
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 23 05 53 - Mechanical Identification
 - 3. Section 23 05 93 – Testing, Adjusting and Balancing (TAB)
 - 4. Section 23 05 93A – Testing, Adjusting and Balancing Contractor Responsibilities
 - 5. Section 23 07 13 - Ductwork Insulation
 - 6. Section 23 09 23 - Direct Digital Control Systems
 - 7. Section 23 31 00 - Ductwork
 - 8. Section 23 33 00 - Ductwork Accessories
 - 9. Section 23 36 00 - Air Terminal Units
 - 9. Section 23 37 00 - Air Inlets and Outlets
- 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

SECTION 23 05 29
SLEEVES, FLASHINGS, SUPPORTS AND ANCHORS

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 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. 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

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. NOT USED.

1.03 RELATED SECTIONS

- A. Section 23 00 00 - Basic Mechanical Requirements.

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. Manufacturers:

1. Seaton.
2. Other acceptable manufacturers offering equivalent products.
 - a. Brady
 - b. Bunting
 - c. EMED

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

2.02 TAGS

A. Manufacturers:

1. Seaton
2. Other acceptable manufacturers offering equivalent products.
 - a. W.H. Brady
 - b. Bunting

A. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch (40 mm) diameter with smooth edges.

B. Chart: Typewritten letter size list in anodized aluminum frame.

2.03 PIPE MARKERS

A. Manufacturers:

1. Seton
2. Other acceptable manufacturers offering equivalent products.
 - c. W.H. Brady
 - d. Bunting
 - e. EMED

B. Color: Conform to ASME A13.1.

C. 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.

D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

E. 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 VINYL STICKERS

A. Manufacturers:

1. Seton
2. Other acceptable manufacturers offering equivalent products.
 - a. W.H. Brady
 - b. Bunting
 - c. EMED

B. Description: Vinyl stickers with arrow pointing to the ceiling tile needing to be removed for access to the equipment to be located on the grid.

C. 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:

Zoning Boxes/Valves	Fire/Smoke dampers
Air Conditioning Control	Miscellaneous - similar
Panels and Switches	and/or related items

2.07 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

2.08 Specials: Refer to special requirements noted in the various sections hereinafter bound.

PART 3 EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Apply stencil painting in accordance with Section 09 91 00.
- D. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- E. Identify control panels and major control components outside panels with plastic nameplates.
- F. Identify thermostats relating to terminal boxes or valves with nameplates.
- G. Identify air terminal units and radiator valves with numbered tags.
- H. Tag automatic controls, instruments, and relays. Key to control schematic.
- I. 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

SECTION 23 05 93
SYSTEM TESTING, ADJUSTING AND BALANCING

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 to 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, Fifth Edition 1989.
- B. ASHRAE - 1991 HVAC Applications Chapter 34: Testing, Adjusting and Balancing.
- C. ANSI/ASHRAE Standard 111-1988 - 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 1989 Standard, Fifth 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.UT. 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.UT. 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) valve's 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 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.

1.08 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. 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

4. Air Monitoring Station Data
 - a) Identification/location
 - b) System
 - c) Size
 - d) Area
 - e) Design velocity
 - f) Design air flow
 - g) Test velocity
 - h) Test air flow

5. 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

6. 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

SECTION 23 05 93.A
SYSTEM PREPARATION FOR
TESTING, ADJUSTING AND BALANCING

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 00 00 - Basic Mechanical Requirements.
- B. Section 23 31 00 - Ductwork.
- C. Section 23 33 00 - Ductwork Accessories.
- D. Section 23 37 00 - Air Outlets and Inlets.
- E. Section 23 09 23 - Direct Digital Control Systems.
- F. Section 23 05 93 - System Testing, Adjusting & Balancing.

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.

The following are minimum time requirements:

TAB Agency will provide Engineer with tentative schedules for each area, floor and/or system to be included in this section.

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. 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.

3. Tabulated Data: The motor amperages, voltages shall be recorded showing "actual" and "nameplate" voltage and amperage and submitted and actual RPM. This applies to each piece of electrically driven air conditioning equipment in the system including supply and exhaust fans, fans of fractional horsepower, pumps, etc.

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 1.04C.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

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 23 00 00- General Mechanical Requirements.
- B. Section 23 05 53 - Mechanical Identification.
- C. Section 23 31 00 - Ductwork: Duct liner.
- D. 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.

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- B. Product Data: Provide product description, list of materials and thickness for each service, and locations.
 - C. Samples: Submit two samples of any representative size illustrating each insulation type.
 - D. Manufacturer's Installation Instructions: Indicate procedures which ensure acceptable workmanship and installation standards will be achieved.
- 1.05 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 C:
- A. Blanket insulation similar in construction to Owens-Corning Fiberglass Series or Johns Manville Microlite, one pound per cubic foot minimum density with foil reinforced Kraft (FRK) vapor barrier facing. Insulation shall be wrapped on the ductwork in accordance to manufacturer's stretched-out criteria, 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 vapor barrier Emulsion and covered with vapor barrier emulsion until the tape is completely covered. All penetrations or punctures in facing shall also be taped. Vapor sealing of joints is not required on hot duct application where concealed.
- 2.02 Vapor Seal Emulsion – Where specified herein, joint and seam vapor sealant shall be water based materials equal to Foster 30-35, Hardcast "Flex-Grip" 550 (sprayed to 20 mil thickness), or Childers Chil-Perm WB CP-35.

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- 2.03 All ductwork in the building and in the crawl spaces except exhaust and return ducts shall be insulated externally unless specifically excluded. Only sound attenuated return ducting may be insulated internally, if specifically designated as such.
- 2.04 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.
- 2.05 Low pressure supply duct taps to ceiling diffusers shall be externally insulated including top of ceiling diffuser.
- 2.06 Flexible round ducts are specified in Section 23 31 00 as factory insulated.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install materials in accordance with manufacturer's instructions.
- B. Insulated ductwork conveying air below ambient temperature:
 - 1. Provide insulation with vapor barrier jackets.
 - 2. Finish with tape and vapor barrier jacket.
 - 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - 4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- C. Insulated ductwork conveying air above ambient temperature:
 - 1. Provide with or without standard vapor barrier jacket.
 - 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- D. Duct 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.

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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. 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. Flexible connections on duct shall not be covered. All materials used shall be fire retardant or nonflammable..
- 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 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.
- 3.10 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.
- 3.11 The handling and installation of all insulation materials shall be performed in strict accordance with the manufacturer's recommendations.
- 3.12 TOLERANCE

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

3.13 DUCT INSULATION SCHEDULE:

<u>Duct Type</u>	<u>Insulation Type</u>
Low Pressure Supply Duct (including tops of diffusers)	2" Insulation C

END OF SECTION

SECTION 23 09 23
DIRECT DIGITAL CONTROL SYSTEMS
BACKBONE SYSTEMS HAVE BEEN INSTALLED IN THE SHELL & CORE
INFORMATION ON PREVIOUSLY INSTALLED EQUIPMENT IS FOR INFORMATION ONLY.
ADDITIONAL EQUIPMENT AS NOTED WILL BE REQUIRED AS NOTED ON THE DRAWINGS.

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. 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.

1.04 RELATED SECTIONS

- A. Section 26 05 00 - Equipment Wiring Systems.

1.05 REFERENCES

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

1.06 DEFINITIONS

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

1.07 SYSTEM DESCRIPTION

- A. The system is an existing JCI system.
- B. Automatic temperature control field monitoring and control system using field programmable micro-processor based units with communications to the existing Metasys Campus Building Management System.
- C. Central and remote hardware, software, and interconnecting wire and conduit.
- D. Terminal unit controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, pneumatic or electric unless indicated otherwise.

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- E. The DDC systems shall be installed by JCI under a direct contract with the General Contractor. JCI shall provide "open-book" pricing to the General Contractor and UTHSC-H per the existing UTHSC-H/JCI agreement.**
 - F. All sensors that are installed in insulated pipe or ductwork shall be installed with standoffs to allow proper insulation of all materials and continuation of vapor barriers.**

1.08 SUBMITTALS

- A. Submit under provisions of Section 01 33 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.
 - 6. Provide one additional submittal above that which is asked for in Division 1 to be distributed by UTHSC-H to the IT department for verification.
- C. Product Data: Provide data for each system component and software module.
- D. Manufacturer's Installation Instructions: Include for all manufactured components.

1.09 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 01 77 00.
- B. Accurately record actual location of control components, including panels, thermostats, and sensors.
- C. Revise shop drawings to reflect actual installation and operating sequences.
- D. Include data specified in "Submittals" in final "Record Documents" form.

1.10 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 01 77 00.
- B. Include interconnection wiring diagrams complete field installed system with identified and numbered, system components and devices.
- C. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
- D. Include graphics of the controlled system as they appear on the system graphics with variable, adjustable and fixed pints with showing identified and numbered systems, system components and devices.

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- E. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
- 1.11 QUALIFICATIONS
- A. Manufacturer: JCI controls.
 - B. Installer: JCI controls
 - C. Design system software under direct supervision of a Professional Engineer experienced in design of this work and licensed in the State of Texas.
- 1.12 PRE-INSTALLATION CONFERENCE
- A. Convene a conference one week prior to commencing work of this Section, under provisions of Section 01200.
 - B. Require attendance of parties directly affecting the work of this Section.
- 1.13 COORDINATION
- A. Coordinate work under provisions of Section 00 10 05.
 - B. Ensure installation of components is complementary to installation of similar components in other systems.
 - C. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.
 - D. Coordinate the startup and control sequence verification with the test and balance agent.
 - E. Ensure system is completed and commissioned.
- 1.14 WARRANTY
- A. Provide five year warranty under provisions of Section 01 78 36.
 - B. Warranty: Include coverage for field programmable micro-processor based units.
- 1.15 PROTECTION OF SOFTWARE RIGHTS
- A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:
 - 1. Limiting use of software to equipment provided under these specifications.
 - 2. Limiting copying.
 - 3. Preserving confidentiality.
 - 4. Prohibiting transfer to a third party.

PART 2 PRODUCTS

2.00 MANUFACTURERS OF CONTROLS

- A JCI

2.01 GENERAL DESCRIPTION

- A The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks. Prior to submittal update equipment to the latest technology and coordinate with the Engineer.
- B The Building Management System shall consist of the following:
 - 1 Standalone Network Automation Engine(s)
 - 2 Field Equipment Controller(s)
 - 3 Input/Output Module(s)
 - 4 Local Display Device(s)
 - 5 Portable Operator's Terminal(s)
 - 6 Distributed User Interface(s)
 - 7 Network processing, data storage and communications equipment
 - 8 Other components required for a complete and working BMS
- C The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.
- D System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
 - 1 The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
 - 2 The System shall maintain all settings and overrides through a system reboot.
- E Conduit and boxes shall be installed and supported per 23 05 29. Controls conduit shall be ¾" EMT that is blue in color. The boxes shall be type 1900 and where the mixing box is located inside of the office area, the conduit shall be stubbed on from the junction box into the office space as close to the box as possible above the ceiling.

2.02 FIELD DEVICES

- A Thermostats
 - 1 Electric room thermostats of the heavy-duty type shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, where required. All these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.
 - 2 Actuation / Control Type
 - 3 Primary Equipment
 - (a) Controls shall be provided by equipment manufacturer as specified herein.
 - (b) All damper and valve actuation shall be electric.

4 Air Handling Equipment

- (a) All air handlers shall be controlled with a HVAC-DDC Controller
- (b) All damper and valve actuation shall be electric.

PART 3 EXECUTION

END OF SECTION

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.

1.02 RELATED WORK

- A. Section 09 91 00 - Painting: Weld priming, weather resistant, paint or coating.
- B. Section 23 00 00 - Basic Mechanical Requirements.
- C. Section 23 05 29 - Sleeves, Flashings, Supports and Anchors.
- E. Section 23 07 13 - Duct Insulation.
- F. Section 23 33 00 - Ductwork Accessories.
- G. 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.

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- 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.

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.

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- 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, 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:

- A. The scope of low pressure ductwork is defined as all ductwork downstream of terminal units. 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 if not otherwise specified herein. 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", Hardcast "Flex-Grip 550 (spray applied to 20 mil thickness), 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:

- 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 exhaust 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.
 - 1. The entire system of medium pressure ductwork shall be tested, excluding the VAV/Constant Volume Terminal Units (i.e. The ductwork shall be capped immediately 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.
- 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. Testing may exclude any zoning valves as well. The duct shall be capped upstream and downstream of the valves and tested on both sides. Testing can be done before spin-ins are installed if there is no sheetmetal ductwork after the spin-in, or an additional 1 cfm can be added to the total allowable cfm leakage for each dampered spin-in. The total leakage for both upstream and downstream shall be no more than 1% of the total design cfm.
- H. DUCTMATE or Ward coupling system may be used on rectangular ductwork. Contractor may (where space permits) use rectangular ductwork with DUCTMATE or Ward system in lieu of oval ductwork. Joints shall be assembled with pre-formed isobutylene gasket (min. 3/16" thick x 5/8" wide), equal to Ductmate 440 tape or McGill "Uni-Butyl" tape. After assembly, entire joint shall be coated with 20 mil thickness of Hardcast "Flex-Grip" 550. No other flange-type duct joining systems may be used. Duct gauges shall be as specified herein.
- 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 vaned elbows, but shall request the substitution at the time of submittal of Shop Drawings, and shall request the substitution as required in Section 23 0000. 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. Only single thickness turning vanes shall be used.

2.05 FLEXIBLE DUCTS:

- A. Medium 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 Underwriter's 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 24" in length, shall be installed in straight runs only, and shall be Flexmaster Type 1M 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. Insulated Acoustical Low Pressure Flexible Duct: Provide where indicated on drawings Flexmaster Type 1M UL181 Class I Air Duct. The duct shall be constructed of a CPE fabric supported by helical wound galvanized steel. The fabric shall be mechanically locked to the steel helix without the use of adhesives or chemicals. This flex duct material shall be used on exhaust duct for connecting air inlets (for general lab exhaust, not to be considered for connections to hoods, BSCs or equipment connections) to the distribution duct.

The internal working pressure rating shall be at least 6" w.g. positive and 4" w.g. negative with a bursting pressure of at least 2½ time the working pressure.

The duct shall be rated for a velocity of at least 4000 feet per minute. The duct must be suitable for continuous operation at a temperature range of -20° F to +250° F.

Acoustical performance, when tested by an independent laboratory in accordance with the Air Diffusion Council's Flexible Air Duct Test Code FD 72-R1, Section 3.0, Sound Properties, shall be as follows:

The insertion loss (dB) of a 10 foot length of straight duct when tested in accordance with ASTM E477, at a velocity of 2500 feet per minute, shall be at least:

Octave Band	2	3	4	5	6	7
Hz.	125	250	500	1000	2000	4000
6" diameter	7	31	40	38	40	27
8" diameter	13	29	36	35	38	22
12" diameter	21	28	29	33	26	12

The radiated noise reduction (dB) of a 10 foot length of straight duct when tested in accordance with ASTM E477, at a velocity of 2500 feet per minute, shall be at least:

Octave Band	2	3	4	5	6	7
Hz.	125	250	500	1000	2000	4000
6" diameter	5	8	7	8	11	15
8" diameter	10	7	7	8	10	13
12" diameter	9	6	6	5	9	13

The self generated sound power levels (LW) dB re 10-12 Watt of a 10 foot length of straight duct for an empty sheet metal duct when tested in accordance with ASTM E477, at a velocity of 1000 feet per minute, shall not exceed:

Octave Band	2	3	4	5	6	7
Hz.	125	250	500	1000	2000	4000
6" diameter	42	31	23	18	17	21
8" diameter	41	34	27	19	18	21
12" diameter	54	45	38	31	27	23

Factory insulate the flexible duct with fiberglass insulation. The R value shall be at least 4.2 at a mean temperature of 75° F. Cover the insulation with a fire retardant metalized vapor barrier jacket reinforced with crosshatched scrim having a permeance of not greater than 0.05 perms when tested in accordance with ASTM E96, Procedure A.

Total length of flex duct shall be limited to 10' with no more than 1/2" deflection per foot between supports. One 90 degree ell will be allowed when fitted with ThermaFlair FlexFlow Elbow accessory.

2.06 DUCT LINER: NOTE: ALL DUCTWORK SHALL BE EXTERNALLY INSULATED UNLESS OTHERWISE INDICATED ON THE PROJECT DRAWINGS. (See Section 23 07 19, for the applicable insulation specification.)

- A. Where indicated on the Drawings, ducts shall have lining equal to Johns Manville Permacote Linacoustic anti-microbial duct liner with factory applied edge coating. Duct liner shall be one inch (1") thick unless otherwise indicated. The liner shall be applied to the inside of the duct with heavy density side to the air stream and shall be secured in the duct with fireproof 3M #37 or St. Clair R41B adhesive, completely coating the clean sheet metal. All joints in the insulation shall be "buttered" and firmly butted tightly to the adjoining liner using fireproof

adhesive. Where a cut is made for duct taps, etc., the raw edge shall be accurately and evenly cut and shall be thoroughly coated with fireproof adhesive. On ducts over twenty-four (24") in width or depth, the liner shall be further secured with mechanical fasteners. The fasteners shall be A. J. Gerrard Company pronged straps, or approved equal, secured to the ducts by fireproof adhesive. The clips shall be eighteen inch (18") maximum spacing and shall be pointed up with fireproof adhesive. Liner shall be accurately cut and ends thoroughly coated with fireproof adhesive so that when the duct section is installed, the liner shall make a firmly butted and tightly sealed joint. Where ducts are lined exterior insulation will not be needed unless otherwise noted, except that the two insulations shall not lap less than twenty-four inches (24"). Dimensions given on the Drawings are metal sizes. Refer to Section 23 00 00 for Flame-Spread Properties.

2.07 FACTORY LINED ACOUSTICAL DUCTS: (NOTE: Must appear on the Drawings.)

- A. Where indicated on the Drawings, furnish and install double wall internally insulated duct and fittings.
- B. Duct shall consist of outer metal pressure shell, 1" thick glass fiber insulation and internal perforated metal liner.
- C. Duct and fittings shall be equal to Acousti-K 27 as manufactured by United McGill Sheet Metal Company.

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. Connect diffusers or troffer boots to low pressure ducts with 2 feet maximum length of flexible duct. Hold in place with strap or clamp, and seal as specified.
- F. 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 DUCTWORK APPLICATION SCHEDULE

AIR SYSTEM	MATERIAL (2)	MINIMUM PRESSURE CLASSIFICATION
Supply/Exhaust/Return Systems:		
AHU Supply to Terminal Unit/Lab Control Valve	Galvanized Steel	Medium Pressure 6"
Downstream of terminal units	Galvanized Steel	Low Pressure

Notes to Table:

- (1) Air device connections may be made with insulated flexible duct as specified herein. Provide hard connections where specifically shown on the drawings.
- (2) Any duct exposed within occupied spaces (excluding mechanical rooms) shall be stainless.

3.05 CLEANING OF SYSTEMS:

A. Existing Duct:

1. Propose, furnish and apply the labor, equipment, materials, chemicals, apparatus, and appurtenances required for complete cleaning, disinfecting, coating, inspecting and testing (cleaning) of the ACS as required by these documents, and the contractor's proposal, in place and ready for service (The Work).
2. The types of basic materials and methods required for the project include, but are not limited to:
 - a. Duct cleaning vacuum units.
 - b. Duct cleaning high volume negative pressure dust collectors.
 - c. Duct sweepers or scrapers – in duct robotic cleaners that allow removal of dust, dirt and debris.
 - d. Medium and high efficiency filter collection systems.
 - e. Duct disinfectant materials to neutralize or destroy microbial contaminants. (EPA approved for use in ACS and occupied buildings)
 - f. Duct treating and coating materials for the prevention of future growth of microbial contaminants. (EPA approved for use in ACS and occupied buildings)
 - g. Notifying the OR of all locations and providing as built drawings locating and describing all interior surfaces where rust has accumulated on or near the surfaces to be treated and coated.
 - h. Providing a schedule of cost for cleaning, repair and rust prevention painting or coating of interior surfaces where rust has accumulated on the surfaces to be treated and coated. This schedule shall reflect the conditions at branch fittings (sizes 6", 8" and 10" branch on main trunk ducts) where renovation contractors have improperly cut duct openings and tapped new branch ducts and in line problems with the actual duct surfaces which must be removed and patched. Where possible patch inline problems with access doors to provide additional inspection points. This schedule will allow the OR to provide swift approval of repair costs.
 - i. Cleaning, repair and rust prevention painting or coating of interior surfaces where rust has accumulated on the surfaces to be treated and coated when so authorized by the OR. This contractor shall provide a change order request for each area of repair, but shall not delay the cleaning process if authorization is not immediately received.

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

END OF SECTION

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. Volume control dampers.
- B. Air turning devices.
- C. Duct access doors.
- D. Duct test holes.

1.02 RELATED WORK

- A. Section 23 31 00 - Ductwork.

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 volume control dampers duct access doors duct test holes. Provide product data for hardware used.
- C. Submit manufacturer's installation instructions under provisions of Section 23 00 00 for fire dampers and combination fire and smoke dampers.

PART 2 PRODUCTS

2.01 DAMPERS:

- A. Furnish and install dampers where shown on the Drawings and wherever necessary for complete control of the air flow, including all supply, return and exhaust branches, "division" in main supply, return and exhaust ducts, each individual air supply outlet and fresh air ducts.

Where access to dampers through a fixed suspended ceiling is necessary, the Contractor shall be responsible for the proper location of the access doors.

- B. 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. Volume dampers shall be equal to those of Greenheck, Ruskin, Pottorff or substitute approved by Owner. 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 dampers furnished by the Temperature Control Manufacturer's 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 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.

2.03 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.

2.04 DUCT LOW PRESSURE TAPS (Conical Bell Mouth Fittings)

- A. All duct taps shall be made with low-loss taps, conical taps or full-sized bellmouth taps.
- B. Conical fittings may be used for duct taps and shall include quadrant dampers on all lines to air devices (diffusers and grilles) even though a volume damper is specified for the air device. (This does not apply to medium pressure duct.) Spin-in fittings shall be sealed at the duct tap with a gasket, or compression fit, or sealed with sealant specified for medium pressure ductwork. The location of spin-in fittings in the ducts shall be determined after dual or single duct terminal units are hung or the location of the light fixtures is known so as to minimize flexible duct lengths and sharp bends.
- C. The conical fitting shall be made of at least 26 gage 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.
- D. Each to be provided with minimum 24 gage 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.
- E. 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.
- F. 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 pressure systems where indicated.
- D. 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.
- E. 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.
- F. Provide duct test holes where indicated and where required for testing and balancing purposes. Refer also to Section 23 05 93.

END OF SECTION

SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions and Division 01 Specification Sections, apply to this Section.
- B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

- A. Perform all Work required to provide and install the following products as indicated by the Contract Documents with supplementary items necessary for proper installation.
 - 1. Dual duct variable or constant volume terminal units.
 - 2. Integral controls.
 - 3. Integral sound attenuator.

1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
 - 2. UL 181 - Factory-Made Air Ducts and Connectors.
 - 3. ARI Standard 880 for Air Terminals.
 - 4. ANSI/ASHRAE Standard 130 – Methods of Testing for Rating Ducted Air Terminal Units.

1.04 SUBMITTALS

- A. Product Data:
 - 1. Shop Drawings of product data indicating configuration, general assembly, access space required for service, and materials used in fabrication.
 - 2. Electronic or Printed Catalog performance ratings that indicate nominal inlet size, CFM, applicable static pressure at the inlet or discharge of terminal unit, and noise criteria with sound octave band and sound decibel test in accordance with ARI 880, for the insulation lining selected.
 - 3. Leakage curves indicating inlet static pressure and actual tested leakage rates shall be submitted for all non-standard or custom-built terminal units.

4. Unit manufacturer shall test and certify that each terminal unit used on this Project has been tested as specified.

B. Record Documents:

1. Submit under provision of Division 01.

C. Operation and Maintenance Data:

1. Operating instructions and maintenance manuals indicating maintenance and repair data, parts lists.

D. Sample Units:

1. One sample, 8 inch size, production run unit of each type shall be submitted for examination and approval by the Engineer, Owner, and TAB Firm.
2. This sample unit shall be submitted in addition to the required written submittal, well in advance of any requirement for installation of units, but absolutely no later than 60 calendar days after the Notice to Proceed with Construction.
3. Contractor shall allow a minimum of three (3) weeks for testing of the sample unit from the time shipped to the TAB Firm. The TAB Firm will test double duct terminal for casing leakage, damper leakage, and the specification requirements. This period shall restart if the sample unit is rejected and another unit is resubmitted.
4. If rejected for any reason, Contractor shall expedite the documented corrections and shall resubmit a sample unit as soon as possible.
5. Any delay in submittal of the unit for approval shall not be grounds for Contractor's claim of delay. If approved, the unit shall remain in the possession of the Owner at the Project Site for comparison with units as shipped to the Project.
6. Unit(s) shall be installed in the Project, at an accessible, marked location.

1.05 SHIPMENT TESTING PRIOR TO INSTALLATION

- A. Shipment Testing: At the Owner's discretion, a minimum of ten (10) percent of each size double duct terminal unit (but no less than one unit of each size on the Project) will be tested at the Project Site for casing leakage and damper leakage. Contractor shall allow sufficient time during construction for the TAB Firm to perform all testing as may be required.

B. Unit Non-Performance:

1. If results of the shipment testing show that any of the units do not perform as specified, then an additional ten (10) percent of each size unit (but no less than one unit of a size, unless 100 percent of the size has been tested) shall be tested.

2. If this testing, in the Owner's opinion, shows that ten (10) percent or more of the units tested do not perform as specified, then 100 percent of all unit sizes shall be tested for conformance with these Specifications.
 3. The results of that testing shall be reviewed carefully between the Contractor, manufacturer, Owner, and Engineer. A method of repair or replacement of units will be negotiated. The Owner, however, shall maintain the right of final approval of any proposed solution.
- C. Should for any reason, the testing as described in this Section prove that any of the units do not perform as specified, Contractor shall be responsible for all subsequent labor, travel, travel expenses and incidental expenses, penalties, or other costs attendant to any additional testing as described in this Section, or as required to prove that the units perform as specified. This shall include, but not be limited to, the labor, travel and reasonable incidental expenses of not only the Contractor and TAB Firm, but also those incurred by the Owner as may be specifically required for this purpose.

1.06 WARRANTY

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

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.02 MANUFACTURERS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum three (3) years documented experience.
- B. The same manufacturer shall provide all products supplied and/or installed under this Section.
- C. Manufacturers:
 1. Nailor Industries – 3200-UT

2.03 GENERAL CONSTRUCTION

- A. This section applies to dual duct terminal unit configurations as described within this Specification.
- B. Casing Construction:
 1. Units shall be constructed of 20 gage galvanized steel.
 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.

3. 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.
 4. The access panel for the unit shall be on the bottom of the unit for access down through the ceiling.
- C. Ductwork Connections:
1. Construct units 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).
 2. The discharge connection shall include flange connection for use by the Contractor to secure the discharge ductwork or appurtenances to the unit and shall be reinforced to provide a rigid assembly.
 3. External insulation shall be as specified in the Contract Documents for duct insulation with full vapor barrier.
- D. Casing Liners:
1. Terminal unit casing shall be double wall lined with 1-inch thick, 1.5 lb density fiberglass insulation enclosed between the unit casing and a non-perforated, internal sheet metal cover. The interior wall cover shall be 22 gage galvanized steel. The interior wall cover shall extend over the fiberglass insulation and cover the liner cut edges. The exterior cover shall be 20 gage galvanized steel.
 2. Insulation shall meet requirements of UL181 and NFPA 90A.
 3. Casing shall be insulated throughout its interior.
- E. Damper:
1. Damper blades shall be minimum 18 gage galvanized steel or equivalent 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 rustproof 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. The dampers shall be constructed with the proper rigidity to prevent deformation of the damper blade. 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.
 2. Damper Leakage: Units shall be tested for inlet leakage with 4 inches w.g. static pressure imposed. The maximum percent leakage from all tests shall be reported. The following table provides the maximum allowable damper leakage for the various size diameter inlets at 4 inches w.g. differential pressure.

INLET DIAMETER (INCHES)	MAXIMUM ALLOWABLE CFM (AREA X 2000 FPM)	MAXIMUM ALLOWABLE CFM DAMPER LEAKAGE
4	200	6.0
6	400	6.0
8	700	11.0
10	1000	17.0
12	1500	20.0
14	2150	30.0

3. Flow Measurement: Airflow through the unit shall be accomplished by the use of a multi-port velocity pressure cross sensor or multi-axis flow ring devices with a minimum of four (4) radial distribution pick-up points connected to a center averaging chamber. The chamber is to be designed with adequate internal passages to prevent restrictions that can possibly contribute to control 'hunting'. Calibration of each terminal unit with the building automation system (BAS) Provider's controller is to be performed by the manufacturer prior to shipping the terminal unit to the Project Site.
4. Thermal Anemometry: Terminal Unit Velocity Sensors (Applicable only to a Single Point Probe): The probe shall utilize thermal anemometry as the sensing technique. Velocity range shall be 0 to 3250 feet per minute (fpm) and with an installed accuracy of ± 25 fpm. The velocity probe shall include an insertion type-mounting bracket that mounts flush to the supply duct. The velocity probe shall be mounted parallel to the damper shaft with 1/3 or 2/3 penetration into the duct. The velocity probe shall be mounted a minimum of two duct diameters upstream of the terminal inlet for the pneumatic system. For the BAS, both sensors shall be mounted immediately upstream of the terminal unit.]Electronic probes shall be temperature compensated.

F. Unit Controls:

1. General Performance: Flow stations, control transformers, disconnect switch, and controls enclosure shall be furnished, mounted and adjusted by the terminal unit manufacturer to assure their proper placement within the units. If DDC controls of another manufacturer (not the terminal unit manufacturer) are provided for the Project, the terminal unit manufacturer shall be responsible only for construction of the terminal unit and installation of internal control components installed at the manufacturer's factory and shall not be responsible for 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 in connection with terminal units shall be the responsibility of the BAS Provider.
2. 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 future flexibility, 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.
3. Control Sequences: The control sequence arrangements shall be as described on the Drawings. Terminal units shall be shipped from the manufacturer with all necessary control devices to accomplish each sequence, except as may be prohibited by the BAS Provider. The desired sequence shall be adjustable according to space usage or a change in space conditions.

G. DDC Controls Protocol/Description:

1. BAS Provider will be responsible for providing all damper actuators, linkages, flow transducers, controllers, room temperature sensors, and any other devices required for unit control, except as specified below.
2. BAS Provider will be responsible for calibrating the actuator and its controller through TAB work for scheduled airflow rates. Units shall be capable of field calibration and readjustment with external gauge taps.
3. Unit manufacturer shall provide unit inlet flow sensor and pneumatic tubing for BAS Provider's use.
4. Unit manufacturer shall factory install all devices furnished by BAS Provider to result in a complete functioning unit. Unit manufacturer shall be responsible for reviewing compatibility of devices furnished by BAS Provider to units provided.

H. Pressure and Leakage Certification:

1. Manufacturer shall certify that each unit used on the Project will perform as specified. Each unit shall bear a tag or decal listing the following specified information:
 - a. Test pressure.
 - b. Leakage CFM (damper).
 - c. Leakage CFM.
 - d. Date of manufacture.
 - e. Name of person performing test.

2.04 DUAL DUCT VARIABLE OR CONSTANT VOLUME TERMINAL UNITS

- A. Pressure independent, dual duct variable or constant air volume control assemblies with attenuator-mixers of the sizes, capacities and configurations as scheduled on the Drawings.
- B. 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.
- C. Mixing:
 - a. Dual duct terminal units as specified herein shall provide mixing within the units and not rely upon the discharge ductwork to provide for completion of the mixing process.
 - b. The horizontal average temperature of the air as it leaves the terminal unit shall not vary more than 1 degree F for each 10 degrees F of temperature difference between the two inlet air supplies.
 - 1) For example, if the cold supply air is 55 degrees F and the hot supply air is 95 degrees F, the difference is 40 degrees. The allowable temperature variation of the discharge air is, thus, 4 degrees F.
 - c. The temperature of the discharge air shall be measured using a pattern of four (4) vertical, evenly spaced columns and three horizontal, evenly spaced rows.

- d. The rows and columns shall be spaced so that the resulting 12 points shall be at the centers of equal areas. The plane of the points shall be perpendicular to the direction of airflow, within four (4) inches of the discharge of the terminal unit, within the discharge ductwork. The three readings in each column shall be averaged to determine compliance with the 1 degree F criteria.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Provide clearance for inspection, repair, replacement, and service. Ensure accessibility to all terminal unit electrical control panel doors, controllers and operators are located a minimum of 30 inches from all obstructions (walls, pipe, etc.).
- D. Provide ceiling access doors or locate units above easily removable ceiling components.
- E. Install terminal units with the manufacturer's recommended minimum number of diameters of straight duct directly prior to the entry into each terminal unit connection. If the existing conditions cannot provide that number of diameters, please contact the Engineer to look at the situations specifically.
- F. Support units individually from structure. Do not support from adjacent ductwork. For terminal units that are not internally isolated, refer to Section 20 05 48 for terminal unit vibration isolation requirements. Terminal units shall be supported using units hanger brackets and threaded rods.
- G. Connect to ductwork in accordance with Section 23 31 00.
- H. Wiring and controller compartments and damper motors shall have a minimum 24 inch clear wide and deep working space readily accessible from lift out ceiling tiles or access panels. All dual-duct control power shall be low-voltage control power only.

END OF SECTION 23 36 00

SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Diffusers.
- B. Diffuser boots.
- C. Registers/grilles.

1.02 RELATED WORK

- A. Section 09 91 00 - Painting: Painting of ductwork visible behind outlets and inlets.
- B. Section 23 00 00 - Basic Mechanical Requirements.
- C. Section 23 31 00 - Ductwork.
- D. Section 23 33 00 - Ductwork Accessories.

1.03 REFERENCES

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

1.04 QUALITY ASSURANCE

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

1.05 REGULATORY REQUIREMENTS

- A. Conform to ANSI/NFPA 90A.

1.07 SUBMITTALS

- A. Submit product data under provisions of Section 23 00 00.
- B. Provide product data for items required for this project.

- C. Submit schedule of outlets and inlets indicating type, size, location, application, and noise level.
- D. Review requirements of outlets and inlets as to size, finish, and type of mounting prior to submitting product data and schedules of outlets and inlets.
- F. Submit manufacturer's installation instructions under provisions of Section 23 00 00.

PART 2 PRODUCTS

2.01 AIR SUPPLIES AND RETURNS:

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

2.02 ACCEPTABLE MANUFACTURERS - CEILING DIFFUSERS

- A. Titus.
- B. Nailor
- C. Metalaire

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install items in accordance with manufacturers' instructions.
- B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement. Refer to Section 09 91 00.
- C. Install diffusers to ductwork with air tight connection.
- D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, regardless of whether dampers are specified as part of the diffuser, or grille and register assembly. Where take-off dampers are accessible, dampers at the air device should be omitted.
- E. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 91 00.

END OF SECTION