Install valves with stems upright or horizontal, not inverted.

3.03 FABRICATION OF PIPE:

- A. All the various piping systems shall be made up straight and true and run at proper grades to permit proper flow of the contained material. Lines shall also be graded for proper drainage.
- B. Piping shall follow as closely as possible the routes shown on Drawings which take into consideration conditions to be met at the site.
- C. Should any unforeseen conditions arise, lines shall be changed or rerouted as required after proper approval has been obtained.
- D. All piping shall be installed with due regard to expansion and contraction and so as to prevent excessive strain and stress in the piping, in connections, and in equipment to which the lines are connected.
- E. All piping shall be clean when it is installed. Before installation it shall be checked, upended, swabbed, if necessary, and all rust or dirt from storage or from lying on the ground shall be removed.
- F. Procedure of Assembling Screw Pipe Fittings: All screw joints shall be made with taper threads, properly cut. Joints shall be made tight with Teflon applied to the pipe threads only and not to fittings. When threads are cut on pipes, the ends shall be carefully reamed to remove any burrs. Before installing pipe that has been cut and threaded, the lengths of pipe shall be upended and hammered to remove all shavings and foreign material.

G. Procedure for Assembling Other Joints: Procedures for assembling joints in cast iron and copper lines have been set forth elsewhere in these Specifications. For any special materials, consult the manufacturers for the recommended procedures in assembling the joints.

3.04 APPLICATION

A. Grooved mechanical couplings and fasteners may be used only in accessible locations and for pump fit-up assemblies, when approved by Owner in writing.

B. Install unions downstream of valves and at equipment or apparatus connections.

C. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.

D. Install [ball] [butterfly] valves for shut-off and to isolate equipment, part of systems, or vertical risers.

E. Install [ball] [butterfly] valves for throttling, bypass, or manual flow control services.

F. Provide spring loaded check valves on discharge of condenser water pumps.

G. Use gas plug cocks for throttling service. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.

H. Use butterfly valves [in heating water systems] [in chilled and condenser water systems] [in heating, chilled and condenser water systems].

I. Use only butterfly valves in chilled and condenser water systems for throttling and isolation service.

J. Use lug end butterfly valves to isolate equipment.

K. Provide 3/4 inch (20 mm) ball drain valves at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. [Pipe to nearest drain.]

3.05 PIPE PRESSURE TESTS:

A. See Section 23 00 00.

3.06 CLEANING AND FLUSHING OF WATER SYSTEMS

A. Water circulating Systems shall be thoroughly cleaned before placing in operation to rid systems of rust, dirt, piping compound, mill scale, oil, grease, any and all other material foreign to water being circulated.

B. Extreme care shall be exercised during construction to prevent dirt and other foreign matter from entering the pipe or other parts of systems. Pipe stored on the project shall have open

ends capped and equipment shall have openings fully protected. Before erection, each piece of pipe, fitting, or valve shall be visually examined and dirt removed.

- C. At pipe end locations a temporary bypass will be installed. Bypass shall be *same* size as the supply and return pipe. Prior to flushing the distribution system, the Contractor shall install the temporary bypass and a temporary line size strainer between the supply and return pipes. Contractor shall verify that the isolation valves are open.

END OF SECTION

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SECTION 23 31 00

DUCTWORK

PART 1 GENERAL

1.00 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

1.01 WORK INCLUDED

- A. Low Pressure Ducts
- B. Medium and High Pressure Ductwork
- C. Duct Cleaning

1.02 RELATED WORK

- A. Section 23 05 48 - Vibration Isolation
- B. Section 23 07 13 - Duct Insulation
- C. Section 23 33 00 - Ductwork Accessories
- D. Section 23 36 00 - Air Terminal Units
- E. Section 23 05 93.A - Testing, Adjusting and Balancing

1.03 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
- 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

1.04 REFERENCES

- A. Fundamentals Handbook, American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).
- B. Equipment Handbook, ASHRAE.
- C. HVAC Duct Construction Standards, Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
- D. HVAC Duct System Design, SMACNA.
- E. Round Industrial Duct Construction Standards, SMACNA.
- F. Engineering Design Manual for Air Handling Systems, United McGill Corporation (UMC).
- G. Assembly and Installation of Spiral Duct and Fittings, UMC.
- H. 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: 2 inch WG positive or negative static pressure and velocities less than 1,500 fpm.
- C. Medium Pressure: 6 inch WG positive static pressure and velocities greater than 1,500 fpm.
- D. High Pressure: 10 inch WG positive static pressure and velocities greater than 2,500 fpm.

1.06 REGULATORY REQUIREMENTS

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

1.07 SUBMITTALS

- 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. Each sheet shall be stenciled with manufacturer's name and gauge. Coils of sheet steel shall be

stenciled throughout on ten foot (10') centers with manufacturer's name and must be visible after duct is installed. Sheet metal must conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards."

- F. Where ducts that are exposed to view (including equipment rooms), pass through walls, floors or ceilings, furnish and install sheet metal collars around the duct.

2.02 DUCTWORK LOW PRESSURE: (Includes all exhaust ductwork downstream of fans.)

- A. The scope of low pressure ductwork is defined as all ductwork downstream of terminal units, and all exhaust ductwork downstream of fans. 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 and tested at 3" static with the same test procedures as medium pressure ductwork.
- 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 1985 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 upstream of fans).

- A. The scope of medium pressure ductwork is defined as all ductwork downstream of all air handlers, up to and including terminal units, plus all return air ductwork. 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 discharge of terminal units.)
1. All medium pressure ducts shall be pressure tested according to SMACNA Chapter 10 test procedures. Design pressure for testing ductwork shall be six inches (6") 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, including the VAV/Constant Volume Terminal Units (i.e. The ductwork shall be capped immediately prior 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.
 3. At the option of the Owner, the Contractor may be allowed to eliminate the terminal units from testing by capping the supply ductwork prior to the terminal units, then inspecting the connection to the terminal units when complete. This option may only

be exercised by the Resident Construction Manager, and then only if documented in writing prior to testing.

- G. All exhaust ductwork, including toilet room exhausts, shall be constructed as for medium pressure ducts and shall be tested for leaks in the same manner as for medium pressure supply ducts.
- H. 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. No other flange-type duct joining systems may be used without written approval from OFPC Engineering.
- I. 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 vanned 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. Where turning vanes are to be provided and installed as required above, in ducts of over 12" thickness (vanes are over 12" long), contractor shall provide and install Tuttle and Bailey double thickness vanes or approved equal. The installation of the turning vanes shall be as described for 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, triple locked corrugated aluminum core 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 a minimum "K" factor of 0.29 at 60 degrees F. mean and a vapor barrier permeability rating of 0.05 per ASTM method E96-66, Procedure A. The C factor shall be 0.24 to meet HUD requirements. 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 5'-0" in length, shall be installed as indicated in the diffuser connection detail, and shall be Flexmaster Type TL-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 and High 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. 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 DUCT LINER: NOTE: ALL DUCTWORK SHALL BE EXTERNALLY INSULATED UNLESS OTHERWISE INDICATED ON THE PROJECT DRAWINGS.

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. Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.
- F. Coat buried, metal ductwork without factory jacket with one coat and seams and joints with additional coat of asphalt base protective coating.
- G. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

- H. Connect terminal units to medium or high 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 3 diameters of straight duct to the entrance of all terminal units.
- I. Connect diffusers with 5'-0" maximum length or troffer boots with 2' maximum length of flexible duct to low pressure ducts. Hold in place with strap or clamp, and seal as specified.
- J. 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.
- K. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

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

AIR SYSTEM MATERIAL

Low Pressure Supply (Heating Systems)	Steel
Low Pressure Supply (Systems with Cooling Coils)	Steel
Medium and High Pressure Supply	Steel
Return and Relief	Steel
General Exhaust	Steel

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.

3.05 DUCTWORK TESTING:

- A. All ductwork shall be pressure tested per SMACNA test procedures.

END OF SECTION

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TX Firm Registration No. F-003068

SECTION 23 33 00
DUCTWORK ACCESSORIES

PART 1 GENERAL

1.00 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

1.01 WORK INCLUDED

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

1.02 RELATED WORK

- A. Products installed, but not furnished under this section include airflow stations and automatic control dampers to be provided by Controls Contractor under section 23 09 23.
- B. Section 23 05 48 - Vibration Isolation
- C. Section 23 31 00 - Ductwork
- D. Section 23 36 00 - Air Terminal Units: Medium and High Pressure Damper Assemblies

1.03 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

1.04 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 manual volume dampers, automatic control dampers, duct access doors, and 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 manual volume 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.
- B. Splitter dampers shall be fabricated of steel not lighter than 16-gauge. The leading edge of the damper shall be hemmed. Each splitter shall be a minimum of 12" long or 1-1/2 times the width of the smaller of the two branches it controls, whichever is greater. Dampers shall be carefully fitted, and shall be controlled by locking quadrants equal to Ventlok No. 555 on exposed uninsulated ductwork, No. 644 on exposed externally insulated ductwork and No. 677 (2-5/8" diameter) chromium plated cover plate for concealed ductwork not above lay-in accessible ceilings. Furnish and install end bearings for the damper rods on the end opposite the quadrant when No. 555 or No. 644 regulators are used, and on both ends when No. 677 regulators are used.
- C. On concealed ductwork above lay-in accessible ceilings use Ventlok No. 555 or No. 644 locking quadrant for splitter dampers.
- D. 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.
- E. Manual volume dampers shall be equal to Ruskin, or approved equal. 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.
- F. Install all automatic control dampers, furnished by the Temperature Control Manufacturer, in strict accordance with the manufacturer's recommendations and requirements of these Specifications.
- G. 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 AND FIRE/SMOKE DAMPERS

A. Fire Dampers

1. Furnish and install where shown on the drawings or required by the Specifications, fire dampers meeting the following requirements.
2. Each fire damper shall be constructed and tested in accordance with Underwriters Laboratories Safety Standard 555. All dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the architectural drawings) protection rating, 165 or 212 degree F fusible link, and shall bear a U.L. label in accordance with Underwriters Laboratories labeling procedures. Fire dampers shall be constructed such that the damper frame material and the curtain material shall be galvanized.
3. Fire dampers shall be curtain blade or multi-blade type and the damper shall be so constructed that the blades are either out of the air stream or installed in an oversized sleeve to provide a 100 percent free area of the duct in which the damper is housed.
4. The damper manufacturer's literature submitted for approval prior to the installation shall include performance data developed from testing in accordance with AMCA 500 Standards and shall show the pressure drops for all sizes of dampers required at anticipated airflow rates. Maximum pressure drop through fire damper shall not exceed 0.05 inch water gauge.
5. Fire dampers shall be equipped for vertical or horizontal installation as required by the locations shown in the drawings. Fire dampers shall be installed in wall and floor openings utilizing steel sleeves, angles and other material and practices required to provide an installation equivalent to that utilized by the manufacturer when the respective dampers were tested by Underwriters Laboratories. Mounting angles shall be a minimum of 1 1/2 inch by 1 1/2 inch by 14-gauge and bolted, tack welded or screwed to the sleeve at maximum spacing of 12 inches and with a minimum of two connections at all sides. Mounting angles shall overlap at least equal to the gauge of the duct defined by the appropriate SMACNA Duct Construction Standard, latest edition, and as described in NFPA 90A. The entire assembly, following installation, shall be capable of withstanding 6" water gauge static pressure.
6. The damper installation shall be in accordance with the damper manufacturer's instructions.
7. All fire dampers shall comply with the specification as written above and shall be Greenheck model DFD-150 or DFDR-150 (type C, CR or CO), Ruskin model DIBD2 (Style C, CR or CO), Nailor model D0120 or D0130, or Pottorff model VFD-10D-A.
8. The contractor shall completely seal the assembly to the building components using Hardcast 1602 sealant tape to allow for expansion and contraction of the sleeve and damper assembly.

9. Dampers shall be UL labeled for use in dynamic systems. Closure reading shall be 110% of the maximum design airflow at the point of installation. The minimum closure pressure rating shall be 8" wg for airflow in either direction.

B. Combination Fire/Smoke Dampers

1. Furnish and install where shown on the drawings, or as required by the specifications, combination fire/smoke dampers meeting the following requirements.
2. Each combination fire/smoke damper shall be 1 1/2 hour fire rated under UL Standard 555, 4th Edition, and shall be further classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to it. The damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers required by this specification. Testing and UL qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be no higher than Leakage Class I (4 cfm per square foot at one inch water gauge pressure and 8 cfm per square foot at 4 inches water gauge pressure). The maximum air pressure drop through each combination fire/smoke damper shall not exceed 0.10 inch water gauge at the design air quantity. (Note that this may require a larger damper than the connected duct size.)
3. The damper frame shall be a minimum of 20-gauge galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be integral high surface area non electrolytic materials construction to incorporate a friction free frame blade lap seal, or molybdenum disulfide impregnated stainless steel or bronze oilite sleeve type turning in an extruded hole in the frame or an extruded frame raceway. The dampers may be either parallel or opposed blade type. The blades shall be constructed with a minimum of 14-gauge equivalent thickness. The blade edge seal material shall be able to withstand 450 degrees F. The jamb seals shall be flexible stainless steel compression type or lap seal type.
4. In addition to the leakage ratings specified herein, the combination fire/smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 250 degrees F. Electric operators shall be installed by the damper manufacturer at the time of damper fabrication. The damper and operator shall be supplied as a single entity that meets all applicable UL555 and UL555S qualifications for both dampers and operators. The manufacturer shall provide a factory-assembled sleeve. The sleeve shall be a minimum of either 20-gauge for dampers where neither width nor height exceeds 48 inches or 16-gauge where either dimension equals or exceeds 48 inches.
5. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures of at least 4 inches water gauge in the closed position, and 2500 fpm air velocity in the open position.
6. Each combination fire/smoke damper shall be equipped with a UL Classified Firestat/releasing device. The Firestat/releasing device shall electrically and mechanically lock the damper in a closed position when the duct temperatures exceed 165 degrees F and still allow the appropriate authority to operate the damper as may be required for smoke control functions. The damper must be operable while the temperature is above 250 degrees F. The actuator/operator

package shall include two damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One switch shall close when the damper is fully open, and the other switch shall close when the damper is fully closed. The Firestat/releasing device and position indicator switches shall be capable of interfacing electrically with the smoke detectors, building fire alarm systems, and remote indicating/control stations.

7. The damper releasing device shall be mounted within the airstream. The device shall be activated and the damper shall close and lock when subjected to duct temperatures in excess of approximately 285 degrees F.
8. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated in the plans, and shall be furnished and installed by the damper manufacturer as required by the U.L. rating mentioned above. Motors shall be electric or pneumatic to match the type of temperature control system specified elsewhere in this specification. All required relays, EP switches, wiring piping and other labor and material necessary to completely interconnect the smoke detector system shall be furnished by the Contractor.
9. Each damper shall be furnished in a square or rectangular configuration. The Contractor shall furnish and install sleeves manufactured by the approved damper manufacturer for each damper. The sleeves shall be constructed with square or rectangular to square, rectangular, round, or oval adapters as required. Dampers shall be installed in the sleeves in accordance with manufacturers U.L. installation instructions. The entire assembly, following installation, shall be capable of withstanding 6" W.G. static pressure.
10. All combination fire/smoke dampers shall comply with the specification as written above and shall be Greenheck model FSD-33, Ruskin model FSD-60, Nailor model 1220, or Pottorff model FSD-151.
11. The contractor shall completely seal the assembly to the building components using Hardcast 1602 sealant tape to allow for expansion and contraction of the sleeve and damper assembly.
12. Dampers shall be UL labeled for use in dynamic systems. Closure reading shall be 110% of the maximum design airflow at the point of installation. The minimum closure pressure rating shall be 8" wg for airflow in either direction.

C. Submittal and Installation

1. Submittal(s) for fire and combination fire/smoke dampers shall include the following:
 - a. Assign identification numbers for each damper with corresponding number noted on the drawings.
 - b. Provide air quantity, size, free area of damper, pressure drop and proposed velocity through each damper.
 - c. Provide manufacturer's data of damper and its accessories or options.
2. One sample 18" x 12" damper shall be furnished for the purpose of illustrating damper operation to the Owner's operating and maintenance personnel.

3. Access doors as specified elsewhere shall be provided to make all parts of the damper accessible. Doors shall open not less than 90 degrees following installation and shall be insulated type where installed in insulated ducts.
4. Contractor shall install each damper square and true to the building. The installation shall not place pressure on the damper frame, but shall enclose the damper as required by UL555.
5. After each fire damper and combination fire and smoke damper has been installed and sealed in their prescribed openings and prior to the installation of the ceilings, the Contractor shall, as directed by the Construction Inspector, activate part or all the dampers as required to verify "first-time" closure. Activation of the damper shall be accomplished by manually operating the resettable link, disconnecting the linkage at the fusible link of the fire damper, and manually operating the fire/smoke damper through the pneumatic or electronic controls as appropriate. Failure of the damper to close properly and smoothly on the first attempt will be cause to replace the entire damper assembly.

2.03 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.

2.04 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.

2.05 SCREENS

- A. Furnish and install screens on all duct, fan, etc., openings furnished by this Contractor that 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.

2.06 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.

2.07 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 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 fitting shall be provided with a 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'.

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 dampers, and combination fire and 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.B.

END OF SECTION

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SECTION 23 36 00

AIR TERMINAL UNITS (VAV)

PART 1 GENERAL

1.00 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

1.01 SECTION INCLUDES

- A. Variable Volume Terminal Units
- B. Constant Volume Exhaust Terminal Units
- C. Integral Damper Motor Operators
- D. Integral Controls

1.02 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 23 09 23 – Direct Digital Control Systems
- B. Section 23 05 93.A - Testing, Adjusting and Balancing
- C. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- D. Section 26 27 26 - Wiring Devices

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 05 93.A - Testing, Adjusting and Balancing
- E. Section 26 05 19 - Cable, Wire and Connectors, 600 Volt
- F. Section 26 27 26 - Wiring Devices

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

- D. ARI 880 - Standard for Air Terminals

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 airflow, 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.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data under provisions of Section 23 00 00.
- B. 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 VARIABLE VOLUME TERMINAL UNITS:

The Contractor shall furnish and install pressure independent single duct variable air volume control assemblies), of the sizes, capacities and configurations shown on the Drawings.

- A. CASING CONSTRUCTION:

1. The units shall be constructed of a minimum of 22-gauge galvanized steel and internally lined with a minimum of 1 inch thick, three pound per cubic foot density insulation. The insulation shall be foil faced with the edges and seams sealed or "captured", encapsulating all fibers of the insulation. The insulation shall be neatly installed with no rough edges to interrupt the smooth flow of air through the box. Closed cell polymer insulation may be used instead of the fiberglass described above if UL 25/50 labeled. The casing shall be insulated throughout its interior, up to or at least to within 2" of the heating coil connection. Insulation for the heating coil shall enclose the coil casing and tube bends and shall overlap the box internal

lining by at least 3". The external insulation shall be as specified in other sections of this specification for duct insulation with full vapor barrier, and shall be field installed unless coil and plenum section is furnished as an integral part of the box.

2. All interior features of the boxes (such as mixing baffles, damper housings, etc.) shall be secured within the casing to avoid excessive movement or rattling with air movement or externally generated vibration. All external features of the terminal units shall be designed not to extend beyond the ends of the unit. (For example, the actuator mounting brackets, etc. shall not extend beyond the plane of the inlet "bulkhead.") The only exception shall be flow sensors installed in the inlet duct connections. Note that if a separate flow station is installed within a frame within the casing, then it shall be so installed not to allow airflow to bypass the flow measurement station.
3. The terminal units shall be constructed with inlet and discharge ductwork connections. The inlet ductwork connections shall extend a minimum of 4 inches from the unit casing including an allowance for the installation of airflow station(s) or probe(s). The discharge connection shall include 1" extension with slip and drive connections for use by the Contractor to secure the discharge ductwork or appurtenances to the unit and shall be reinforced to provide a rigid assembly.

B. CASING LEAKAGE: Assembled units shall be so constructed and sealed to limit air leakage to the following listed quantities at 6" static pressure. If sealing is required to obtain the leakage performance, seal as for medium pressure ductwork Hardcast 1602 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:

<u>Diameter</u>	<u>Maximum Allowed CFM (Area x 2000 fpm)</u>	<u>Maximum Allowable CFM Casing Leakage</u>
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

C. ACCESS PLENUM AND DOOR: Single duct units provided with reheat coils also shall be provided with an access section or plenum between the terminal and the coil for coil inspection. The construction of the plenum shall be equal to the quality of materials and workmanship to that of the terminal unit. The access plenum may also be used as a transition, and shall be constructed with a transition angle not to exceed 15 degrees. The access plenum shall contain a minimum of a 12 inch diameter or 12 inch by 12 inch (or full width of unit if less than 12") access door as manufactured by Ventlok, Flexmaster Inspector, Ward or equal. Door frame may be bolted, screwed or flanged and sealed to the casing. Door shall be gasketed and shall be double wall construction or insulated similar to main casing. Door shall be held in place with latches or other captive retainer devices. An additional access panel shall be provided immediately downstream of the dampers for inspection and service of the dampers. If the damper assembly is easily removed from the rear of the box, the access size can be reduced to 8" round or 8" x 8" for inspection only.

D. DAMPER CONSTRUCTION: The damper blades shall be an equivalent of 18-gauge galvanized steel or equal aluminum and shall be securely riveted or bolted through the damper shafts to assure no slippage of the blades. The damper shafts shall operate in rust-proof self-lubricating bearings. Damper shafts penetrating the unit casings shall be

sealed against leakage, and bearings shall be installed for protection against wear in the casing penetration. Damper shafts shall be formed of, or cut from solid stock; no hollow shafts will be allowed. The dampers shall seat against gasketed stops or the dampers shall have gasketed edges. Gaskets shall be mechanically fastened to the blades. If the fastening method is not full contact clamping type, then the addition of adhesive to the gasket shall be required. The dampers shall be so constructed to prevent "oil canning" of the damper blade. The units shall be tested for leakage in both inlets with 6" static pressure imposed on one inlet at a time. The maximum percent leakage from all tests shall be reported. Leakage curves as a function of pressure shall be supplied as part of the submittal data. The damper actuator linkage, if used, shall be constructed of material of sufficient strength to avoid buckling under extreme loads. Also, linkages shall not allow play greater than 5 degrees of damper movement. The controls for the dampers shall cause the dampers to fail in the position of last control (freeze in place), or fail to the open position.

- E. DAMPER LEAKAGE: The following is the maximum damper leakage allowable for the various size diameter inlets at 6" wg differential pressure. The damper leakage shall not exceed the values listed in the table below at 6" S.P., following ARI 880 Testing Procedures.

<u>Diameter</u>	<u>Maximum Allowed CFM (Area x 2000 fpm)</u>	<u>Maximum Allowable CFM Damper Leakage</u>
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

- F. UNIT PRESSURE DROP: For dual duct units with an integral attenuator-mixer, but with no other accessories, the static pressure across the assembly with an equivalent 2000 fpm inlet velocity through one inlet shall not exceed 0.50 inches water gauge, with the total flow through either inlet. Single duct unit pressure drop shall be limited to 0.15 inches water gauge under the same conditions above.

- G. CERTIFICATION: The Unit Manufacturer shall certify that each unit used on this project will perform as specified. Each unit shall bear a tag or decal listing the following specified information:

1. Test Pressure
2. Leakage CFM (damper)
3. Leakage CFM (casing)
4. Date of Mfg.
5. Room or area served
6. Unit size - 6", 8", etc.
7. Calibrated CFM, i.e. 800 CFM

- H. FLOW MEASUREMENT: Airflow thru the unit shall be accomplished by the use of a multi-port sensing device with a minimum of four radially distributed pick-up points connected to a center averaging chamber with adequate internal passages to prevent restrictions that can result in control 'hunting'. On all systems, sensors shall be mounted as required by the temperature controls supplier.

- I. SOUND: (Note that the maximum sound levels listed in this paragraph refer to raw sound levels, with no credits taken for the construction.)

1. DISCHARGE SOUND

Maximum discharge Sound Power Levels at 2000 fpm primary air inlet velocity with 1.5 inch wg inlet static pressure shall not exceed that listed in the following table. No credit for lined discharge duct, branching, flow division, end reflection, room absorption or any other effects shall be allowed.

Octave Band (Hz)	Center Frequency (dB re 10 ⁻¹² Watts)	Sound Power Level
2	125	76
3	250	66
4	500	63
5	1000	58
6	2000	60
7	4000	55

2. RADIATED SOUND

Maximum discharge Sound Power Levels at 2000 fpm primary air inlet velocity with 1.5 inch wg inlet static pressure shall not exceed that listed in the following table. No credit for ceiling plenum, ceiling tiles, room absorption, or any other effects shall be allowed.

Octave Band (Hz)	Center Frequency (dB re 10 ⁻¹² Watts)	Sound Power Level
2	125	72
3	250	67
4	500	64
5	1000	54
6	2000	47
7	4000	45

All sound power levels shall be obtained from testing in accordance with ARI-ADC Standard 880 and shall be certified at ARI-880 certification points.

J. MANUFACTURER: All Terminal Units shall be as manufactured by Titus (Model MDV-3100-UT), Metal*Aire (Series TH500-ECO), or Nailor Industries (3000-UT). *Note that the model and series numbers listed may differ slightly from catalogue information. 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.

K. GENERAL PERFORMANCE: Devices using mechanical CFM limiters will not be accepted, nor shall it be necessary to change control components to make airflow rate changes. If used, pneumatic actuator motors, pneumatic controllers, and pneumatic or DDC flow stations shall be furnished, mounted and adjusted by the terminal unit assembly Manufacturer to assure their proper placement within the units. It shall be noted that the terminal unit Manufacturer shall be responsible for the workmanship and materials of the entire assembly of unit and controls if pneumatic controls are specified and supplied with the unit. If DDC controls of another Manufacturer (NOT the terminal unit Manufacturer) are provided for this project, the terminal unit Manufacturer shall be responsible only for the construction of the terminal unit and the installation of internal control components installed at the Manufacturer's factory, and shall not be responsible for the installation of controls not

installed at the terminal unit Manufacturer's factory, nor shall the Manufacturer be responsible for the performance of the DDC controls. The performance of DDC controls, especially in connection with terminal units, shall be the responsibility of the DDC controls Manufacturer.

- L. CONTROL PERFORMANCE: Assemblies shall be able to be reset 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 simple screwdriver or keyboard adjustments to arrange each unit for any maximum airflow 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 four diameters of straight duct directly prior to the entry into each terminal unit connection and of the same size as the box connection.
- M. CONTROL SEQUENCES: The control sequence arrangements shall be as described below, whether the controls used on this project are pneumatic or DDC, and the terminal units shall be shipped from the Manufacturer with all necessary control devices to accomplish each sequence, except as may be prohibited by the controls Manufacturer. The desired sequence shall be adjustable according to space usage or a change in space conditions.
- O. DDC SYSTEMS:
 - 1. Electronic motors and controllers shall be installed by the terminal unit Manufacturer unless specifically prohibited by the by the controls Manufacturer. In such an event, the controls Manufacturer shall be responsible for the installation of the controls. The controls Manufacturer shall be responsible for the operational performance of the entire system. The terminal unit Manufacturer shall remain responsible only for the performance of the mechanical components of the unit.
 - 2. DDC Controls Protocol/Description: Refer to Sequence of Operation on Drawings.

2.02 CONSTANT VOLUME EXHAUST VALVES:

- A. Furnish and install Phoenix pressure independent self-regulating venture exhaust valve as scheduled on the Drawings.

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.
- C. Provide ceiling access doors or locate units above easily removable ceiling components.
- D. Support units individually from structure. Do not support from adjacent ductwork.
- E. Connect to ductwork in accordance with Section 23 31 00.

END OF SECTION

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