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MECHANICAL AND PLUMBING

ELECTRICAL

SECTION 23 01 30

HVAC SYSTEM DUCT CLEANING

PART 1 -- GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Specifications throughout all Divisions to the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

A. Basic and supplemental requirements common to HVAC Work.

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 Contract Documents.

1. NADCA Standards: The HVAC system cleaning contractor shall perform the services specified here in accordance with the current published standards of the National Air Duct Cleaners Association (NADCA).

2. All terms in this specification shall have their meaning defined as stated in the NADCA Standards.

3. NADCA Standards must be followed with no modifications or deviations being allowed.

D. Applicable Standards and Publications: The following current standards and publications of the issues currently in effect form a part of this specification to the extent indicated by any reference thereto.

1. National Air Duct Cleaners Association (NADCA): “Assessment, Cleaning & Restoration of HVAC Systems (ACR).”

2. National Air Duct Cleaners Association (NADCA): “Introduction to HVAC System Cleaning Services,” 2004.

3. Underwriters’ Laboratories (UL): UL Standard 181.

4. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE): Standard 62-89, "Ventilation for Acceptable Indoor Air Quality".

5. Environmental Protection Agency (EPA): "Building Air Quality," December 1991.

6. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): “HVAC Duct Construction Standards - Metal and Flexible,” 1985.

7. North American Insulation Manufacturers Association (NAIMA): "Cleaning Fibrous Glass Insulated Air Duct Systems," 1993.

1.04 QUALIFICATION OF THE HVAC SYSTEM CLEANING CONTRACTOR

A. Membership: The HVAC system cleaning contractor shall be a certified member of the National Air Duct Cleaners Association (NADCA).

B. Certification: The HVAC system cleaning contractor shall have a minimum of one (1) Air System Cleaning Specialist (ASCS) certified by NADCA on a full time basis dedicated to the cleaning of HVAC systems.

C. Supervisor Qualifications: A person certified as an ASCS by NADCA, shall be responsible for the total work herein specified.

D. Experience: The HVAC system cleaning contractor shall submit records of experience in the field of HVAC system cleaning as requested by the Design Professional. Bids shall only be considered from firms which are regularly engaged in HVAC system maintenance with an emphasis on HVAC system cleaning and decontamination.

E. Equipment, Materials and Labor: The HVAC system cleaning contractor shall possess and furnish all necessary equipment, materials and labor to adequately perform the specified services.

1. The Contractor shall assure that its employees have received safety equipment training, medical surveillance programs, individual health protection measures, and manufacturer's product and material safety data sheets (MSDS) as required for the work by the U.S. Occupational Safety and Health Administration, and as described by this specification. For work performed in countries outside of the U.S.A., contractors should comply with applicable national safety codes and standards.

2. The contractor shall maintain a copy of all current MSDS documentation and safety certifications at the site at all times, as well as comply with all other site documentation requirements of applicable OSHA programs and this specification.

3. Contractor shall submit to the mechanical contractor all Material Safety Data Sheets (MSDS) for all chemical products proposed to be used in the cleaning process.

F. Licensing: The HVAC system cleaning contractor shall provide proof of maintaining the proper license(s), if any, as required to do work in this state. Contractor shall comply with all Federal, state and local rules, regulations, and licensing requirements.

1.05 DOCUMENTS

A. Mechanical Drawings: The mechanical contractor shall provide the HVAC system cleaning contractor with one copy of the following documents:

1. Project drawings and specifications.

2. Approved construction revisions pertaining to the HVAC system.

3. Any existing indoor air quality (IAQ) assessments or environmental reports prepared for the facility.

1.06 SCOPE OF WORK

A. This section defines the ***minimum*** requirements necessary to render HVAC components clean, and to verify the cleanliness through inspection and/or testing in accordance with items specified herein and applicable NADCA Standards.

B. The Contractor shall be responsible for the removal of visible surface contaminants and deposits from within the HVAC system in strict accordance with these specifications.

C. The HVAC system includes any interior surface of the facility's air distribution system for conditioned spaces and/or occupied zones. This includes the entire heating, air-conditioning and ventilation system from the points where the air enters the system to the points where the air is discharged from the system. The return air grilles, return air ducts to the air handling unit (AHU), the interior surfaces of the AHU, mixing box, coil compartment, condensate drain pans, humidifiers and dehumidifiers, supply air ducts, fans, fan housing, fan blades, air wash systems, spray eliminators, turning vanes, filters, filter housings, reheat coils, and supply diffusers are all considered part of the HVAC system. The HVAC system may also include other components such as dedicated exhaust and ventilation components and make-up air systems.

1.07 HVAC SYSTEM COMPONENT INSPECTIONS AND SITE PREPARATION

A. HVAC System Component Inspections: Prior to the commencement of any cleaning work, the HVAC system cleaning contractor shall perform a visual inspection of the HVAC system to determine appropriate methods, tools, and equipment required to satisfactorily complete this project. The cleanliness inspection should include air handling units and representative areas of the HVAC system components and ductwork. In HVAC systems that include multiple air handling units, a representative sample of the units should be inspected.

B. The cleanliness inspection shall be conducted without negatively impacting the indoor environment through excessive disruption of settled dust, microbial amplification or other debris. In cases where contamination is suspected, and/or in sensitive environments where even small amounts of contaminant may be of concern, environmental engineering control measures should be implemented.

C. Damaged system components found during the inspection shall be documented and brought to the attention of the Design Professional.

D. Site Evaluation and Preparations: Contractor shall conduct a site evaluation, and establish a specific, coordinated plan which details how each area of the building will be protected during the various phases of the project.

E. Inspector Qualifications: Qualified personnel should perform the HVAC cleanliness inspection to determine the need for cleaning. At minimum, such personnel should have an understanding of HVAC system design, and experience in utilizing accepted indoor environmental sampling practices, current industry HVAC cleaning procedures, and applicable industry standards.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION

3.01 GENERAL HVAC SYSTEM CLEANING REQUIREMENTS

A. Containment: Debris removed during cleaning shall be collected and precautions must be taken to ensure that Debris is not otherwise dispersed outside the HVAC system during the cleaning process.

B. Particulate Collection: Where the Particulate Collection Equipment is exhausting inside the building, HEPA filtration with 99.97% collection efficiency for 0.3-micron size (or greater) particles shall be used. When the Particulate Collection Equipment is exhausting outside the building, Mechanical Cleaning operations shall be undertaken only with Particulate Collection Equipment in place, including adequate filtration to contain Debris removed from the HVAC system. When the Particulate Collection Equipment is exhausting outside the building, precautions shall be taken to locate the equipment down wind and away from all air intakes and other points of entry into the building.

C. Controlling Odors: Measures shall be employed to control odors and/or mist vapors during the cleaning process.

D. Component Cleaning: Cleaning methods shall be employed such that all HVAC system components must be Visibly Clean as defined in applicable standards (see NADCA Standards). Upon completion, all components must be returned to those settings recorded just prior to cleaning operations.

E. Air-Volume Control Devices: Dampers and any air-directional mechanical devices inside the HVAC system must have their position marked prior to cleaning and, upon completion, must be restored to their marked position.

F. Service Openings: The contractor shall utilize service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry, and inspection.

1. Contractor shall utilize the existing service openings already installed in the HVAC system where possible.
2. Other openings shall be created where needed and they must be created so they can be sealed in accordance with industry codes and standards.
3. Closures must not significantly hinder, restrict, or alter the airflow within the system.
4. Closures must be properly insulated to prevent heat loss/gain or condensation on surfaces within the system.
5. Openings must not compromise the structural integrity of the system.
6. Construction techniques used in the creation of openings should conform to requirements of applicable building and fire codes, and applicable NFPA, SMACNA and NADCA Standards.
7. Cutting service openings into flexible duct is not permitted. Flexible duct shall be disconnected at the ends as needed for proper cleaning and inspection.
8. All service openings capable of being re-opened for future inspection or remediation shall be clearly marked and shall have their location reported to the **owner** in project report documents.

G. Ceiling sections (tile): The contractor may remove and reinstall ceiling sections to gain access to HVAC systems during the cleaning process. In sterile areas of health care facilities, coordinate tile removal with facility ICRA requirements.

H. Air distribution devices (registers, grilles & diffusers): The contractor shall clean all air distribution devices.

I. Air handling units, terminal units (VAV, Dual duct boxes, etc.), blowers and exhaust fans: The contractor shall insure that supply, return, and exhaust fans and blowers are thoroughly cleaned. Areas to be cleaned include blowers, fan housings, plenums (except ceiling supply and return plenums), scrolls, blades, or vanes, shafts, baffles, dampers and drive assemblies. All visible surface contamination deposits shall be removed in accordance with NADCA Standards. Contractor shall:

1. Clean all air handling units (AHU) internal surfaces, components and condensate collectors and drains.
2. Assure that a suitable operative drainage system is in place prior to beginning wash down procedures.

3. Clean all coils and related components, including evaporator fins.

J. Duct Systems. Contractor shall:

1. Create service openings in the system as necessary in order to accommodate cleaning of otherwise inaccessible areas.

2. Mechanically clean all duct systems to remove all visible contaminants, such that the systems are capable of passing Cleaning Verification Tests (see NADCA Standards).

3.02 HEALTH AND SAFETY

A. Safety Standards: Cleaning contractors shall comply with applicable federal, state, and local requirements for protecting the safety of the contractor's employees, building occupants, and the environment. In particular, all applicable standards of the Occupational Safety and Health Administration (OSHA) shall be followed when working in accordance with this specification.

B. Occupant Safety: No processes or materials shall be employed in such a manner that they will introduce additional hazards into occupied spaces.

C. Disposal of Debris: All Debris removed from the HVAC System shall be disposed of in accordance with applicable federal, state and local requirements.

3.03 MECHANICAL CLEANING METHODOLOGY

A. Source Removal Cleaning Methods: The HVAC system shall be cleaned using Source Removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and safely remove contaminants from the facility. It is the contractor's responsibility to select Source Removal methods that will render the HVAC system Visibly Clean and capable of passing cleaning verification methods (See applicable NADCA Standards) and other specified tests, in accordance with all general requirements. No cleaning method, or combination of methods, shall be used which could potentially damage components of the HVAC system or negatively alter the integrity of the system.

1. All methods used shall incorporate the use of vacuum collection devices that are operated continuously during cleaning. A vacuum device shall be connected to the downstream end of the section being cleaned through a predetermined opening. The vacuum collection device must be of sufficient power to render all areas being cleaned under negative pressure, such that containment of debris and the protection of the indoor environment are assured.

2. All vacuum devices exhausting air inside the building shall be equipped with HEPA filters (minimum efficiency), including hand-held vacuums and wet-vacuums.

3. All vacuum devices exhausting air outside the facility shall be equipped with Particulate Collection including adequate filtration to contain Debris removed from the HVAC system. Such devices shall exhaust in a manner that will not allow contaminants to re-enter the facility. Release of debris outdoors must not violate any outdoor environmental standards, codes or regulations.

4. All methods require mechanical agitation devices to dislodge debris adhered to interior HVAC system surfaces, such that debris may be safely conveyed to vacuum collection devices. Acceptable methods will include those, which will not potentially damage the integrity of the ductwork, nor damage porous surface materials such as liners inside the ductwork or system components.

B. Cleaning of coils

1. Any cleaning method may be used which will render the Coil Visibly Clean and capable of passing Coil

Cleaning Verification (see applicable NADCA Standards). Coil drain pans shall be subject to Non-Porous Surfaces Cleaning Verification. The drain for the condensate drain pan shall be operational. Cleaning methods shall not cause any appreciable damage to, displacement of, inhibit heat transfer, or erosion of the coil surface or fins, and shall conform to coil manufacturer recommendations when available. Coils shall be thoroughly rinsed with clean water to remove any latent residues.

C. Antimicrobial Agents and Coatings

1. Antimicrobial agents shall only be applied if active fungal growth is reasonably suspected, or where unacceptable levels of fungal contamination have been verified through testing.

2. Application of any antimicrobial agents used to control the growth of fungal or bacteriological contaminants shall be performed after the removal of surface deposits and debris.

3. When used, antimicrobial treatments and coatings shall be applied in strict accordance with the manufacturer's written recommendations and EPA registration listing.

4. Antimicrobial coatings shall be applied according to the manufacturer's written instructions. Coatings shall be sprayed directly onto interior ductwork surfaces, rather than "fogged" downstream onto surfaces.

3.04 CLEANLINESS VERIFICATION

A. General: Verification of HVAC System cleanliness will be determined after mechanical cleaning and before the application of any treatment or introduction of any treatment-related substance to the HVAC system, including biocidal agents and coatings.

B. Visual Inspection: The HVAC system shall be inspected visually to ensure that no visible contaminants are present.

1. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean; however, the Design Professional reserves the right to further verify system cleanliness through Surface Comparison Testing or the NADCA vacuum test specified in the NADCA standards.

2. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.

3. NADCA vacuum test analysis should be performed by a qualified third party experienced in testing of this nature.

C. Verification of Coil Cleaning

1. Cleaning must restore the coil pressure drop to within 10 percent of the pressure drop measured when the coil was first installed. If the original pressure drop is not known, the coil will be considered clean only if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection (see NADCA Standards).

3.05POST-PROJECT REPORT

A. At the conclusion of the project, the Contractor shall provide a report to the Design Professional indicating the following:

1. Success of the cleaning project, as verified through visual inspection and/or gravimetric analysis.

2. Areas of the system found to be damaged and/or in need of repair.

END OF SECTION

BASIC HVAC REQUIREMENTS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Specifications throughout all Divisions to the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.02 SUMMARY

A. Basic and supplemental requirements common to HVAC Work.

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. Disagreement between the Drawings and Specifications or within the Drawings or Specifications shall be estimated using the better quality or greater quantity of material or installation, and a request for information shall be made to the Design Professional.

D. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the Contract Documents.

E. The following codes form the basis for minimum requirements for the Project:

1. Building Code – 2015 IBC with City of Webster Amendments
2. Electrical Code - National Electrical Code, 2014 Edition
3. Mechanical Code - 2015 IMC with City of Webster Amendments
4. Plumbing Code - 2015 IPC with City of Webster Amendments
5. Fire Code – 2015 - International Fire Code with City of Webster Amendments
6. 2015 International Energy Code
7. Other - NFPA 13 and NFPA 14
8. Other - Texas Department of State Health Services Hospital Licensing Standards and Life Safety Code (NFPA 101)
9. Other – Federal Department of Justice Americans with Disabilities Act and Texas Accessibility Standards

1.04 DEFINITIONS

A. These definitions are included to clarify the direction and intention of these Specifications. For further clarification contact the Design Professional.

1. Concealed/Exposed: “Concealed” areas are those areas that 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. “Exterior” areas are those outside the building exterior envelope and exposed to the outdoors.

2. Furnish: The term “furnish” is used to mean “supply and deliver to the Project Site, ready for unloading, unpacking, assembly, installation and similar operations”.

3. Install" The term "install" is used to describe operations at Project Site including the actual "unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations."

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

1.05 QUALITY ASSURANCE

A. HVAC systems shall be coordinated with other systems and trades to include but not be limited to: Plumbing systems, fire suppression systems, electrical systems, fire alarm, security systems, transport systems, telephone and data systems.

B. Verification of Dimensions: The Contractor shall be responsible for the coordination and proper relation of Contractor's 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 Design Professional of any discrepancy before performing and 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 Design Professional.

C. 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.

D. The Drawings are subject to the requirements of Reference Standards 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.

E. When the Drawings do not give exact details as to the elevation of pipe 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 and 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.

F. Where core drilling of floor or wall penetrations is required, Work shall be performed in accordance with Division 03 Specifications. Where applicable Division 03 Specifications are not included in the Project, core drilling shall be in accordance with generally accepted standards, and be performed by licensed personnel where applicable.

G. Certify in writing that neither the Contractor nor any of Contractor's subcontractors or suppliers will supply any materials that contain any asbestos in any form for this Project.

1.06 DELIVERY, STORAGE AND HANDLING

A. All equipment, ductwork, and materials shall be delivered to the Project Site clean and sealed for protection.

B. Take particular care not to damage the existing construction in performing Work. All finished floors, step treads and finished surfaces shall be covered to prevent any damage by workers or their tools and equipment during construction of the Project.

C. Equipment and materials shall be protected from rust and dust/debris 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.

D. All material affected by weather shall be covered and protected to keep the material free from damage while material is being transported to the Site and while stored at the Project Site.

E. During the execution of the Work, open ends of all piping and all openings in equipment shall be closed when Work is not in progress, and shall be capped and sealed prior to completion of final connections, so as to prevent the entrance of foreign matter.

F. All equipment shall be protected during the execution of the Work. All ductwork and equipment shall be sealed with heavy plastic and tape to prevent build-up of dust and debris.

G. All ductwork and air handling equipment shall be wiped down with a damp cloth immediately before installation to ensure complete removal of accumulated dusts and foreign matter. In health care occupancies, all ductwork and air handling equipment shall be thoroughly disinfected with a biocidal agent EPA approved for HVAC systems immediately prior to sealing ductwork and equipment airstream openings.

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.

B. All equipment installed shall have local representation; local factory authorized service, and a local stock of repair parts.

C. Responsibility for furnishing proper equipment and/or material and ensuring that equipment and/or material is installed as intended by the manufacturer, rests entirely upon the Contractor. Contractor shall request advice and supervisory assistance from the representative of specific manufacturers during the installation.

D. 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.

E. Materials and equipment manufactured domestically are preferred when possible. Materials and equipment that are not available from a domestic manufacturer may be by a non-domestic manufacturer provided they fully comply with Contract Documents.

F. 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.

2.02 NAMEPLATES

A. 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.

B. Nameplates shall be black laminated rigid phenolic with white core. Nameplate minimum size shall be 1 inch high by 3 inches long with 3/16-inch high engraved letters.

C. Nameplate fasteners: Fasten nameplates to the front of equipment only by means of stainless steel self-tapping screws. Stick-ons or adhesives will not be allowed unless the enclosure rating is compromised then; only epoxy adhesive shall be used to attach nameplates.

2.03 WALL, FLOOR AND CEILING PLATES (ESCUTCHEONS)

A. Except as otherwise noted, provide stainless steel or chrome plated brass floor and ceiling plates around all pipes, ducts, conduits, etc., passing exposed through walls, floors or ceilings, in any spaces except under-floor and plenum spaces.

B. Plates shall be sized to fit snugly against the outside of the pipe or against the insulation on lines that are insulated and positively secured to such pipe or insulation.

C. For finished ceiling installation, secure escutcheons to ceiling with escutcheon fasteners.

D. Plates will not be required for piping where pipe sleeves extend ¾-inch or more above finished floor.

E. Round and rectangular ducts shall have closure plates (not chrome plated) made to fit accurately at all floor, wall and ceiling penetrations.

2.04 ROOF PENETRATIONS AND FLASHING

A. Pipe, conduit and duct sleeves, pitch pockets and flashings compatible with the roofing installation shall be provided and installed for all roof penetrations by a Contractor qualified in such Work. Where working on existing buildings with warranties in place, coordinate the work required with the warranting contractor to assure no warranty breach occurs. Installation shall comply with the Contract Documents.

PART 3 – EXECUTION

3.01 PREPARATION

A. Cooperate with trades of adjacent, related or affected materials or operations, and with trades performing continuations of this Work in order to effect timely and accurate placing of Work and to coordinate, in proper and correct sequence, the Work of such trades.

B. The size of equipment indicated on the Drawings is based on the dimensions of a particular manufacturer. While other manufacturers may be acceptable, it is the responsibility of the Contractor to determine that the equipment proposed will fit in the space. Fabrication Drawings shall be prepared, when required by the Design Professional or Owner, to indicate a suitable arrangement.

C. 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.

D. Space Requirements:

1. Consider space limitations imposed by contiguous Work in location of equipment and material. Do not provide equipment or material which is not suitable in this respect.

2. Make changes in material and equipment locations of up to five (5) feet, to allow for field conditions prior to actual installation, and as directed by the Design Professional at no additional cost to the Owner.

E. Contractor shall verify the arrangement, location and space requirements of all equipment, using manufacturer certified shop drawings and make any necessary adjustments in equipment placement and connection in order to accommodate the exact equipment installed. Should major changes be required for any reason, the contractor shall notify the Design Professional in a timely manner to minimize any remedial

costs to the Owner. Any resulting changes to the HVAC design required, due to failure to provide such timely notification, shall be made at no additional cost to the Owner.

F. Connections for equipment other than Division 23:

1. Provide all ductwork, transition pieces, etc., required for a complete installation of vent hoods, fume hoods, etc.

3.02 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. Piping may be run exposed in rooms typically without ceilings such as mechanical rooms, janitor's closets, tight against pan soffits in exposed "tee" structures, or storage spaces, but only where necessary. Shutoff and isolation valves shall be easily accessible.

D. All pipe, ducts, 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 and ducts run in furred ceilings, etc., shall be similarly installed, except as otherwise shown. All pipe openings shall be kept closed until the systems are closed with final connections.

E. Prior to the installation of any ceiling material, gypsum, plaster or acoustical board, the Contractor shall notify the Owner's Project Manager so that arrangements can be made for an inspection of the above-ceiling area about to be "sealed" off. The Contractor shall provide written notification to the Owner at least five (5) calendar days prior to the inspection.

F. Precedence of Materials:

1. The Specifications determine the nature and setting of materials and equipment. The Drawings establish quantities, dimensions and details.

2. If interference is encountered, the following installation precedence of materials shall guide the Contractor to determine which trade shall be given the "Right of Way":

Building lines

Structural members

Structural support frames supporting ceiling equipment

Electric tracked vehicle system

Pneumatic trash and linen system

Pneumatic tube system

Soil and drain piping

Vent piping

Supply, return and outside air ductwork

Exhaust ductwork

HVAC water and steam piping

Condensate piping

Fire protection piping

Natural gas piping

Medical/Laboratory gases

Domestic water (cold and hot, softened, treated)

Refrigerant piping

Electrical conduit

3. Coordinate fire suppression, plumbing and HVAC systems with transport systems as required to maintain transport system right-of-way.

3.03 TESTING

A. When existing systems are to be tied into to serve portions of a new project, or if existing systems are likely to be affected by the new project, testing shall be conducted to establish the current performance and operating capacity of the existing systems. The test should be designed such that a similar test if necessary can be performed after construction to verify that air supplies to spaces or cooling/heating supplies to existing equipment have not been adversely affected. Submit test report of results of pre-design testing to the Design Engineer.

B. When any piece of mechanical equipment is operable and it is to the advantage of the Contractor to operate the equipment, Contractor may do so, provided that Contractor properly supervises the operation, and has the Owner'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. For HVAC systems serving Clean Rooms, Operating Rooms, Procedure Rooms, Cardiac Catheterization Labs, Critical Care Units and other Patient Care areas, the HVAC system serving such areas ***will not be operated without all permanent filter systems in place*** and the return ducts for such systems will not be utilized until the space has been "final cleaned" by the Hospital personnel. In such cases, the units shall be operated in 100% outside air mode, using local negative pressure units to effect the required pressure balance to the construction area, until such cleaning has taken place. Refer to Section 23 31 00 for details on duct cleaning should the systems be operated in violation of this requirement.

C. Regardless of whether or not the equipment has or has not been operated, the Contractor shall properly clean the equipment, install clean filter media (refer to Section 23 41 00 for additional requirements), 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.

D. Before the Work is accepted, and authorized representative of the manufacturer of the installed materials and/or equipment shall personally inspect the installation and operation of manufacturer's materials and/or equipment to determine that materials and/or equipment are properly installed and in proper operating order. The qualifications of the manufacturer's representative shall be appropriate to the technical requirements of the installation. The qualifications of the manufacturer's representative shall be submitted to the Owner for approval. The decision of the Owner concerning the appropriateness of the manufacturer's 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. In addition, the Contractor shall submit to the Design Professional a signed statement from each manufacturer's 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."**

E. Check inspections shall include hydronic and condensate piping, equipment, heating, air conditioning, insulation, ventilating equipment, controls, mechanical equipment and such other items hereinafter specified or specifically designated by the Design Professional.

F. The Contractor shall execute, at no additional cost to the Owner, any tests required by the Owner or the National Fire Protection Association, ASTM, etc. The Contractor shall provide all equipment, materials and labor for making such tests. The Owner will pay reasonable amounts of fuel and electrical energy costs for system tests. Fuel and electrical energy costs for system adjustments and tests, which follow Substantial Completion by the Owner, will be borne by the Owner.

G. Notify the Owner's Project Manager and the Design Professional in writing at least seven (7) calendar days prior to each test and prior to other Specification requirements requiring Owner and Design Professional to observe and/or approve tests.

H. All tests shall have pertinent data logged by the Contractor at the time of testing. Data shall include date, time, personnel performing, observing and inspecting, description of the test and extend of system tested, test conditions, test results, specified results and other pertinent data. Data shall be delivered to the Design Professional as specified under "Requirements for Final Acceptance". The Contractor or Contractor's authorized job superintendent shall legibly signal all Test Log entries.

I. System shall exhibit no objectionable noise when operated within normal parameters, as specified within the construction documentation. Should any portion of the system exhibit noise levels that are deemed objectionable by either the Owner or the Design Professional, a solution shall be agreed upon and necessary modifications made to eliminate or attenuate the noise to within an acceptable range. Such changes shall be made at no additional cost to the Project or Owner.

3.04 TRAINING

A. Operating and Maintenance Manuals and instruction shall be provided as specified under the Division 01 Section entitled "Project Closeout Procedures".

B. Specific training and operating instructions for individual equipment components shall be as specified in the individual Specification Sections.

C. All equipment, piping, conduit, ductwork, grilles, insulation, etc., furnished and installed in exposed areas shall be cleaned, prepared and painted as specified in Division 09.

END OF SECTION

CONTRACTOR COORDINATION WITH TESTING, ADJUSTING AND BALANCING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. 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 prepare the building HVAC systems for testing, adjusting, and balancing (TAB) Work indicated by the Contract Documents, including the following:

1. Preparation of air systems for testing, adjusting and balancing.

2. Preparation of hydronic for testing, adjusting and balancing.

3. Providing materials and labor to assist TAB Firm in meeting testing, adjusting and balancing requirements.

B. Testing, adjusting and balancing of the air conditioning systems and related ancillary equipment will be performed by a technically qualified TAB Firm. The preparation for and corrections necessary for the testing, adjusting and balancing of these systems, as described herein, are the responsibility of this Contractor.

C. 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.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specified 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. AABC: National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems.

2. AABC: Testing and Balancing Procedures.

3. ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.

4. ANSI/ASHRAE Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning, and Refrigeration Systems.

5. NEBB – National Environmental Balancing Bureau, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.

1.04 QUALITY ASSURANCE

A. Provide and coordinate the services of qualified, responsible Subcontractors, suppliers and personnel as required for correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including during the testing, adjusting and balancing period.

B. In order that systems may be properly tested, adjusted, and balanced, the Contractor shall operate systems at Contractor's expense for the length of time necessary to properly verify the systems' completion and readiness for TAB.

C. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. Allow adequate time for the testing and balancing activities during the construction period and prior to Substantial Completion.

PART 2 – PRODUCTS

2.01 GENERAL

A. Not applicable.

PART 3 – EXECUTION

3.01 PREPARATION

A. Contractor shall be responsible to prepare the building heating, ventilating, and air conditioning systems ready for TAB when scheduled.

B. Operational readiness requires that construction status of the building will permit the closing of doors, windows, ceilings installed, etc., to obtain simulated or projected operating conditions.

C. Notification of system readiness:

1. Upon completion of the system installation Work, the Contractor shall notify the Owner and TAB Firm in writing, certifying that the Work has been accomplished and that the air conditioning systems are in operational readiness for testing, adjusting and balancing.

2. TAB Firm shall notify the Contractor of TAB Firm's readiness for balancing.

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 a duly appointed representative of the Design Professional, 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 the responsibility of the Contractor.

3.02 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. Allow sufficient time for the TAB Firm to perform TAB Firm's Work within the Project schedule. Complete installation Work by system or floor, whichever is the most efficient for scheduling. Develop the project schedule in close coordination with the TAB Firm.

D. The Drawings and Specifications indicate valves, dampers and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions. Install these devices in a manner that will leave the devices accessible and readily able to be adjusted. Immediately correct any malfunction encountered that the TAB Firm reports so that the balancing Work can proceed with minimal delay.

E. Contractor shall promptly correct deficiencies of materials and workmanship identified as delaying completion of TAB Work.

3.03 SYSTEM VERIFICATION

A. Air Distribution Systems:

1. Verify installation for conformity to the Contract Documents. All supply, return, and exhaust ducts shall be terminated and pressure tested for leakage as required by the Contract Documents.

2. 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.

3. All supply, return, exhaust and transfer grilles, registers, diffusers and terminal devices are installed and airflow at each device shall be verified.

4. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be sealed or blanked off to eliminate excessive uncontrolled bypass or leakage of air.

5. All fans (supply, return and exhaust) operating and verified for freedom from vibration, with proper fan rotation and belt tension. Heater elements in motor starters are 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.

6. All single and/or double duct variable and constant volume terminal units ("mixing boxes") shall be installed and functional (i.e. controls functioning).

7. Duct systems and air handing units and coils are clean and free of debris.

8. Air systems are pressure independent and can be tested by floor, riser, system, etc., but once all the systems are installed, the total flows and system tracking will require final testing, adjusting and balancing.

B. Water Circulating Systems:

1. Check and verify pump alignment and rotation.

2. Open all valves to their full open position, close bypass stop valves. Set mixing valves to full-flow through systems components. After the system is flushed and checked for proper operation, remove and clean all strainers. Repeat the operation until circulating water is clean.

3. Record the amperage of each pump motor on each phase and voltage after reaching rated speed. Readings shall not exceed nameplate rating.

4. Verify that the electrical heater elements are of the proper size and rating.

5. All water circulating systems shall be full and free of air. Expansion tanks shall be set for proper water level and all air vents shall be installed at high points of systems and operating freely. Systems shall be cleaned and flushed. Chemicals shall be added to closed systems to treat piping and inhibit corrosion.

6. Check and set operating temperatures and other parameters of the heat exchangers and control devices to the design requirements.

7. Installation and system verification of condenser water, hot water, and chilled water systems must be 100 percent complete prior to balancing.

C. Building Automation System (BAS):

1. Verify that all control components are installed in accordance with the Contract Documents and that all control components are functional, including all electrical interlocks, damper sequences, air and water resets, fire and freeze stats, high and low temperature thermostats, safeties, etc.

2. 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 BAS Provider.

3. BAS Provider shall thoroughly check all controls, sensors, operators, sequences, etc., before notifying the TAB Firm that the building automation system is operational. The BAS Provider shall provide technical support, software access and necessary computers, including technicians to the TAB Firm at no cost, for a complete and timely check of these systems.

4. BAS Provider shall assist the Contractor with functional performance testing and point-to-point testing back to the main graphics.

END OF SECTION

SYSTEM TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. 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. Testing, adjusting and balancing (TAB) of the air conditioning (supply, return and exhaust) systems and related ancillary equipment will be performed by a technically qualified TAB Firm.

B. Testing, adjusting and balancing (TAB) of the air conditioning (supply, return and exhaust) systems and related ancillary equipment will be performed by a technically qualified TAB Firm (with a current certification of the firm and person doing the work by either NEBB or AABC).

C. TAB Firm shall check, adjust, and balance components of the domestic hot water plumbing systems which will result in optimal flow, temperature control, and quality conditions in these systems. This is intended to be accomplished after the system components are installed and operating as specified in the Contract Documents, but before piping system sterilization is performed. If, for some reason the piping system TAB work cannot be accomplished prior to the sterilization process, all testing equipment (gauges, flow meters, etc.) that come into contact with the system shall be certified to be cleaned and sterilized and not have been used for testing of other, non-potable water systems. It is the responsibility of the Plumbing Contractor to place the equipment into service. Coordinate all TAB work with Plumbing Contractor and General Contractor to facilitate the abovementioned scheduling of work.

D. Air systems shall be balanced in accordance with AABC Standard, Latest Edition or NEBB Standards for Testing, Adjusting, Balancing of Environmental Systems (Latest Edition).

E. TAB Firm shall check, adjust, and balance all hydronic systems including pumps, water distribution systems, coils, and related equipment.

F. Liaison and Early Field Inspection:

1. TAB Firm shall act as a liaison between the Owner, Design Professional and Contractor. TAB Firm shall perform the following reviews (observations) and tests.

    a. During construction, review all HVAC submittals such as control diagrams, air handling devices, etc., that pertain to the ability to satisfactorily balance systems.

2. During the balancing process, as the TAB Firm discovers abnormalities and malfunctions of equipment or components, the TAB Firm shall advise the Contractor in writing so that the condition can be corrected by the Contractor prior to finishing the TAB Scope of Work. Data from malfunctioning equipment shall not be recorded in the final TAB report.

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. AABC – National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems.

2. NEBB – National Environmental Balancing Bureau, Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.

3. ASHRAE HVAC Applications Chapter 37: Testing, Adjusting and Balancing.

4. ANSI/ASHRAE Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Buildings, Heating, Ventilation, Air Conditioning and Refrigeration Systems.

5. CTI – Cooling Technology Institute CODE ATC-105.

1.04 QUALITY ASSURANCE

A. TAB Firm shall be contracted through the General Contractor.

B. TAB Firm shall have operated a minimum of five (5) years under TAB Firm's current name and shall be in good standing with the State of Texas, Franchise Tax Board. TAB Firm shall submit full incorporated name, Charter Number, and Taxpayer's I.D. Number for proper verification of TAB Firm's status.

C. TAB Firm's personnel performing Work at the Project Site shall be either Professional Engineers or certified air and water balance technicians, who shall have been permanent, full time employees of the TAB Firm for a minimum of six (6) months prior to the start of Work for this Project.

D. TAB Firm shall have a background record of at least five (5) years of specialized experience in the field of air and hydronic system balancing and shall possess properly calibrated instrumentation.

1.05 SUBMITTALS

A. The activities described in this Section shall culminate in a report to be provided in quadruplicate (4) individually bound and also provided electronically to the Contractor to be presented to the Owner at the Project close-out. Neatly type and arrange data. Include with the data, the dates, 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 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 report must have been made at the Project Site by the permanently employed technicians or engineers of the TAB Firm.

C. Submit reports on electronic forms approved by the Design Professional 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. Variable or Constant Volume Terminal Unit Test Sheet:

a. Identification number.

b. Room number/location.

c. Terminal type (FP if fan powered and/or (SDVV, SDCV, DDVV, DDCV), and (HWRH or ERH if reheat coil is used).

d. Terminal size.

e. Area factor.

f. Design velocity.

g. Design maximum and minimum air flow.

h. Test (final) velocity.

i. Test (final) maximum and minimum air flow.

j. For DDC instrumentation: Measure and record computer readout and calibration factor at the final measurement conditions.

k. Air dry bulb temperature at the discharge of the terminal unit.

5. Heating Coil Data:

a. Identification number.

b. Location.

c. Service.

d. Manufacturer.

e. Air flow, design and actual.

f. Water flow (GPM) design and actual.

g. Pressure drop water (feet w,g.) or, design and actual.

h. Entering water temperature, design and actual.

i. Leaving water temperature, design and actual.

j. Entering air temperature, design and actual.

k. Leaving air temperature, design and actual.

l. Air quantity CFM design, and CFM actual.

m. Air pressure drop, design and actual.

n. Sensible BTU/hr design, and actual.

o. Electric heat kW, number of stages, kW per state – specified and actual (if applicable).

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.

7. Include in the Appendix all submittals for air handling units, pumps, fans, heat exchangers, energy recovery units control system, etc.

PART 2 – PRODUCTS

Not used

PART 3 – EXECUTION

3.01 AIR BALANCE

A. When systems are installed and ready for operation, the TAB Firm shall perform an 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 the following criteria;

1. Supply diffusers: 0 to +10% of design value.

2. Return grilles & louvers: +/- 5% of design value.

3. Exhaust Grilles or louvers: 0 to -10% of design value

4. In all cases regardless of compliance with the above listed values, required pressure differentials between adjacent spaces shall be maintained as specified (refer to sub-paragraph 3.01B (8) below).

B. 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 opposed blade damper (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.

C. The general scope of balancing by the TAB Firm shall include, but is not limited to, the following:

1. Filters: Check air filters and filter media and balance only systems with essentially clean filters and filter media. The 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 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 reheat coil at each VAV 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 HVAC VAV terminal unit and VAV air handling unit within a range of 0 to +5% of design flow. The TAB firm shall compare the sum of the CAV/VAV box diffuser readings with the flow indicated by the box's controller prior to calibrating the box's controller. If the two readings agree within +/- 5%, the factory calibration factors shall not be changed. If the readings are not within +/-5%, a documented trouble shooting procedure consisting of checking and resolving the following shall be conducted prior to calibrating the controller to verify the final calibration.

8. Outlet Air Flow: Adjust each exhaust inlet and supply diffuser, register and grille to within +/- 5 percent 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 percent and supply to design -5 percent. Positive areas will have opposite tolerances.

9. Pitot Tube Traverses: For use in future troubleshooting by Owner, 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 units.

11. The TAB report shall include a static profile of each AHU with the supply fan controlling to the minimum sensed duct static pressure necessary for the system terminal units to achieve maximum cooling design flow simultaneously. This static pressure shall be documented in the report and shall become the duct static pressure set point.

12. The TAB report shall record the VFD speed for all supply and return fan measurements included in the report.

13. The TAB contractor shall verify building and space pressure relationships in all modes of operation.

3.02 HYDRONIC SYSTEM BALANCE

A. When systems are installed and ready for operation, the TAB Firm shall perform water balance for each heating hot water system.

B. The general scope of balancing by the TAB Firm shall include, but not be limited to, the following:

1. Adjusted System Tests: Adjust balancing valves at each coil and heat exchanger to within a range of 0 to +10% of design flow. Adjust balancing valves at pumps to obtain design water flow within a range of 0 to +10% of design flow. Record pressure rise across pumps and GPM flow from pump curve. Permanently mark the balanced position for each valve. (Note: If discharge valves on the pumps are used for balancing record the head being restricted by the valves).

2. Temperature Readings: Read and record entering and leaving water temperature at each water coil, converter and heat exchanger. Adjust as necessary to design conditions. Provide final readings at all thermometer well locations.

3. Pressure Readings: Water pressure shall be recorded at all gauge connections. Pressure readings at coils and pumps shall be related to coil and pump curves in terms of GPM flow through flow measuring status, if provided and installed, at each air handler. The flow of water through all water coils shall be adjusted by manipulating valves until the rated pressure drops across each coil is obtained and total water flow is verified by flow measuring status. For coils equipped with 3-way valves, the rated pressure drop shall first be adjusted through the coils. The bypass valve shall then be adjusted on each coil until an equal pressure drop between supply and return connections is the same as with the flow through the coil.

4. Ampere Readings: Reading and record full load amperes for each pump motor.

3.03 SOUND VIBRATION AND ALIGNMENT

A. The TAB Contractor shall measure the HVAC background noise level in all the spaces specified in Division 23: Mechanical, Section I: Mechanical General, 1.01F. The sound level shall be measured at the patient head location in patient in patient sleeping and therapy rooms. In all other rooms the sound level is to be measured at the approximate center of the room 48″ above floor level. The TAB report shall document the measure NC level for each space. The TAB report shall also include an NC curve for any space that exceeds the specified NC limit.

B. Sound: Read and record sound levels at up to fifteen (15) locations per floor in the building as designated by the Design Professional. All measurements shall be made using an Octave Band Analyzer. All tests shall be conducted when the building is quiet and in the presence of the Design Professional, at the Design Professional's option.

C. Vibration: Read and record vibration for all water circulating pumps, air handling units, and fans which have motors larger than 10 horsepower. Include equipment vibration, bearing housing vibration, foundation vibration, building structure vibration, and other tests as directed by the Design Professional. Readings will be made using portable IRD (or approved equal) equipment capable of filtering out various unwanted frequencies and standard reporting forms. Maximum vibration at any point listed above, or specified, shall not exceed one mil on fans and one mil on pumps unless otherwise specified. Equipment manufacturer shall rectify all systems exceeding vibration tolerances.

3.04 BUILDING AUTOMATION SYSTEMS

A. In the process of performing the TAB Work, the Contractor shall:

1. Work with the Building Automation System (BAS) Provider and Owner 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 the intended controllers operate all dampers, valves and other controlled devices.

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 all duct mounted dampers, dampers in terminal units, 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 and operation of all controllers.

8. Verify the proper application of all normally open 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. BAS Provider will relocate sensors as deemed necessary by the TAB Firm or Contractor.

11. Verify that the sequence of operation for any control mode is in accordance with approved Shop Drawings and Specifications. Verify that no demand for simultaneous heating and cooling occurs at the terminal units.

12. Verify that all controller set points meet the Contract Documents.

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 system components track with changes from full flow to minimum flow.

END OF SECTION

DUCTWORK INSULATION

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. 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 ductwork insulation and jackets indicated by the Contract Documents with supplementary items necessary for proper insulation.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specified 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. International Energy Conservation Code – 2015 Edition
2. ASTM B209 – Aluminum and Aluminum-Alloy Sheet and Plate.
3. ASTM C168 – Terminology Relating to Thermal Insulation Materials.
4. ASTM C518 – Steady-State Thermal Transmission Properties by means of the Heat Flow Meter Apparatus.
5. ASTM C553 – Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
6. ASTM C612 – Mineral Fiber Block and Board Thermal Insulation.
7. ASTM C1071 – Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
8. ASTM C1104 – Standard Test Method for Determining the Water Vapor Sorption of Un-Faced Mineral Fiber Insulation.
9. ASTM C1290 – Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
10. ASTM C1136 – Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.

11. ASTM C1338 – Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.

12. ASTM E84 – Surface Burning Characteristics of Building Materials.

13. ASTM E96 – Water Vapor Transmission of Materials.

14. ASTM E119 – Standard Test Methods for Fire Tests of Building Construction and Materials.

15. ASTM G21 – Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

16. NFPA 255 – Surface Burning Characteristics of Building Materials.

17. SMACNA – HVAC Duct Construction Standards – Metal and Flexible.

18. UL 181 – Standard for Factory-Made Air Ducts and Air Connectors.

19. UL 723 – Surface Burning Characteristics of Building Materials.

20. ASTM E2336 – Standard for Grease Ducts.

1.04 QUALITY ASSURANCE

A. All ductwork requiring insulation shall be insulated as specified herein and as required for a complete system. In each case, the insulation shall be equivalent to that specified and materials applied and finished as described in these Specifications.

B. All insulation, jacket, adhesives, mastics, tapes, 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.

C. Application Company Qualifications: Company performing the Work of this Section must have minimum three (3) years of experience, specializing in the trade.

D. All insulation shall be applied by mechanics skilled in this particular Work and regularly engaged in such occupation.

E. 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.

1.05 SUBMITTALS

A. Product Data:

1. Provide product description, list of materials, "k" value, "R" value, mean temperature range, and thickness for each service and location.

B. Record Documents:

1. Submit under provisions of Division 1.

C. Operation and Maintenance Data:

1. Samples: When requested, submit three (3) samples of any representative size illustrating each insulation type.

2. Manufacturer's Installation Instructions: Indicate procedures that ensure acceptable standards will be achieved. Submit certificates to this effect.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to the Project Site under provisions of Division 01.

B. Deliver materials to Site in original factory packaging, labeled with manufacturer's identification including product thermal ratings and thickness.

C. Store insulation in original wrapping and protect from weather and construction traffic. Protect insulation against dirt, water, chemical and mechanical damage.

D. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulation cements.

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. CertainTeed Corporation.

B. Johns Manville Corporation.

C. Knauf Corporation.

D. Owens-Corning.

E. Armacell, LLC North America.

F. Unifrax 1 LLC (FyreWrap)

G. ITW Insulation Systems

H. Venture Clad Jacketing Systems

2.03 INSULATION MATERIALS

A. Type D1: Flexible glass fiber; ASTM C553 and ASTM C1290; commercial grade; "k" value of 0.25 at 75 degrees F; 1.5 lb/cu ft. minimum density; 0.002 inch foil scrim kraft facing for air ducts.

B. Type D2: Rigid glass fiber; ASTM C612, Class 1; "k" value of 0.23 at 75 degrees F; 3.0 lb/cu ft. minimum density; 0.002 inch foil scrim kraft facing for air ducts.

2.04 INSULATION ACCESSORIES

A. Adhesives: Waterproof vapor barrier type, meeting requirements of ASTM C916; Chillers CP-82.

B. Finish: Vapor barrier finish coating, Childers CP-11.

C. Jacket: Pre-sized glass cloth, minimum 7.8 oz/sq. yd.

D. Type D4 Insulation Adhesive: Fire resistive to ASTM E84, Childers CP-82.

E. Impale Anchors: Galvanized steel, 12 gauge self-adhesive pad.

F. Joint Tape:

1. UL 181 A-P/B-FX approved aluminum foil tape with pressure sensitive adhesive.

2. Glass fiber cloth, open mesh with adhesive and finish as listed above.

G. Tie Wire and Wire Mesh: Annealed steel, 16 gauge.

H. Stainless Steel Banding: ¾ inch wide, minimum 22 gauge, 304 stainless.

I. Armaflex 520 or 520 BLV contact adhesive.

J. Armatuff seal seam tape.

PART 3 – EXECUTION

3.01 PREPARATION

A. Verify that ductwork has been tested before applying insulation materials.

B. Verify that surfaces are clean, foreign material removed, and dry.

C. Maintain required ambient temperature during and after installation for a minimum period of 24 hours.

3.02 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. Extend duct insulation without interruption through walls, floors and similar penetrations, except where otherwise indicated.

D. Provide external insulation on all round ductwork connectors to ceiling diffusers and on top of diffusers as indicated in the Ductwork Insulation Application and Thickness Schedule and the Drawings. Secure insulation to the top of ceiling diffusers with adhesive that meets NFPA 90A and 90B 25/50 requirements and vapor barrier or tape to match jacket to form a complete vapor seal. Do not insulate top of ceiling diffuser if it is used in ceiling return air plenum or in an open space with no ceiling

E. Flexible and Rigid fiberglass insulation (Types D1 and D2) application for exterior of duct:

1. Insulation shall be cut slightly longer than the circumference of the duct to insure full thickness at the corner.

2. All insulation shall be applied with edges tightly stitched with staples on 3" centers.

3. Install without sag on underside of ductwork. The insulation shall be additionally secured to the bottom of all square or rectangular ducts 24" or wider by means of welded pins or speed clips on 12" centers.

4. Seal vapor barrier penetrations by mechanical fasteners with 2.5" wide, 0.002" thick, UL 181 A-P/B-FX approved aluminum foil tape with pressure sensitive adhesive or one coat of vapor barrier coating reinforced with 20 x 20 glass cloth. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

5. Insulate standing seams and stiffeners that protrude through the insulation with 1-1/2 inch thick, un-faced, flexible blanket insulation. Cover with 2.5" wide 0.002" thick, UL 181 A-P/B-FX approved, aluminum foil tape with pressure sensitive adhesive or one coat of vapor barrier coating reinforced with 20 x 20 glass cloth.

6. Cover seams, joints, pin penetrations and other breaks with 2.5" wide 0.002" thick, UL 181 A-P/B-FX approved aluminum foil tape with pressure sensitive adhesive or one coat of vapor barrier coating reinforced with 20 x 20 glass cloth.

F. All ductwork, accessories, and all plenums including metal and masonry construction, etc., shall be insulated as indicated on the Drawings, as specified herein and as required for a complete system. In each case, the insulation shall be equal to that specified and materials applied and finished as described in these Specifications.

G. Flexible ductwork connections to equipment shall not be insulated.

H. 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.

I. Extreme care shall be taken in insulating high and medium pressure ductwork including all ductwork between the fan discharge and all mixing boxes to ensure 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.

J. Where canvas finish is specified use lagging adhesive to prevent mildew in securing canvas. Do not use wheat paste. In addition, cover all canvas insulation with a fire retardant coating.

K. All ductwork in the Project except toilet exhaust and fume hood exhaust ductwork, shall be insulated externally unless specifically excluded.

L. Flexible round ducts shall be factory insulated.

3.03 INSPECTION

A. Visually inspect the completed insulation installation per manufacturers recommended materials, procedures and repair or replace any improperly sealed joints.

B. Where there is evidence of vapor barrier failure or "wet" insulation after installation, the damaged insulation shall be removed, duct surface shall be cleaned and dried and new insulation shall be installed.

Ductwork System	Application	Insulation Type	Insulation Thickness
Supply Air 50°F & Above (Hot, Cold, Combination)	Outside of Mechanical Rooms	D1	2”
	Inside of Mechanical Rooms Where Installed Below 7’-0” AFF	D2	2”
Rectangular Supply Air Below 50°F	All	D2	2”
Round or Oval Supply Air below 50°F	All	D1	3”
Return Air, Relief Air, and Exhaust Air	All	D1	2”
Supply Air Diffusers	Top of Diffuser	D1	2”

1

2 **END OF SECTION**

HVAC PIPING INSULATION

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. 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 HVAC piping insulation, jackets and accessories indicated by the Contract Documents with supplementary items necessary for proper installation.

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. ASTM B209 – Aluminum and Aluminum-Alloy Sheet and Plate.
2. ASTM C168 – Terminology Relating to Thermal Insulation Materials.
3. ASTM C177 – Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded – Hot – Plate Apparatus.
4. ASTM C195 – Mineral Fiber Thermal Insulating Cement.
5. ASTM C335 – Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
6. ASTM C449 – Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
7. ASTM C518 – Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
8. ASTM C534 – Pre-formed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
9. ASTM C547 – Mineral Fiber Pipe Insulation.
10. ASTM C552 – Cellular Glass Thermal Insulation.
11. ASTM C578 – Rigid, Cellular Polystyrene Thermal Insulation.
12. ASTM C585 – Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
13. ASTM C591 – Un-faced Pre-formed Rigid Cellular Poly-isocyanurate Thermal Insulation.
14. ASTM C610 – Molded Expanded Perlite Block and Pipe Thermal Insulation.

15. ASTM C921 – Jackets for Thermal Insulation.

16. ASTM C1126 – Faced or Un-faced Rigid Cellular Phenolic Thermal Insulation.

17. ASTM D1056 – Flexible Cellular Materials – Sponge or Expanded Rubber.

18. ASTM C1667 – Flexible Cellular Materials – Vinyl Chloride Polymers and Copolymers (Closed Cell Foam).

19. ASTM D2842 – Water Absorption of Rigid Cellular Plastics.

20. ASTM C795 – Insulation for Use in Contact with Austenitic Steel.

21. ASTM E84 – Surface Burning Characteristics of Building Materials.

22. ASTM E96 – Water Vapor Transmission of Materials.

23. NFPA 255 – Surface Burning Characteristics of Building Materials.

24. UL 723 – Surface Burning Characteristics of Building Materials.

1.04 DEFINITIONS

A. Concealed: Areas that cannot be seen by the building occupants.

B. Interior Exposed: Areas that are exposed to view by the building occupants, including underneath countertops, inside cabinets and closets, and all equipment rooms.

C. Exterior: Areas outside the building exterior envelope that are exposed to the outdoors, including building crawl spaces.

1.05 QUALITY ASSURANCE

A. All piping requiring insulation shall be insulated as specified herein and as required for a complete system. In each case, the insulation shall be equivalent to that specified and materials applied and finished as described in these Specifications.

B. 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 systems, unless a specific product is specified for a specific application and is stated as an exception to this requirement.

1. Certificates to this effect shall be submitted along with Contractor's submittal data for this Section of the Specifications.

2. No material shall 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.

C. Application Company Qualifications: Company performing the Work of this Section must have minimum three (3) years experience specializing in the trade.

D. All insulation shall be applied by mechanics skilled in this particular Work and regularly engaged in such occupation.

E. 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.

1.06 SUBMITTALS

A. Product Data:

1. Provide product description, list of materials “k” value, “R” value, mean temperature range, and thickness for each service and location.

2. Samples: When requested, submit three (3) samples of any representative size illustrating each insulation type.

B. Operation and Maintenance Data:

1. Indicate procedures that ensure acceptable standards will be achieved. Submit certificates to this effect.

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the Project Site in original factory packaging, labeled with manufacturer’s identification including product thermal ratings and thickness.

B. Store insulation in original wrapping and protect from weather and construction traffic. Protect insulation against dirt, water, chemical and mechanical damage.

C. Maintain ambient temperature and conditions required by manufacturers of adhesives, mastics and insulation cements.

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. Insulation:

1. Owens-Corning (Type P1).

2. Certainteed Corporation (Type P1).

3. Johns Manville Corporation (Type P1).

4. Knauf Corporation (Type P1).

5. Dow Chemical Company (Type P2).

6. Armstrong/Armacell (Armaflex) (Type P3).

7. RBX Industries/Rubatex (Type P3).

8. Johns-Manville Minwool-1200 (Type P4).

9. Resolco International by (Insul-Phen) (Type P5).

10. FOAMGLAS (Cellular Glass) by Pittsburgh Corning (Type P6).

11. Johns-Manville Thermo-12 Gold Calcium Silicate (Type P7).

B. Jackets:

1. Childers Products Company.

2. PABCO.

3. RPR Products, Inc.

4. Alpha.

5. Venture Tape Corporation.

6. Pittsburgh Corning - FOAMGLAS

2.03 INSULATION

A. Type P1: Fiberglass preformed insulation; ASTM C 547; minimum 3.0 lb/cu ft density, ASTM C335,'k' value of 0.23 at 75 degrees F; noncombustible.

B. Type P5: Phenolic closed cell, ASTM C1126 rigid foam, 2.2 lbs. nominal density, CFC free; ASTM C518, 'k' value of 0.13 at 75 degrees F. (Note material thickness limit is 3 inches as tested in accordance with ASTM E84).

C. Type P6: Cellular Glass, ASTM C552, 7.5 lbs./cu.ft, density, ASTM E96 (Wet Cup Method) 0.00 water vapor perm , ASTM C518 ‘k’ value of 0.29 at 75 degrees F.

2.04 JACKETS

A. Factory Applied Jackets:

1. White kraft bonded to reinforced foil vapor barrier with self-sealing adhesive joints.

2. ASJ White, triple-ply laminate polypropylene, mold resistant, metalized polyester vapor barrier film backing: Venture 1555U or Insulrap 30 Vapor Barrier I-30.

B. Field Applied Jackets:

1. PVC Jackets: UL listed 25/50 rated per ASTM E 84, UV resistant, minimum insulation thickness 0.020 inches for pipe outside diameters up to 18 inches and 0.030 inches for pipe outside diameters 18 inches and above. Standard manufactured PVC cover fittings cover system consisting of one-piece, pre-molded, PVC covers with fiberglass inserts manufactured from 20-mils thick, high-impact, ultraviolet-resistant. Use ultraviolet resistant adhesive as recommended by the manufacturer.

2. Reinforcing Mesh: Glass Fiber Childers Chil-Glas #10 or synthetic 9X8 mesh with minimum weight of 0.9 ounces per square yard.

3. Aluminum Jackets: ASTM B 209; 0.020 inch thick; smooth finish with factory applied moisture barrier.

4. Stainless Steel Jackets: Type 304 stainless steel; 0.010 inch thick; smooth finish.

5. VentureClad 1577CW or Foster Vapor Fas 62-05, zero permeability and mold resistant jacket material, 5-ply laminate with 5-6 mil film with adhesive on one side. Jacketing laminated film must have UV coating for additional exterior protection.

2.05 COATINGS, SEALANTS, TAPES AND ADHESIVES

A. Insulating Cement: ASTM C 195; hydraulic setting mineral wool; Ryder One-Coat.

B. Sealants: Foster 95-50; Childers CP-70 or CP-76

1. Apply at valves, fittings and where insulation is terminated. Brush-apply sealant to end of insulation and continue along pipe surface.

2. Below-ambient closed cell pipe insulation (Type P5, P5A, P5B): apply sealant on all longitudinal and butt insulation joints to prevent moisture transmission.

C. Lap Seal Tape: Self-adhering 2' wide tape specifically engineered to cover end joints of AP Armaflex Black Lap Seal tube material for use on end seams and butt joints that have already been sealed with Armaflex 520 adhesive. Not to be used on longitudinal seams.

D. Adhesives: Use to adhere the longitudinal lap seam of vapor barrier jackets and at butt joints between insulation or fitting covers. Provide Childers CP-82 or Foster 85-20/85-60 as general purpose adhesive. For use with calcium silicate or expanded perlite insulation, use Childers CP-97 or Foster 81-27 fibrous adhesive when adhering pipe saddles and shields to the insulation.

E. Primers: For proper bonding with lagging adhesive/canvas provide light coat of Childers CP-50 AMV1 or Foster 30-36 diluted 50 percent with water over insulation or Pittcoat 300 primer thinned with mineral spirits to cover insulating cements prior to finish coating.

F. Coatings and Mastics:

1. Vapor barrier coating for indoor, below-ambient applications: Foster 30-80 or Childers CP-38 on all elbows, fittings, and valves. Coating shall adhere to MIL-C-19565C, Type II and shall be QPL listed.

2. Weather barrier/breather mastics for above-ambient piping applications: Childers CP-10/CP-11 or Foster 46-50.

3. High humidity applications: Foster 30-80 AF or Childers CP-137 AF fungus/mold resistant coating that meets ASTM D 5590 with zero growth rating.

4. Exterior applications: Childers CP 30LO (must be covered by metal jacketing), Childers CP-45 Encacel V, or Foster 60-95 Monolar for insulated elbows/fittings, longitudinal seams, and butt joints of vapor barrier jackets or glass cloth jackets.

5. Finish coat over closed cell elastomeric: Foster 30-64 or Armstrong "Finish" acrylic finish.

6. Canvas Finishes:

a. Apply lagging adhesive to prevent mildew for securing canvas. Apply anti-fungal lagging adhesive that adheres to ASTM D 5590 with zero growth rating. (Foster 30-36AF, Childers CP-137AF) Do not use wheat paste.

b. Exterior Applications: cover all canvas insulation with a fire-retardant weather barrier mastic. On canvas jacketed systems where seam joints at fittings are rough, cover with an application of insulating cement and smooth with a trowel before the canvas is applied with adhesive. Canvas shall be free of wrinkles and have a smooth, neat appearance.

G. Reinforcing Mesh: Childers Chil-Glas #10 or Foster Mast-a-Fab 9x8 reinforcing mesh with coatings and mastics.

H. Lagging Adhesives/Coatings: Childers CP-50A HV2 or Foster 30-36 for adhering canvas and glass cloths over thermal insulation installed indoors. Adhesive shall adhere to MIL-A-3316C Class I, Grade A.

1. High humidity applications (unconditioned space): Foster 30-36 AF or Childers CP-137 AF fungus/mold resistant coating that meets ASTM D 5590 with zero growth rating. Coating shall adhere to MIL-C-19565C, Type II and must be QPL listed.

2.06 INSERTS, SUPPORTS AND SHIELDS

A. Application: Piping ½ inch diameter or larger for all systems except direct buried.

B. Shields shall be made of galvanized steel or made of black iron painted on both sides with a minimum two coats of aluminum paint. Required metal shield sizes are as follows:

Nominal IPS (inches)	Metal Thickness (gauge)	Minimum Lengths of Shield (inches)
½ to 1½	18	12
2	14	12
2-½ to 6	12	16
8 and above	10	20

C. Inserts for shields shall be manufactured of 7.5 lb/cu. ft. density cellular glass or 5.0 lb/cu. ft. density cellular, phenolic insulating material suitable for the planned temperature range. Provide factory fabricated inserts with integral galvanized pipe saddles. Inserts shall be the same thickness as the adjacent insulation.

D. When installing elastomeric insulation, Armafix IPH or Armafix NPH shall be used to prevent compression of insulation at standard split, clevis hangers or other pipe support systems. A pair of non-skid pads shall be adhered to the clamps to prevent axial movement of the insulation. In addition, to prevent loosening of the clamps, an anti-vibratory fastener, such as a nylon-locking nut, shall be used.

E. Depending on the type of pipe support design, stainless steel bands or aluminum bands may be required to keep shield material next to the jacketing material.

2.07 INSULATION ACCESSORIES

A. Insulation Bands: 3/4 inch wide; 0.007 inch thick galvanized steel when exposed to interior environment, 0.010 inch thick stainless steel or 0.015 inch thick aluminum when exposed to humid interior environment or outside environment.

B. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum or 0.010 inch thick stainless steel to match jacket.

C. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum to match jacket.

D. Sealants: Use at valves, fittings and where insulation is terminated. Brush apply sealant to end of insulation and continue along pipe surface.

E. Adhesives: Use to adhere the longitudinal lap seam of vapor barrier jackets and at butt joints between insulation or fitting covers. Provide Childers CP-82 or approved equal as general purpose adhesive. Use Childers CP-97 fibrous adhesive for calcium silicate or when adhering pipe saddles and shields to the insulation.

F. Primers: Provide Childers CP-50 diluted 50 percent with water or Pittcoat 300 primer thinned with mineral spirits to cover insulating cements prior to finish coating.

G. Finish: Provide Childers CP-30 L.O. as a general purpose finish to coat the longitudinal seams and butt joints of vapor barrier jackets or glass cloth jackets. Use Childers CP-50 reinforced with glass cloth as an adhesive and sizing for canvas and in other locations as indicated.

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. Installation of insulation and jacket materials shall be in accordance with manufacturer's published instructions.

C. Handle and install materials in accordance with manufacturer's instructions in the absence of specific instructions herein.

D. On exposed piping, locate insulation cover seams with the ridge of the lap joint is directed down.

E. Exposed insulated piping within six feet of the floor shall be protected with an aluminum or stainless jacket material to protect the insulation.

F. Continue insulation through walls, sleeves, pipe hangers, floors and other pipe penetrations.

G. Provide dams in insulation at intervals not to exceed 20 feet on cold piping systems to prevent migration of condensation or fluid leaks. Indicate visually where the dams are located for maintenance personnel to identify and also provide dams at butt joints of insulation at fittings, flanges, valves, and hangers.

H. Insulate entire system including fittings, valves, flanges and strainers.

I. Use closed cell insulation on cold piping system flexible connections, expansion joints and unions and on all refrigerant lines where passing vertically through interior partitions for sound abatement. Bevel and seal ends of insulation and continue sealant a minimum of 4 inches along the piping, unless stated otherwise. Install insulation by "pushing" only, to result in a slightly compressed state, using Armaflex 520 or Armaflex 520 BLV adhesive to seal all joints and seams (cloth tape is not allowed to be used to seal joints or seams). On cold piping, insulation shall be adhered directly to the piping at the high end of the run using a two-inch strip of Armaflex 520 or 520 BLV adhesive on the I.D. of the insulation and on the pipe. All penetrations through the insulation and termination points must be adhered to the substrate to prevent condensation migration. Where exposed to view or sunlight, coat exposed closed cell elastomeric insulation with two coats of Armacell "WB" or K-Flex "374". Where exposed to physical abuse, provide stainless steel or aluminum jacketing as specified above. All exposed piping shall have the seams located on the lower half of the pipe.

J. On heating piping systems conveying fluids over 180^{o}F with unions, flanges, valves, strainers and equipment that is anticipated to be removed for maintenance, the insulation shall terminate (beveled to pipe) just prior to the flange or union with vapor barrier sealed to pipe. The tapered segment of insulation shall not interfere with the removal of unions flange bolts or equipment. The unions, flanges, valves and strainers shall be insulated with removable insulated covers with toggle catches or Velcro straps.

K. Insulate fittings, joints and valves with molded insulation of the same material and thickness as adjoining pipe. Open voids and cracks in insulation shall be kept at a minimum when placing insulation on abnormal or irregular shapes. Use closed cell or recommended fill material as instructed by the insulation manufacturer to close openings. At ball valves, provide Nibco "NibSeal" (or approved equal, if supplied

valve is from a different manufacturer, such as Milwaukee Valve "Insulator") handle extension/vapor barrier sealing system. Fiberglass batt insulation shall not be used as a fill material on chilled water piping or fittings.

L. All sections of molded pipe covering shall be firmly butted together. Where an insulation covering is applied, it shall lap the adjoining section of insulation by at least three inches (3 inches). Where insulation terminates, it shall be neatly beveled and finished. All materials used shall be fire retardant or non-flammable.

M. 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 be sealed. Where insulation with a vapor barrier terminates, seal off with vapor barrier continuous to the surface being insulated. Ends shall not be left raw.

N. Where pipe chases are tight, adequate provision shall be made at the rough-in stage using offset fittings or other means (except springing the pipe) to ensure that insulation can be applied throughout the length of the pipe.

O. Where canvas finish is specified, use lagging adhesive to prevent mildew in securing canvas. Do not use wheat paste. In addition, cover all canvas insulation with a fire-retardant coating.

1. On canvas jacketed systems where seam joints at fittings are rough, they shall be covered with an application of insulating cement and smoothed with a trowel before the canvas is applied with adhesive. The canvas must be free of wrinkles and have a smooth, neat appearance.

P. INSERTS, SUPPORTS AND SHIELDS

1. Shields

a. Install between pipe hangers or pipe hanger rolls and inserts. Curved metal shields shall be used between the hangers or support points and at the bottom of insulated pipe.

b. Hangers shall support the load of the insulated pipe section on the outside of the insulation and shall not be in direct contact with the pipe.

c. Manufacturer shall be responsible to size the length of shield required to prevent insulation from breaking.

d. Provide rigid insulation at each support point, a minimum of 2 inches longer than shield length.

e. Curved metal shields shall be designed to limit the bearing stress on the insulation to 35 psi and shall be curved to fit up to mid-perimeter of the insulated pipe.

2. When installing phenolic insulation provide a 5 lb. density insert of same thickness and contour as adjoining 3.75 lb. density insulation, between the support shield and piping, and under the finish jacket, on piping 1-1/2 inch diameter or larger, to prevent insulation from sagging at support points. Provide inserts for the full circumference of the pipe and not less than 2 inches more than the length of the pipe support shield or minimum 12 inches long (whichever is greater). Adhere the pipe support shield to insulation with a UL approved adhesive that meets E-84 requirements.

3. When installing elastomeric insulation, Armafix IPH or Armafix NPH shall be used to prevent compression of insulation at standard split, clevis hangers or other pipe support systems. A pair of non-skid pads shall be adhered to the clamps to prevent axial movement of the insulation. In addition, to prevent loosening of the clamps, an anti-vibratory fastener, such as a nylon-locking nut, shall be used.

4. Seal all insulation at supports, protrusions and interruptions. Maintain vapor barrier with finish coat.

3.02 PIPING INSULATION APPLICATION AND THICKNESS SCHEDULE

A. In no case shall installed piping insulation have insulation thicknesses that are less than what is required by local energy codes and ASHRAE 90.1 (whichever is more stringent), based on comparable insulation conductivity values at the specified mean rating temperature.

Piping Systems	Location	Type	Pipe Size	Insulation Thickness
Building Heating Hot Water (Maximum 160 Degrees F)	Interior Concealed	P1	2-1/2" and Smaller	1-1/2"
			3" and Larger	2-1/2"
		P5	2-1/2" and Smaller	1"
			3" and Larger	1-1/2"
		P6	2-1/2" and Smaller	1-1/2"
			3" and Larger	2"

END OF SECTION

HYDRONIC PIPING

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. 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. Furnish and install all labor, materials, equipment, tools and services and perform all the operations required in connection with, or associated with the construction of complete hydronic piping systems, including chilled and heating hot water piping, condenser water piping process chilled or hot water piping, condensate drain piping and generator cooling water piping systems as indicated on the Drawings.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specified 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. ANSI/ASME Sec 9 – Welding and Brazing Qualifications.
2. ASTM A53 – Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless.
3. ANSI/ASME B16.3 – Malleable Iron Threaded Fittings Class 150 and 300.
4. ANSI/ASME B16.9 – Factory-Made Wrought Butt Welding Fittings.
5. ANSI/ASME B16.23 – Cast Copper Alloy Solder Drainage Fitting – DWV.
6. ANSI/ASME B16.29 – Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings – DWV.
7. ANSI/ASME B31.9 – Building Services Piping.
8. ANSI/AWS D1.1 – Structural Welding Code.
9. ASTM A53 – Pipe, Steel, Black and Hot-Dipped Zinc Coated (Galvanized), Welded and Seamless, or Ordinary Uses.
10. ASTM A105 – Standard Specification for Carbon Steel Forgings for Pipe Applications.

11. ASTM A234 – Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.

12. ASTM A312 – Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipe.

13. ASTM A536 – Standard Specification for Ductile Iron Castings.

14. ASTM B88 – Standard Specification for Seamless Copper Water Tube.

1.04 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating shall be clearly marked on the outside of the valve body.

B. All grooved joint couplings, fittings, flanges, valves, and specialties of the same type shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

C. Welding Materials and Procedures: Conform to Chapter V, ASME/ANSI B31.9 and applicable state labor regulations.

D. Welders Certification: Furnish in accordance with AWS D10.12 and ASME B31.9.

E. Each threaded fitting shall be stamped as specified by ANSI B16.3.

F. Each welded fitting shall be stamped as specified by ANSI B31.9.

1.05 SUBMITTALS

A. Product Data:

1. Submit product data on pipe materials, pipe fittings, valves and accessories. Clearly indicate make, model, type, size and pressure rating for each device.

2. Submittal data for all fittings shall include a letter signed by an official of the manufacturing company certifying compliance with these Specifications.

B. Record Documents:

1. Grooved joint couplings and fittings shall be shown on drawings and product submittals and shall be specifically identified with the applicable Victaulic style or series designation.

2. Include Welder's Certification of compliance in accordance with Chapter V, ASME/ANSI B31.9.

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.

B. Wall, Floor and Ceiling Plates:

1. Provide chrome-plated brass floor and ceiling plates.

C. Threaded Fittings:

1. All threaded fittings shall be USA factory made, wrought carbon or alloy steel threaded fittings conforming to ASTM A234 or malleable iron threaded fittings conforming to ASME B16.3.

2. Acceptable manufacturers: Grinnell, Tube Turns, Hackney Ladish Company, or Taylor Forge.

D. Grooved Fittings:

1. All grooved joint couplings, fittings, valves and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. Fittings shall comply with ASTM A536; ASTM A234; or factory fabricated from carbon steel piping conforming to ASTM A53.

2. Acceptable manufacturers: Victaulic Company of America.

3. Gaskets shall be verified as suitable for the intended system service, a minimum temperature of 250 degrees, fluid chemistry, and system pressure prior to installation. Gaskets shall be molded and produced by the coupling manufacturer.

E. Welded Fittings:

1. All welded fittings shall be USA factory made wrought carbon steel butt welding fittings conforming to ASTM Spec. A234 or ASME B16.9.

2. Acceptable manufacturers: Grinnell, Tube Turns, Hackney Ladish Company, or Taylor Forge.

F. Flanges:

1. All 150 lb. and 300 lb. ANSI flanges shall be weld neck and shall be domestically manufactured, forged carbon steel, conforming to ANSI B16.5 and ASTM A-191 Grade I or II or A-105 as made by Tube Turns, Hackney Ladish Company. Slip on flanges shall not be used. Complete test reports may be required for any fitting selected at random.

2. Flanges shall have the manufacturer's trademark permanently identified in accordance with MSS SP-25. Contractor shall submit data for firm certifying compliance with these Specifications.

3. Bolts used shall be carbon steel bolts with semi-finished hexagon nuts of American Standard heavy dimensions. All-thread rods will not be an acceptable substitute for flange bolts. Bolts shall have a tensile strength of 60,000 psi and an elastic limit of 30,000 psi.

4. All flanges shall be gasketed. Place gasket between flanges of flanged joints. Gaskets shall fit within the bolt circle on raised face flanges and shall be full face on flat face flanges. Gaskets shall be cut from 1/16 inch thick, non-metallic, non-asbestos gasket material suitable for operating temperatures from -150 degrees F to +750 degrees F, KLINGERsil C-4400, Johns-Manville Style 60 service sheet packing or accepted substitution. Gaskets must be compatible with flowing fluid, temperature and pressure of system.

G. Copper Fittings:

1. Mechanically formed, drilled and extruded tee-branch connections shall not be permitted.

2. For piping 4" and smaller, the use of Viega "Pro-Press" or Nibco compression type fittings will be accepted. Coupling fittings shall include a positive stop to assure proper pipe seating on both sides of the coupling. Nibco fittings shall be furnished with EPDM leak detection O-rings.

2.02 PIPE

B. Building Chilled Water and Heating Water Piping – 150 psi and below:

1. Steel:

a. Pipe 2-1/2 inches and smaller: Black steel ASTM A53, Grade A or B, seamless, Schedule 40.

1) Fittings: Screwed, AAR malleable iron, Class 150.

2) Joints: Screwed.

3) Unions: Forged steel, ASTM A105, screwed with stainless steel seats.

b. Pipe 3 inches and larger: Black steel ASTM A53, Grade B, seamless:

1) 3 inches through 6 inches – Schedule 40.

2) 8 inches through 16 inches – Schedule 30.

3) 18 inches through 20 inches – 0.375 inch wall thickness.

4) 24 inches – 0.500 inch wall thickness.

5) Fittings:

a) ASTM A234 carbon steel welding type, long radius type elbows unless specified otherwise on the Drawings.

b) ASTM A536 ductile iron; A234 carbon steel; or factory fabricated A53; grooved end long radius type elbows unless specified otherwise on the Drawings.

6) Joints:

a) Butt welded.

b) Grooved mechanical couplings.

7) Flange: ANSI B16.5 Class 150, forged carbon steel.

2. Copper:

a. Pipe 4 inches and smaller; Copper Tubing: ASTM B88, Type L, hard drawn. All brass and bronze piping components shall have no more than 15 percent zinc content.

1) Fittings: ASTM B16.18, cast bronze, or ASME B16.22 wrought copper and bronze.

2) Joints: ASTM B32, solder, Grade 95TA (lead free).

3) Viega “Pro-Press” or Nibco compression type fittings. . Coupling fittings shall include a positive stop to assure proper pipe seating on both sides of the coupling. Nibco fittings shall be furnished with EPDM leak detection O-rings.

2.03 GROOVED MECHANICAL COUPLINGS AND FITTINGS

A. Grooved mechanical couplings shall consist of two ductile iron housing segments conforming to ASTM A536, with pressure responsive elastomer gasket, and zinc electroplated carbon steel bolts and nuts.

1. Sizes 2-1/2 inches through 8 inches:

   a. Rigid Type Couplings: Housings cast with offsetting, angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9. Victaulic Style 107 Quick-VIc ™.

   b. Flexible type couplings: Use in locations where vibration attenuation and stress relief are required. Victaulic Style 77 or 177 Quick-Vic ™.

   c. Flange Adapters: Flat face, for direct connection to ANSI Class 125 or 1590 flanged components. Victaulic Style 741.

2. Sizes 10 inches through 12 inches:

   a. Rigid Type Couplings: Housings cast with offsetting, angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9. Victaulic Style 07.

   b. Flexible Type Couplings: Use in locations where vibration attenuation and stress relief are required. Victaulic Style 77.

   c. Flange Adapters: Flat face, for direct connection to ANSI Class 125 or 150 flanged components. Victaulic Style 741.

3. Sizes 14 inches through 24 inches: AGS 'W' series couplings shall include a widened gasket and wide profile housings.

   a. Rigid Type Couplings: Housing key with lead-in chamfer, with key designed to fill the wedge shaped AGS groove to provide rigidity and system support and hanging in accordance with ANSI B31.1 and B31.9. Victaulic Style W07.

   b. Flexible Type Couplings: Housing key with lead-in chamfer, with key designed to fit into the wedge shaped AGS groove to allow for linear and angular movement. Victaulic Style W77.

   c. AGS couplings shall be installed to full metal-to-metal bolt pad contact at the required torque.

B. Grooved mechanical fittings shall be manufactured of ductile iron conforming to ASTM A536; forged carbon steel conforming to ASTM A234; or fabricated from carbon steel pipe conforming to ASTM A53.

1. Sizes 14 inches through 24 inches with wedge shaped 'AGS' grooved ends:

   a. Install AGS fittings with AGS couplings. Installing AGS products with standard grooved fittings and couplings will result in installation difficulties and could lead to joint separation and leakage.

2.04 VALVES

A. General:

1. All valves used in 150 psi circulating systems shall be ANSI Class 150. All valves in 300 psi systems shall be Class 300 valves and shall be constructed of all ASTM B-61 composition. All globe and angle valves shall be screw-over bonnet design. Metal used in the stems of all bronze ball, globe and angle valves shall conform to ASTM B371 Alloy 694, ASTM B99 Alloy 651 or other corrosion resistant equivalents. Secure written approvals by Owner for the use of alternative materials.

2. The following manufacturers are acceptable: NIBCO, Keystone, Crane, Jamesbury, Dezurik, Daniels, Williams, Velan or Vogt.

3. All iron body valves shall have the pressure containing parts constructed of ASTM designed of 126 Class B iron. Stem material shall meet ASTM B16 Alloy 360 or ASTM 371 Alloy 876 silicon bronze or its approved equivalent model by listed manufacturers.

4. All cast steel body valves shall have the pressure containing parts constructed of ASTM designation A-216-GR-WCB carbon steel. Stems shall meet ASTM designation A-186-F6 chromium stainless steel. Seat ring shall be hard faced carbon steel or 13^ chromium A-182-F6 stainless. Hand wheels shall be A47 grade 35018 malleable iron or ductile iron ASTM A536.

5. All forged steel body valve shall have the pressure containing parts constructed of ASTM 105, Grade 2 forged carbon steel. Seat and wedges shall meet ASTM-A-182-F6 chromium stainless steel. Seat rings shall be hard faced. Valves shall conform to ANSI B16-34 pressure-temperature rating.

6. All globe valves, angle valves and shutoff valves shall have malleable iron hand wheels, except iron body valves 2-1/2 inches and larger which may have either malleable iron or ASTM A-126 Class B, gray iron hand wheels.

7. Packing for all valves shall be free of asbestos fibers and selected for the pressure-temperature service of the valve. It is incumbent upon the manufacturer to select the best quality, standard packing for the intended valve service.

8. Provide stem extensions on all insulated valves.

9. Valve chain operators shall be of cast iron or malleable iron and designed to provide positive grip on wheel. Provide chain guide to prevent chain from slipping or jumping on wheel. Employ rustproof chain complete with closing link of sufficient length to operate at 6 feet-6 inches above floor level.

10. Provide valve suitable for connection to adjoining pipe as specified for pipe joints above. Use valves that are full size of pipe in which installed.

B. Globe Valves:

1. 150 Pound Class Valves:

a. Threaded pipe 2 inches and smaller; NIBCO T235-Y, 150-pound screwed, inside screw, rising stem, bronze body, union Bonnet.

b. Welded pipe 2-1/2 inches and larger: NIBCO F-718-B, Cast Iron with Brass trim.

2. 300 Pound Class Valves:

a. Threaded pipe 2 inches and smaller: NIBCO T276-AP, Class 300 screwed, inside screw rising stem, bronze body, union bonnet, stainless steel disc.

b. Welded pipe 2-1/2 inches and larger. NIBCO F-768-B, Class 250 iron body, flanged, bolted bonnet, brass trim.

C. Soft Seated Butterfly Valves:

1. 200 Pound Soft Seated:

a. NIBCO LD-2000 or approved equal.

b. Ductile iron body with aluminum bronze disc, 400 series stainless steel stem.

c. Valves 6 inches and smaller shall have lever operators; 8 inches and larger shall have gear operators.

d. All butterfly valves shall be suitable for bi-directional dead-end service without the need for a downstream flange.

D. High Performance Butterfly Valves:

1. A 150 Pound Class Valve:

a. NIBCO LCS-6822, carbon steel lug body valve, ANSI rated Class150.

b. Valves to provide shutoff to 285 psi.

c. Provide 316 or UNS-S31803 stainless shaft, cast stainless steel disc, stainless steel seat and PTFE seat ring.

2. 300 Pound Class Valves: NIBCO LCS-7822 300 lb. ANSI class raised face, lug body, carbon steel body, stainless steel pin and shaft and disc, stainless steel seat and PRFE seat ring, gear operated.

E. Check Valves:

1. 150 Pound Class Valves:

a. Threaded pipe 2 inches and smaller. NIBCO T453-B, bronze body, Class 200, screwed connection, regrinding disc and seat with screw in cap.

b. Welded pipe 2-1/2 inches and larger. NIBCO F910-B. Flanged style, spring-loaded type. Rate for 150 psig working pressure; Cast Iron Body, Bronze plates and 316 Stainless Steel springs.

F. Plug Valves:

1. 150 Pound Class Valves:

a. Threaded pipe 2 inches and smaller: Dezurik 128 S 1 RS 26, Keystone 542, 150-pound screwed, eccentric plug valve, carbon steel or semi-steel body, Buna-N faced plug, lever operated, non-lubricated, short pattern plug valve.

b. Welded pipe 2-1/2 inches and larger: Dezurik 128 F 1 RS 26, Homestead 583. 150-pound flanged eccentric carbon steel or semi-steel, Hycar or Buna-N faced plug manually operated, non-lubricated, short pattern plug.

2. 300 Pound Class Valves:

a. Threaded pipe 2 inches and smaller: Tufline 066, PoweII 3058, 300 psi working pressure, cast carbon steel body and plug, threaded end valve, bolted bonnet, non-lubricated or lubricated with lubricant suitable for water -20ºF to 450ºF temperature, wrench operated.

b. Flanged piping 2-1/2 inches, cast carbon steel body and plug conforming to ASTM A216, Gr. WCB. Gear operated, bolted gland. Flanged per ANSI B16.5. Pipe sizes 4 inches through 12 inches. Non-lubricated or lubricated with lubricant suitable for water -20ºF to 450ºF temperature, 100 percent port.

G. Ball Valves:

1. Threaded pipe 2 inches and smaller: NIBCO T 585-70-66. For threaded pipe 2-1/2 inches to 3 inches: Crane 9301-S or approved equivalent model by listed manufacturers.

a. Threaded full port two-piece bronze body ASTM-B584 Alloy 844, ASTM B61, or ASTM B62 (No brass containing more than 15 percent Zink will be acceptable).

b. Stainless steel ball and stem, blowout proof stem with stem extension made of non-thermal conducting material and having an adjustable memory stop after insulation is installed.

2. Welded pipe 2-1/2 inches and larger: NIBCO F-515-CS-66FS or accepted substitute for 150 pound Class; NIBCO F-535-CS-66FS for 300 pound class, split steel body, full bore, blowout proof stem, flanged.

PART 3 – EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

D. After completion, fill, clean, and treat systems.

3.02 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. Pipe Installation:

1. All the various piping systems shall be made up straight and true and run in orderly manner, plumb and parallel to building structure. Install piping to conserve building space. Coordinate location with other trades and so not interfere with use of space for other work.

2. Piping shall follow as closely as possible the routes shown on Drawings which take into consideration conditions to be met at the site.

3. Should any unforeseen conditions arise, lines shall be changed or rerouted after proper approval has been obtained.

4. All piping shall be installed with due regard to expansion and contraction and so as to prevent excessive strain and stress in the piping, in connections, or in equipment to which the lines are connected.

5. Group piping whenever practical at common elevations.

6. Slope piping and arrange system to drain at low points. Use eccentric reducers where applicable to maintain the bottom of pipe level.

7. Bench tap connections are to be from the top to horizontal position of pipe run.

8. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

9. Provide and install Pete's plugs adjacent to thermo wells for electronic temperature sensors, to electronic pressure sensors and install Pete's plugs adjacent where shown or noted on piping drawings or drawing details.

10. Provide clearance for installation of insulation, and access to valves and fittings.

11. Prepare pipe, fittings, supports and accessories for finish painting. Chilled water piping insulated with cellular glass does not require finish painting.

12. All piping shall be clean when it is installed. Before installation it shall be checked, upended, swabbed if necessary, and all rust or dirt from storage or from laying on the ground shall be removed.

13. Where leaks occur, the pipe shall be repaired and the tests repeated. No leaks shall be corrected by peening. Defective piping and joints shall be removed and replaced.

14. Procedure of Assembling Screw Pipe Fittings: All screw joints shall be made with taper threads, properly cut. Joints shall be made tight with Teflon™ tape or Teflon™-based compound appropriate to the medium, material and temperature range of the system. Compound shall be applied to the pipe threads only and not to fittings. When threads are cut on pipes, the ends shall be carefully reamed to remove any burrs. Before installing pipe that has been cut and threaded, the lengths of pipe shall be upended and hammered to remove all shavings and foreign material.

D. Valve Installation:

1. Locate all valves such that the removal of their bonnets is possible. All flanged valves shown in horizontal lines with the valve stem in a horizontal position shall be positioned so the valve stem is inclined one bolt hole above the horizontal position.

2. Screw pattern valves placed in horizontal lines shall be installed with their valve stems at an angle of a minimum of 30 degrees above the horizontal position.

3. All valves must be true and straight at the time the system is tested and inspected for final acceptance.

4. Valves shall be installed as nearly as possible to the locations indicated in the Drawings. Any change in valve location must be so indicated on the Record As-Built Drawings.

5. All valves must be of threaded or flanged type. No solder connected or grooved fitting valves shall be used on this Project.

6. Equipment, valves, expansion joints, relief devices, strainers, etc., must be removed or isolated during the test if the pressure/force ratings of the devices are not as high as that specified for the test. Piping shall be drained and protected any time ambient temperature is below freezing.

7. Where leaks occur, the pipe shall be repaired and the tests repeated. No leaks shall be corrected by peening. Defective piping and joints shall be removed and replaced.

8. All threaded valves installed in copper piping shall be provided with copper or bronze male adapters on each side of valves. Sweat solder adapters to pipe before installing valves.

9. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with architectural drawings.

10. Install valves with stems upright or horizontal, not inverted.

11. All manually operated shutoff valves located 8 feet (bottom of pipe) or higher above finished floor or stationary platform in mechanical rooms, accessible pipe chases or as noted on Project Drawings shall be chain wheel operated. Chains shall be installed and secured to allow clear passage at walk through areas.

3.03 TESTING

A. All welds are subject to inspection, visual and/or x-ray, for compliance with Specifications. The Contractor shall be responsible for all labor, material and travel expenses involved in the re-inspection and re-testing of any welds found to be unacceptable. In addition, the Contractor shall be responsible for the costs involved in any and all additional testing required or recommended by ASME/ANSI Standards B31.9 due to the discovery of poor, unacceptable or rejected welds.

B. Welds lacking penetration, containing excessive porosity or cracks, or are found to be unacceptable for any reason, must be removed and replaced with an original quality weld as specified herein. All qualifying tests, welding and stress relieving procedures shall, moreover, be in accordance with Standard Qualification for Welding Procedures, Welders and Welding Operators,, Appendix A, Section 6 of the Code, current edition.

C. System Pressure Tests:

Line	Testing Medium	Testing Pressure (psig)	Time (hours)
Chilled Water and Condenser Water	Water	1-1/2 times working pressure, minimum 125	24
Heating Water and Generator Cooling Water	Water	1-1/2 times working pressure, minimum 125	24

1. Refer to the Drawings for system design pressure

3.04 HOT TAP PROCEDURE

A. Contractor shall provide the Owner's representative drawings, with the location of all hot taps shown, 10 days prior to scheduled start of work. Contractor shall also clearly identify all locations in the field.

B. Upon receipt of drawings, the Owner will field verify abatement requirements. The Owner shall also identify and coordinate the impact of potential system shut downs and Owner requirements and will issue a Notice to Proceed.

C. Upon Owner's issuance of a Notice to Proceed the Contractor shall perform the following hot tap procedures:

1. Preparation:

a. Remove insulation at identified and approved hot tap locations and save for reinstallation as noted below.

b. Ultra-sound pipe at each weld location to verify pipe thickness. If pipe fails to pass ultra-sound, follow procedure outlined in Paragraph A to establish new tap location.

c. Temporarily reinstall pipe insulation upon completion of ultra-sound to prevent condensation.

d. Repeat above listed steps on all approved hot tap locations.

2. Installation

a. Remove insulation as required for installation of scheduled hot tap.

b. Weld saddle sleeve to pipe.

c. Welding Materials and Procedures: Conform to Chapter V, ANSI/ASME SEC B31.9 and applicable state labor regulations.

d. Welders Certification: In accordance with ANSI/AWS D10.12.

e. Install new valve on saddle sleeve.

f. Install blind flange on valve to prevent accidental opening.

g. Pressure test valve/seating to one and a half (1-1/2) times design operating pressure for 24 hours. Owner's representative shall witness this test.

h. Upon passing pressure test and prior to hot tapping pipe:

1) Verify that Owner has staff ready to perform emergency shut-off procedures.

2) Verify emergency patch is on location and sized to match pipe being tapped.

3) Verify cleaning company is on call with portable shop vacuum(s).

i. Hot tap pipe, remove plug and wire to valve handle.

j. Clean all strainers in pipes affected by hot tape made that day.

k. Re-insulate pipe.

l. Repeat above listed steps for all remaining taps.

D. Unless approved by Owner, all hot taps in horizontal lines shall be made at or above center line of pipe.

3.05 TRAINING

A. Victaulic Company shall provide on-site training for Contractor's field personnel in the use of grooving tools, application of groove, and installation of grooved end couplings. The manufacturer's representative shall periodically visit the jobsite and provide the Contractor information concerning the best recommended practices in grooved product installation. A distributor's sales representative is not considered qualified to conduct the training or jobsite visit(s).

B. Installers of Viega or Nibco press fittings shall have been trained by a factory representative in the proper techniques for installation and crimping to assure leak-proof system sealing. It is the contactor's responsibility to show proof of such training to the Design Professional upon request.

3.06 APPLICATION

A. Install valves and unions at equipment connections. Install unions on equipment side of valves. Provide dielectric isolation only where non-ferrous components connect to ferrous components.

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

C. Install ball valves in piping 3 inches and smaller and butterfly valves in piping 4 inches and larger for shut-off and to isolate equipment, parts of systems, or vertical risers.

D. Install ball valves in piping 2 inches and smaller and butterfly valves in piping 2-1/2 inches and larger for throttling, bypass or manual flow control services. Under this application, throttling valves are not to be used for shutoff, and additional valves shall be installed for application.

E. Use plug valves for throttling service where indicated on Drawings.

F. Provide gate or ball drain valves at main shutoff valves, low points of piping, bases of vertical risers and at equipment. Pipe to nearest drain.

3.07 FLUSHING AND CLEANING OF PIPING SYSTEMS

A. Building HVAC Piping Systems:

1. Clean piping thoroughly. Purge pipe of construction debris and contamination before placing the piping systems in service. Provide whatever temporary connections are required for cleaning, purging and circulating fluids through the piping system.

2. On completely new piping system installations, the Contractor shall use temporary strainers and temporary pumps that can create fluid velocities up to 10 ft/sec if necessary to flush and clean the piping systems. Do not use Owner's permanent strainers to trap debris during pipe flushing operations. Fit the temporary construction strainers with a line size blow-off valve.

3. When constructing minor piping modifications or additions verify with Owner if the Owner's pumps and strainers can be used for flushing and chemical cleaning operations. When the flushing and cleaning operations are complete, the Contractor shall insure the strainer baskets and screens installed in the piping systems permanent strainers replaced with clean elements. Keep temporary strainers in service until the equipment has been tested, then replace straining element with a new strainer and clean and deliver the old straining elements to Owner. Fit the Owner's strainers with a line size blow-off valve.

4. Install bypass piping or hoses at the supply and return piping connections at heat exchangers, chillers, cooling towers, pumps and cooling coils, etc. to prevent debris from being caught or causing damage to equipment which will be connected to the piping system.

5. Circulate a chemical cleaner in chilled and heating water as well as condenser and generator cooling piping systems to remove mill scale, grease, oil and silt. Circulate GE-Betz Entec 323 detergent with GE-Betz Entec 234 anti-foam compound. Circulate to 48 hours, flush system and replace with clean water. Dispose of chemical solution in accordance with local codes. The chilled and heating water system should then be treated with GE-Betz Entec 338, nitride borate, 350 ppm as nitride with MBP inhibitor. When the chemical cleaning is complete, remove, clean and reinstall all permanent

screens. Contractor shall notify Owner so that the re-installation of clean strainer screens may be witnessed.

3.08 WELDING

A. Scope: This article applies to welded chilled and heating water piping fittings and other appurtenances.

1. Piping and fittings shall be welded and fabricated in accordance with the latest edition of ASME/ANSI the latest editions of Standards B31.9 for all systems. Machine beveling in shop is preferred. Field beveling may be done by flame cutting to recognized standards.

2. Ensure complete penetration of deposited material with base metal.

a. Contractor shall provide filler metal suitable for use with base metal. Contractor shall keep inside of fittings free from globules of weld metal.

b. All welded pipe joints shall be made by the fusion welding process, employing a metallic arc or gas welding process.

c. All pipe shall have the ends beveled 37-1/2 degrees and all joints shall be aligned true before welding.

d. Except as specified otherwise, all changes in direction, intersection of lines, reduction in pipe size and the like shall be made with factory-fabricated welding fittings. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction is not permitted.

3. Align piping and equipment so that no part is offset more than 1/16-inch. Set all fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.

4. No weld shall project into the pipe so as to restrict it. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.

5. Remove all split, bent, flattened or otherwise damaged piping from the Project Site.

6. Remove dirt, scale and other foreign matter from the inside of piping, by swabbing or flushing, prior to the connection of other piping sections, fittings, valves or equipment.

7. Schedule 40 pipe shall not be welded with less than three (3) passes including one stringer/root, one filter and one lacer. Schedule 80 pipe shall be welded with not less than four (4) passes including one stringer/root, two filler and one lacer. In all cases, however, the weld must be filled before the cap weld is added.

END OF SECTION

HYDRONIC SPECIALTIES

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. 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 air vents, pressure gauges, thermometers, strainers, air separators, expansion tanks, relief valves, water flow measuring and balancing systems, and water flow integrating meters as indicated by the Contract Documents with supplementary items necessary for their proper installation and operation.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specified 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. ANSI/ASME Boilers and Pressure Vessel Code, Section VIII, Division 1 Design and Fabrication of Pressure Vessels.

1.04 QUALITY ASSURANCE

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

1.05 SUBMITTALS

A. Product Data:

1. Submit shop drawings and product data, including component sizes, rough-in requirements, service sizes, and finishes.

2. Submit manufacturer’s installation instructions.

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. Pressure Independent Control Valves: Danfoss

B. Strainers: Keckley, Mueller, Muessco, Strainers, Inc., Grinnell, Nibco

2.03 EXPANSION TANKS

A. Tank Construction: Closed, welded steel, tested and stamped in accordance with Section VIII, Division 1, of ANSI/ASME Boiler and Pressure Vessel Code, 125 psig rating. Clean, prime coat, and supply with steel support saddles. Supply with renewable heavy duty butyl rubber bladder. Construct tank with tappings for installation of accessories.

B. Provide with quick connect air charging valve connection (standard tire valve) tank drain.

C. Provide automatic cold water fill assembly complete with pressure relief valve, pressure reducing valve and valved bypass.

D. Set expansion tank pressure relief valve and pressure reducing valve at pressures indicated on Drawings.

E. Tank dimensions and/or capacities are as scheduled on Drawings.

2.04 PRESSURE INDEPENDENT TEMPERATURE CONTROL VALVES

A. Basis of specification is the Danfoss AB-QM. Any alternates submitted must demonstrate compliance with the specifications as written. All valves and actuators supplied under this specification must be from a single manufacturer. Installation procedures, commissioning, functionality, and flow performance must remain identical throughout all sizes supplied and installed.

B. Warranty: Valve and actuator shall be warranted by the manufacturer for 5 years from the date of purchase.

C. Temperature control valve:

1. Balancing valves, auto flow limiters, and associated balancing **shall not be used** where pressure independent temperature control valves are installed.

2. The valve will be pressure independent, and control pressure across the control valve orifice. Valve shall require no more than 5 PSIG to operate pressure independent.

3. The control valve must have the ability to limit flow to the maximum design flow specific for each coil. Flow shall not vary more than +/-5% through the entire operating pressure range of 5 to 60 psi

4. Provide **user adjustable** maximum flow within valve control range; Adjustment method shall indicate percentage of valve flow range and utilize spring locked method of adjustment.

5. Controlling the regulation of pressure shall be mechanical only (no metering) utilizing an integrated EPDM diaphragm design, stainless steel spring, and pressure control disc and shall require no internal maintenance or replaceable cartridges.

6. Regulate internal control valve differential pressure to provide 100% control valve authority at all positions of the valve, and maintain proportional / linear flow coil characteristics and maintain a linear flow characteristic throughout the operating range of 5 to 60 psi

7. Be offered in sizes ranging ½” to 10”, providing a flow rate range of 0 to 1946 gpm

8. Be available in union tailpiece kits for sizes ranging from ½” to 2”; and flanges for sizes ranging from 2-1/2" to 10'; if ISO gaskets are required the manufacturer will supply an adequate quantity for the project.

9. Provide back seated globe design of **brass or ductile iron construction**. Valve shall provide Class 4 shut-off on all sizes.

10. The manufacturer shall provide 3rd party operation and flow documentation to certify the characteristics of the valve.
11. Pressure independent control valves shall be installed by the mechanical (piping) contractor and supplied by the temperature control contractor
12. The valves maximum coil flow setting shall be the **responsibility of the mechanical contractor** and must be completed prior to the installation of the actuator by the temperature control contractor

D. Temperature control valve actuator:

1. Electronic Actuator shall be self-learning, and have the ability to self-commission to match the set point flows of the valves.
2. Be an actuator from the same manufacturer as the valve.
3. The actuator shall provide full stroke at each flow setting of the valve.
4. Actuator mounting shall be integral with the valve body on sizes thru 1¼".
5. Have the ability to supply on/off, floating, proportional, safety spring and/or feed-back options.
6. Be available in a thermostatic, thermal or electronic version.
7. Provide a visible position indication.
8. Operate the valve through its full range and have a minimum close off pressure of 90psi.
9. Have an option of selectable system characteristic (Log or Lin) for motorized actuators.
10. The actuator shall be selected, supplied, installed and commissioned by the temperature control contractor.

2.05 FLEXIBLE HOSE

A. Furnish and install Amber-Booth Metalflex flexible hose connectors or accepted substitution. Hose and braid shall be bronze and male fittings shall be steel.

B. Install connector in a straight line without offset. Piping shall be supported so that connector does not carry pipe load.

C. Install in line without twisting connector.

D. For pipe sizes ½ inch to 2 inches only. Model BR-SM.

2.06 STRAINERS

A. 2 inches and smaller: Screwed brass or bronze body, Y pattern with 20 mesh stainless steel perforated screen. 150 psi or 300 psi pressure rating to match system pressure.

PART 3 – EXECUTION

3.01 PREPARATION

A. Flush and clean expansion tanks prior to delivery to the Project Site, and keep sealed during construction.

3.02 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 manual air vents at entrance to all heating hot water coils, with a "cane" shaped discharge tube, positioned to permit draining to a portable receptacle.

D. Provide valved drain and hose connection on strainer blow down connection.

E. Select system relief valve capacity so that capacity is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

F. Pipe relief valve outlet to nearest floor drain.

G. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

H. Equip stem gauges with coil siphons.

END OF SECTION

HVAC DUCTWORK

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. 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 ductwork, flexible duct, hangers, supports, sleeves, flashings, vent flues, and all necessary accessories as indicated in the Contract Documents. Provide any supplementary items necessary for proper installation

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specified 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. ASHRAE – Handbook of Fundamentals; Duct Design.
2. ASHRAE – Handbook of HVAC Systems and Equipment; Duct Construction.
3. International Energy Conservation Code – 2015 Edition
4. ASTM A 90 – Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.
5. ASTM E 96 – Standard Test Methods for Water Vapor Transmission of Materials.
6. ASTM A 167 – Stainless and Heat Resisting Chromium-Nickel Steel Plate, Sheet and Strip.
7. ASTM A525 – General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip Process.
8. ASTM A 527 – Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.
9. ASTM B209 – Aluminum and Aluminum Alloy Sheet and Plate.
10. NFPA 90A – Installation of Air Conditioning and Ventilating Systems.
11. NFPA 90B – Installation of Warm Air Heating and Air Conditioning Systems.
12. NFPA 96 – Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooling Equipment.

13. NFPA 45 – Laboratory Ventilating Systems and Hood Requirements.
14. SMACNA – HVAC Duct Construction Standards (Latest Edition).
15. SMACNA – Rectangular Industrial Duct Construction Standards (Latest Edition).
16. SMACNA – Round Industrial Duct Construction Standards (Latest Edition).
17. SMACNA – HVAC Air Duct Leakage Test Manual (Latest Edition).
18. UL 181 – Factory-Made Air Ducts and Connectors.
19. Engineering Design Manual for Air Handling Systems United McGill Corporation (UMC).
20. Assembly and Installation of Spiral Ducts and Fittings, UMC
21. Engineering Report No. 132 (Spacing of Duct Hangers), UMC
22. AWSD1.1 American Welding Society Structural Welding Code.

1.04 DEFINITIONS

1. 2 inch W.G. Pressure Class: Ductwork systems up to 2 inch w.g. positive or negative static pressure with velocities less than or equal to 1500 fpm.
2. 3 inch W.G. Pressure Class: Ductwork systems over 2 inch w.g. and up to 3 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
3. 4 inch W.G. Pressure Class: Ductwork systems over 3 inch w.g. and up to 4 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
4. 6 inch W.G. Pressure Class: Ductwork systems over 4 inch w.g. and up to 6 inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
5. 10 inch W.G. Pressure Class: Ductwork systems over 6 inch w.g. and up to 10 inch w.g. positive or negative static pressure with velocities greater than 2500 fpm.

1.05 SUBMITTALS

A. Product Data:

1. Provide the following information for each sheet metal system furnished on the Project.
    a. System name and type.
    b. Duct system design pressure.
    c. Duct material.
    d. Duct gauge.
    e. Transverse joint methods.
    f. Longitudinal seam type.

g. Sealant type.

h. SMACNA rectangular reinforcement type.

i. SMACNA intermediate reinforcement type.

j. SMACNA transverse reinforcement type.

B. Record Documents:

1. Submit Shop Drawings on all items of ductwork, plenums, and casings including construction details and accessories specified herein in accordance with Division 01. Ductwork construction details and materials used for duct sealant, flexible connections, etc., shall be submitted and approved prior to the fabrication of any ductwork.

2. Draw ductwork Shop Drawings on minimum ¼ inch equal to one foot scale building floor plans and shall indicate duct sizes, material, insulation type, locations of transverse joints, fittings, ductwork, bottom elevation, offsets, ductwork specialties, fire and fire/smoke dampers, and other information required for coordination with other trades. Clearly designate fire and fire/smoke partitions on the Shop Drawings. Detail Drawings for Mechanical Rooms and air handling unit locations shall be submitted at a minimum scale of ¼ inch equal to one foot.

3. Coordinate with other trades and building construction prior to submitting Shop Drawings for review. Indicate location of all supply, return, exhaust and light fixtures from approved reflected ceiling plans on Shop Drawings.

1.06 DELIVERY AND STORAGE

A. Deliver products to the Project Site and store and protect products under provisions of Division 01 and Section 23 05 00.

B. Protect materials from rust both before and after installation.

1.07 WARRANTY

A. All ductwork shown on the Drawings, specified or required for the air conditioning and ventilating systems shall be constructed and erected in a first class workmanlike manner.

B. The Work shall be guaranteed for a period of one (1) year from Project Substantial Completion date 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 Owner at Contractor's expense.

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 APPLICATION

A. Ductwork systems shall be constructed in accordance with the following materials as a minimum standard. Refer to Drawings for any deviation from this Table:

AIR SYSTEM	MATERIAL	MINIMUM PRESSURE CLASSIFICATION(1)
Supply and Return Systems:		
Terminal Unit Connection	Metal Flexible Duct	As Specified
Terminal Units to Supply Air Device	Galvanized Steel(2)	2.0" w.g.
Return Air Device to Return Distribution	Galvanized Steel(2)	-2.0" w.g.
Return Air Distribution	Galvanized Steel	-4.0" w.g.
Exhaust Systems:		
Exhaust Air Device to Exhaust Distribution	Galvanized Steel(2)	-2.0" w.g.
Exhaust Air Distribution	Galvanized Steel	-4.0" w.g.
General Exhaust Vertical Riser to Fan	Galvanized Steel	-4.0" w.g.

B. Notes to Table:

1. Positive pressure unless noted otherwise in Table.

2. Air device connections may be made with insulated flexible duct as specified herein.

3. Applies to exhaust system for general laboratory exhaust, fume hoods, and bio-safety cabinets. Refer to Drawings for construction of additional exhaust systems.

2.03 DUCTWORK MATERIAL AND CONSTRUCTION

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 on Drawings. All air distribution ductwork shall be fabricated, erected, supported, etc., in accordance with all applicable standards of SMACNA where such standards do not conflict with NFPA 90A and where class of construction equals or exceeds that noted herein.

B. Ductwork shall be constructed of G-90 coated galvanized steel of ASTM A653 and A924 Standards.

C. Minimum gauge of round, oval or rectangular ductwork shall be 26 gauge per SMACNA Standards.

D. All duct sizes shown on the Drawings are clear inside dimensions. Allowance shall be made for internal lining, where specified, to provide the required free area.

E. 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.

F. Except for specific duct applications specified herein, all sheet metal shall be constructed from prime galvanized steel sheets and/or coils up to 60 inches in width. Each sheet shall be stenciled with manufacturer's name and gauge.

G. Sheet metal must conform to SMACNA sheet metal tolerances as outlined in SMACNA's "HVAC Duct Construction Standards".

H. Spin-in fittings shall be as specified under Section 23 33 00 – Ductwork Accessories.

I. Duct Sealing: All ductwork, regardless of system pressure classification, shall be sealed in accordance with Seal Class A, as referenced in SMACNA Standards. All transverse joints, longitudinal seams, and duct wall penetrations shall be sealed.

1. DO NOT THIN. Do not apply when rain or freezing temperatures will occur within 36 hours. All seams and joints in shop and field fabricated ductwork shall be sealed by Duct sealant which shall be applied per manufacturer's instructions. Minimum drying time shall be allowed per manufacturer's instructions. Additional time for drying shall be allowed in climates where temperature and humidity may affect the curing of the sealant. Sealant shall be allowed to completely dry and cure before air is circulated through the ductwork.

2. Sealant shall be water based latex UL 181B-M sealant with flame spread of 0 and smoke developed of 0. Sealants shall be similar to Hard Cast Versa-Grip 181, Ductmate Pro Seal or Design Polymerics DP 1010.

3. Sealer shall be rated by the manufacturer and shall be suitable for use at the system pressure classification of applicable ductwork.

4. Except as noted, oil or solvent-based sealants are specifically prohibited.

5. For exterior applications, "Uni-Weather" (United McGill Corporation) solvent-based sealant shall be used.

6. Duct testing; All ducts should be tested in accordance with the requirements of IECC 2015, paragraph R403.3.3 or R403.3.4., except that all ducts shall be tested, regardless of their location within or external to the building envelope.

2.04 RECTANGULAR AND ROUND DUCTWORK

A. Metal gauges listed in SMACNA HVAC Duct Construction Standards, Metal and Flexible Duct, are the minimum gauges which shall be used. Select metal gauge heavy enough to withstand the physical abuse of the installation. In no case shall ductwork be less than 26 gauge per SMACNA Standards. Transverse bead all flat surfaces which are more than 12" wide. Transverse beading shall be on 12" centers and shall be a minimum of 1/8" deep at the center of the bead and 3/8 wide at the base of the bead. **Do not cross-break negative pressure ductwork.**

B. All longitudinal seams for pressures up to 2.0" w.g. rectangular duct shall be selected for the specified material and pressure classification. Seams shall be as referenced in SMACNA Standards.

C. All longitudinal seams for ductwork pressures in excess of 2.0" w.g. shall be "Pittsburgh Lock" only.

D. All transverse joints and intermediate reinforcement shall be as shown in SMACNA Tables 1-4 through 1-9, and Figure 1-4 with Drive Slip connections (reinforced or un-reinforced as required) on the short sides and hemmed "S" slip connections (reinforced or un-reinforced as required) on the long sides. "S" and drive connectors are acceptable for use on ducts with pressure classification of +/- 1" w.g. (maximum).

E. All transverse joints and intermediate reinforcement on rectangular duct shall be as shown in SMACNA Standards. Transverse joints shall be selected consistent with the specified pressure classification, material and other provisions for proper assembly of ductwork.

F. Spiral round duct and fittings shall be as manufactured by United McGill Sheet Metal Company or approved equivalent. All fittings shall be factory fabricated, machine formed and welded from galvanized sheet metal.

G. Joints in spiral duct and fittings shall be assembled, suspended, sealed and taped per manufacturer's published assembly and installation instructions.

H. Contractor may use DUCTMATE, Elgen or Ward Industries coupling systems, as an option, on rectangular ductwork. The DUCTMATE, Elgen or Ward Industries systems shall be installed in strict accordance with manufacturer's recommendations.

2.05 CONICAL BELLMOUTH FITTING AND TAPS

A. Conical bell mouth fittings shall be made from 26-gauge G-90 coated galvanized steel. Two piece construction with a minimum overall length of 6 inches and factory sealed for high-pressure requirements. Average off loss coefficient for sizes 6, 8 and 10 shall be less than 0.055. Branch taps, including taps to terminal units, may also be 45° entry expanded taps. Such taps shall be constructed and installed in accordance with Fig. 2-6 of the SMACNA Manual.

B. Provide each fitting with minimum 24 gauge damper plate with locking quadrant operator and sealed end bearings. Damper blade shall be securely attached to shaft to prevent damper from rotating around shaft. Shaft shall be extended to clear insulation and allow normal operation without damaging the insulation.

C. Provide a flange and gasket with adhesive peel-back paper for ease of application. The fittings shall be further secured by sheet metal screws spaced evenly at no more than 4 inches on center with a minimum of four (4) screws per fittings.

D. Conical bell mouth fittings shall be Series 3000G as manufactured by Flexmaster U.S.A., Inc. or Buckley Air Products, Inc., "AIR-TITE".

2.06 CASINGS AND PLENUMS – 2 INCH W.G. PRESSURE CLASS

A. All 2 inch w.g. pressure class casings and plenums for mixed air plenums shall be constructed in accordance with SMACNA Standards. Where plenums are connected to louvers, the Plenum bottom shall be watertight, sloped and sealed to drain water to the outside face of the building through the face of the louver.

B. All casings shall enclose the filter and automatic dampers as shown on the Drawings. Casings shall be fabricated of galvanized sheet metal erected with three-foot center maximum standing seams reinforced with ¼-inch bars. The casing shall be stiffened on three-foot centers maximum with angle irons tack welded in place.

C. All openings to the casing shall be properly sealed to prevent any air leakage. Access doors shall be installed as indicated on the Drawings and shall be air tight, double skin insulated construction with frames welded in place. Doors shall be rubber gasketed with #390 Ventlok gasketing and equipped with fasteners equal to Ventlok #310 latches and #370 hinges that can be operated from both the inside and the outside.

D. Casings shall be anchored by the use of angle irons sealed and bolted to the curb and floor of the apparatus casing. Casings shall be tested and provided tight at a pressure of three inches water column.

E. Insulate per Section 23 07 13.

2.07 CASINGS AND PLENUMS – 6 INCH W.G. PRESSURE CLASS

A. Shall enclose filters and automatic dampers at air handling unit systems. Casings shall be constructed of cellular, standing seam panels with 3 inch deep reinforced "hat" sections as manufactured by metal deck manufacturers and as described in SMACNA Standards.

B. All openings to the casing shall be properly sealed to prevent air leakage. Install access doors for easy access to equipment. Access doors shall be air tight, double skin insulated construction with frames welded in place. Doors shall be rubber gasketed with #390 Ventlok gasketing and equipped with fasteners equal to Ventlok #310 latches and #370 hinges that can be operated from both the inside and the outside. Hinges shall be equivalent to Ventlok #370.

C. Anchor casing by the use of galvanized angle irons sealed and bolted to the curb and floor of the apparatus casing as indicated in SMACNA Standards.

D. Provide sufficient access openings to allow access for maintenance of all parts of the apparatus. Access door size shall be as large as feasible for the duty required.

E. Insulate per Section 23 07 13.

2.08 ELBOWS RECTANGULAR DUCTS

A. Construct elbows as follows in order of preference:

1. Rectangular, single thickness vaned elbows.

2. Long radius, un-vaned elbows.

3. Short radius, single thickness vaned elbows.

B. Long radius elbows shall have a centerline radius of not less than one and one-half (1-1/2) times the duct width. Short radius elbows shall have a centerline radius of not less than one times the duct width.

C. Contractor shall have the option to substitute short radius vaned elbows, but shall request the substitutions at the time of submittal of Product Data.

D. Provide turning vanes in all rectangular elbows and offsets.

E. 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. Submit Shop Drawings on factory fabricated and job fabricated turning vanes.

F. 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 vane.

G. In 90-degree turns that are over 12 inches wide in the plane of the turn, provide and install double thickness vanes on integral side rails. For ducts less than 12 inches in width, use single thickness vanes. The installation of the turning vanes shall be as described for single thickness vanes. On other types of turns or elbows, single thickness trailing edge vanes shall be used.

2.09 FLEXIBLE DUCT

A. Flexible duct shall be used where flexible duct connections are shown on the Drawings to air distribution devices and terminal units and as scheduled under "Ductwork System Applications".

B. Acoustical Flexible Duct to Diffusers, Grilles, and Terminal Units.

1. Maximum length 6'-0" (six feet), installed with no more than 90 degrees of bend. Where longer duct runs or more bends are necessary, provide rigid round ductwork.

2. Acoustical flexible duct shall be manufactured with an acoustically rated polyethylene fabric or CPE inner film as the core fabric, mechanically locked by corrosion-resistant galvanized steel helix.

3. Core shall be factory pre-insulated with a total thermal performance of R3.5 or greater. Outer jacket shall be a fire-retardant polyethylene vapor barrier jacket with a perm rating not greater than 0.10 per ASTM E96, Procedure A.

4. Duct shall be rated for a minimum positive working pressure of 6 inches w.g. and a negative working pressure of 4 inches w.g. minimum.

5. Temperature range shall be -20ºF to 250ºF.

6. Duct must comply with the latest NFPA Bulletin 90A and be listed and labeled by Underwriters Laboratories, Inc. as Class I Air Duct, Standard 181, and meet GSA, FHA and other U.S. Government standards; flame spread less than 25; smoke developed less than 50.

7. Acoustical flexible duct shall be similar to Peppertree "Commercial EH" Type "HM", Flexmaster Type 1M, Atco Rubber Products "039", or Thermaflex M-KE for construction and acoustical performance standards.

C. Metal Flexible Duct:

1. Shall be used for terminal unit connections to sheet metal ductwork and air distribution devices in non-accessible ceiling areas, or where shown on the Drawings.

2. Maximum length 5'-0" (five feet). Where longer duct runs or direction changes are necessary, provide rigid round ductwork.

3. Duct shall be constructed of 0.005 inch thick 3003-H14 aluminum alloy in accordance with ASTM B209. Duct shall be spiral wound into a tube and spiral corrugated to provide strength and flexibility.

4. Core shall be either factory pre-insulated or field insulated per the requirements of Section 23 07 13, with a total thermal performance of R-6 or greater. The duct shall be rated for a minimum positive and negative working pressure of 10 inch w.g.(through 16" diameter).

5. Temperature range shall be -40ºF. to 250ºF.

6. Duct must comply with the latest NFPA Bulletin 90A and be listed and labeled by Underwriters Laboratories, Inc. as Class I Air Duct, Standard 181, and meet GSA, FHA and other U.S. Government standards; flame spread less than 25; smoke developed less than 50.

7. For health care occupancies, provide Medical Grade metal flexible duct similar to Flexmaster Type MGA-TL-M.

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. All exhaust ductwork from Airborne Infectious Isolation Rooms shall be marked **"Caution; AIIR Exhaust" every 20 feet or change of direction.** Marking shall be by painted stencil or commercially available plastic labels affixed to the duct or insulation surface.

D. Cleanliness:

1. Before installing ductwork, wipe ductwork to a visibly clean condition.

2. During construction, provide temporary closures of metal or taped polyethylene on open ductwork and duct taps to prevent construction dust or contaminants from entering ductwork system. Seal ends of ductwork prior to installation to keep ductwork interior clean. Remove closures only for installation of the next duct section.

3. For ductwork supplying Clean Rooms, Operating Rooms and/or other Patient Care areas, sanitize ductwork with a biocidal agent EPA approved for HVAC systems immediately prior to installing and sealing ductwork.

4. During duration of construction, maintain the integrity of all temporary closures until air systems are activated.

E. Provide openings in ductwork where required to accommodate sensors, controllers, and other devices. Furnish and install access doors at all fire dampers, smoke dampers, and combination fire/smoke dampers.

F. Provide pitot 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. Sleeve of pitot tube opening shall be no more than one inch long. Opening shall be one inch wide to accept pitot tube.

G. Install all ducts tight to structure unless otherwise noted. The Mechanical Contractor shall coordinate with all other trades and the General Contractor prior to the construction or installation of the duct system. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

H. Install duct type smoke detectors furnished under Section 28 30 00. Furnish and install access doors at each sampling tube assembly. Coordinate location of detectors and installation requirements with the Electrical Subcontractor.

I. Slope underground ducts to plenums or low pump out points at 1:500. Provide access doors for inspection.

J. Coat buried, metal ductwork without factory jacket with one coat and seams and joints with additional coat of asphalt base protective coating.

K. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

L. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Use stainless steel for ductwork exposed to view and stainless steel for ducts where concealed.

M. All visible welds in ductwork between bio-safety cabinets, canopy hoods and fume hoods and the ceiling shall be ground and polished.

N. Slope duct toward grilles for moisture-laden ducts. Provide drain and trap at elbow of main moisture exhaust duct system.

O. Flexible Duct:

1. The terminal ends of the duct core shall be secured by compression coupling, nylon tie strap or stainless steel worm gear type clamp.

2. Fittings on terminal units and on sheet metal duct shall have flexible duct core slipped over duct and coupling or clamp tightened, then connection sealed with sealant insulation of flexible duct shall be slipped over connection to point where insulation abuts terminal unit or insulation on duct.

3. These insulation connections shall be sealed by applying UL 181 A-P/B-FX approved aluminum foil tape with pressure sensitive adhesive to bridge the two surfaces and result in a complete vapor barrier.

P. Support flexible ducts as per SMACNA standards to prevent sags, kinks and having 90 degree turns. Maximum distance between supports shall be 5'-0". Minimum width of support shall be 1' and support shall not reduce the inner diameter of the duct when at rest.

Q. Hangers and Supports:

1. All ductwork supports shall be in accordance with Table 4-1 (rectangular duct) and Table 4-2 (round duct) of the SMACNA Standards, with all supports directly anchored to the building structure.

2. Rectangular duct shall have at least one pair of supports on minimum 8'-0" (eight feet) centers. All horizontal round and flat oval ducts shall have duct hangers spaced 10'-0" (ten feet) maximum.

3. Lower attachment of hanger to duct shall be in accordance with Table 4-4 of the SMACNA Standards.

4. Vertical ducts shall be supported where they pass through the floor lines with 1-1/2 inch x 1-1/2 inch x ¼ inch angles for duct widths up to 60 inches. Above 60 inches in width, the angles must be increased in strength and sized on an individual basis considering space requirements.

5. Hanger straps on duct widths 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 sides.

6. Hanger straps on duct widths over 60 inches shall be bolted to duct reinforcing with 3/8 inch bolts minimum.

3.02 DUCTWORK SYSTEM CLEANING

A. Upon request of the Design Professional at any time prior to project completion, a random inspection of the internal cleanliness of the duct system may be performed.

B. If the results of the random inspection indicate a "dirty" condition inside the duct system or if the system has been operated without all scheduled filters in place, or if the integrity of temporary closures has been compromised, Contractor shall have ductwork cleaned according to the applicable National Air Duct Cleaners Association (NADCA) Standards, by an independent, third-party Certified Regular Member of the NADCA, and obtain a written report certifying the results of the aforementioned cleaning.

1. For ductwork supplying Clean Rooms or patient care areas, also sanitize the ductwork interior per NADCA standards with a biocidal agent specifically approved by the EPA for use in HVAC systems.

C. Before turning the installation over to the Owner, Contractor shall certify that the air handling systems have only been operated with scheduled filters in place. Otherwise, Contractor shall present evidence that the ductwork was cleaned as required above.

3.03 TESTING

1. All medium and high pressure duct systems (positive or negative) shall be pressure tested according to SMACNA test procedures (HVAC Air Duct Leakage Test Manual).

2. Design pressure for testing ductwork shall be determined from the maximum pressure generated by the fan at the nominal motor horsepower selected.

3. Total allowable leakage shall not exceed 1 percent of the total system design airflow rate.

4. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.

5. Leaks identified during leakage testing shall be repaired by:

   a. Complete removal of the sealing materials.

   b. Thorough cleaning of the joint surfaces.

   c. Installation of multiple layers of sealing materials.

6. The entire ductwork system shall be tested, excluding connections upstream of the terminal units (i.e. ductwork shall be capped immediately prior to the terminal units, and tested as described above).

7. After testing has proven that ductwork is installed and performs as specified, the terminal units shall be connected to ductwork and connections sealed with extra care. Contractor shall inform the Owner when joints may be visually inspected for voids, splits, or improper sealing of the joints. If any leakage exists in the terminal unit connections/joints after the systems have been put into service, leaks shall be repaired as specified for other leaks.

A. All low-pressure duct systems (positive or negative) shall be inspected for visible and audible signs of leakage.

1. Leaks identified by inspection shall be repaired by:

   a. Complete removal of the sealing materials.

   b. Thorough cleaning of the joint surfaces.

   c. Installation of multiple layers of sealing materials.

2. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.

B. Ductwork leakage testing and/or inspection shall be performed prior to installation of external ductwork insulation.

END OF SECTION

DUCTWORK ACCESSORIES

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. 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 ductwork, accessories indicated in the Contract Documents with supplementary items necessary for proper installation.

1. Airflow control dampers and spin-in fittings.
2. Fire dampers, smoke dampers, and combination fire and smoke dampers.
3. Flexible duct connections.
4. Duct access doors.
5. Screens.
6. Duct test holes.
7. Guy wire systems.

1.03 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specified 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. AMCA 500D – Laboratory Method of Testing Dampers for Rating.
2. AMCA 500L – Laboratory Method of Testing Louvers for Rating.
3. NFPA 90A – Installation of Air Conditioning and Ventilating Systems.
4. NFPA 101 – Life Safety Code.
5. SMACNA – HVAC Duct Construction Standards.
6. UL 33 – Heat Responsive links for Fire-Protection Service.

7. UL 555 – Standard for Fire Dampers.

8. UL 555C – Standard for Ceiling Dampers.

9. US 555S – Standard for Smoke Dampers.

1.04 SUBMITTALS

A. Product Data:

1. Provide product data for shop fabricated assemblies including, but not limited to volume control dampers, duct access doors, and duct test holes. Provide product data for hardware used.

B. Record Documents:

1. Fire Dampers: The damper manufacturer's literature submitted for approval prior to the installation shall include performance data developed from testing in accordance with AMCA 500D standards and shall show the pressure drops for all sizes of dampers required at anticipated air flow rates. Maximum pressure drop through open fire dampers shall not exceed 0.05-inch water gauge.

2. Combination Fire/Smoke Dampers: Assign identification numbers for each damper with corresponding number noted on Drawings. Provide air quantity, size, free area of damper, pressure drop and proposed velocity through each damper. Provide manufacturer's data of damper and its accessories or options.

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. Dampers:

1. Greenheck.

2. Louvers and Dampers, Inc.

3. Nailor Industries.

4. Pottorrf

5. Prefco.

6. Ruskin.

7. TAMCO

8. United Enertech

B. Regulators, Locking Quadrants:

1. Rossi HVAC Hardware

2. Young Regulator.

2.03 AIRFLOW CONTROL DAMPERS

A. Furnish and install dampers where shown on the Drawings and wherever necessary for complete control of airflow, including all supply, return, outside air, and exhaust branches, "division" in main supply, return and exhaust ducts, and each individual air supply outlet. Where access to dampers through permanent suspended ceiling (gypsum board) is necessary, the Contractor shall be responsible for the proper location of the access doors.

B. Dampers larger than three (3) square feet in area shall be controlled by a self-locking splitter damper assembly.

C. Volume damper 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.

D. Volume dampers and other manual dampers shall be carefully fitted, and shall be manually controlled by damper regulators as follows:

1. On exposed or accessible un-insulated ductwork, provide the "Everlock" damper handle by Rossi HVAC Hardware (no substitutions), with a 2" standoff bracket for external insulation. Provide the optional damper position indicator with the damper operator.

2. On exposed or accessible externally insulated ductwork the regulator rod shall be 3/8" square aluminum, designed to fit, full length, through a formed square channel in the damper blade, designed for use on duct with insulation thickness specified for duct, and shall have four (4) 3/16 inch holes provided to rivet or screw regulator to the duct surface. The flange that covers the raw edge of the insulation shall be high enough so that it slightly compresses the insulation and holds insulation in place. The handle shall be 3/8 inch above the flange, and shall easily turn without roughing up the insulation.

3. On concealed ductwork above inaccessible ceilings, the regulator shall be Young 270-301 flush mounted, remote regulator with flexible cable (length as required) with chrome plated exposed cover plates located as directed by the Design Professional.

E. Spin-in fittings may be used for duct taps to air devices and shall include dampers on all duct to air devices (diffusers and grilles) even though a volume damper is specified for the air device. Spin-in fittings shall be similar to Flexmaster FLD with "Everlock" damper handle and blade as specified above. Spin-in fittings shall be sealed at the duct tap with sealant as specified herein. Determine location of spin-in fittings after terminal units are hung or after location of light fixtures are confirmed to minimize flexible duct lengths and sharp bends.

2.04 FIRE DAMPERS

A. Each fire damper shall be constructed and tested in accordance with Underwriters Laboratories Safety Standard 555, latest edition. Dampers shall possess a 1-1/2 hour or 3 hour (as appropriate for the construction shown in the Architectural Drawings) protection rating, 160° F or 165° F fusible link, and shall bear a U.L. Label in accordance with Underwriter's Laboratories labeling procedures. Construct fire dampers such that damper frame material and curtain material are galvanized.

B. Fire dampers shall be curtain blade type and damper shall be constructed so that the blades are out of the air stream to provide 100 percent free area of duct in which the damper is housed.

C. Equip fire dampers for vertical or horizontal installation as required by location shown on Drawings. Install fire dampers in wall and floor openings utilizing steel sleeves, angles and other material and practices as required to provide an installation equivalent to that utilized by the manufacturer when the respective dampers were tested by Underwriter's Laboratories. Mounting angles shall be minimum 1-1/2 inch by 1-1/2 inch by 14 gauge and bolted, tack welded or screwed to the sleeve at maximum spacing of 12 inches and with a minimum of two connections at all sides. Mounting angles shall overlap at least equal to the duct gauge as defined by the appropriate SMACNA Duct Construction Standard, latest edition, and as described in NFPA 90A. The entire assembly, following installation, shall be capable of withstanding 6 inch water gauge static pressure.

D. All fire dampers shall be dynamic rated type.

E. Completely seal the damper assembly to the building components using manufacturer recommended material(s).

2.05 COMBINATION FIRE/SMOKE DAMPERS

A. Provide one damper motor for each 12 square feet of damper area.

B. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under UL Standard 555, Current Edition, and shall be further classified by Underwriter's Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. Damper manufacturer shall have tested and qualified with UL, a complete range of damper sizes covering all dampers required by this Specification. Testing and UL qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be no higher than Leakage Class 1 (4 CFM per square foot at one-inch water gauge pressure and 8 CFM per square foot at 4 inches water gauge pressure). Maximum air pressure drop through each combination fire/smoke damper shall not exceed 0.10 inch water gauge at the design air quantity. (Note that this may require a larger damper than the connected duct size). All ratings shall be dynamic.

C. Damper frame shall be minimum 20-gauge galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be integral high surface area non-electrolytic materials construction to incorporate a friction free frame blade lap seal, or molybdenum disulfide impregnated stainless steel or bronze iolite sleeve type turning in an extruded hole in the frame or an extruded frame raceway. Dampers may be either parallel or opposed blade type. Blades shall be constructed with a minimum of 14-gauge equivalent thickness. Blade edge seal material shall be able to withstand 450° F. Jamb seals shall be flexible stainless steel compression type or lap seal type.

D. In addition to the leakage ratings specified herein, combination fire/smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 350° F. Electric operators shall be installed by the damper manufacturer at the time of damper fabrication. Damper and operator shall be supplied as a single entity that meets all applicable UL555 and UL555S qualifications for both dampers and operators. Manufacturer shall provide a factory-assembled sleeve. Sleeve shall be minimum 20-gauge for dampers where neither width nor height exceeds 48 inches or 16-gauge where either dimension equals or exceeds 48 inches.

E. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions with pressures at least 4 inches water gauge in the closed position, and 2500 FPM air velocity in the open position.

F. Primary power for dampers shall be taken from the Equipment Branch of the Essential Electrical System. Provide the required control power transformer to reduce the primary voltage to 24 VAC. Coordinate the location of all powered dampers with the Division 26 contractor prior to installation to assure all devices are provided with the required power.

G. Each combination fire/smoke damper, except as noted hereinafter, shall be equipped with a UL Classified firestat/releasing device. The firestat/releasing device shall electrically (24 VAC) lock the damper in a closed position when the duct temperatures exceed 165°F and still allow the appropriate authority to operate the damper as may be required for smoke control functions. Damper must be operable while the temperature is above 350°F. Actuator/operator package shall include two damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One switch shall close when the damper is fully open, and the other switch shall close when the damper is fully closed. The firestat/releasing device and position indicator switches shall be capable of interfacing electrically with the smoke detectors, building fire alarm system, and remote indicating/control stations or building automation system (BAS).

H. Damper releasing device shall be mounted within the airstream. Device shall be activated and the damper shall close and lock when subjected to duct temperatures in excess of approximately 285°F.

I. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated on the Drawings, and shall be furnished and installed by the damper manufacturer as required by the U.L. rating mentioned above. Motors shall be electric to match the type of temperature control system specified elsewhere in this Specification. Furnish all relays, wiring, and other labor and material necessary to completely interconnect the smoke detector system.

J. Furnish each damper in a square or rectangular configuration. Furnish and install sleeves manufactured by the approved damper manufacturer for each damper. Construct sleeves with square or rectangular to square, rectangular round or oval adapters as required. Dampers shall be installed in the sleeves in accordance with manufacturer's U.L. installation instructions. The entire assembly, following installation, shall operate smoothly and be capable of withstanding 6 inch gauge static pressure.

K. All combination fire/smoke dampers shall be dynamic type.

L. Completely seal the damper assembly to the building components using manufacturer recommended material(s).

2.06 SMOKE DAMPERS

A. Provide one damper motor for each 12 square feet of damper area.

B. Each smoke damper shall be dynamic rated type and shall be further classified by Underwriter's Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. Damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers required in this Specification. Testing and UL qualifying a single damper size is not acceptable. Leakage rating under UL555S shall be no higher than Leakage Class I (4 CFM per square foot at one-inch water gauge pressure and 8 CFM per square foot at 4 inches water gauge pressure). Maximum air pressure drop through each smoke damper shall not exceed 0.10-inch water gauge at the design air quantity. (Note that this may require a larger damper than the connected duct size). All ratings shall be dynamic.

C. Damper frame shall be minimum 0.125-inch aluminum formed into a structural hat channel shape with corner braces for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be stainless steel sleeve type turning in an extruded hole in the frame or an extruded frame raceway. Dampers shall be opposed blade type. Blades shall be airfoil shaped double skin construction. Blade edge seal material shall be silicone rubber designed to withstand 450°F. Jamb seals shall be aluminum flexible metal compression type.

D. In addition to the leakage ratings specified herein, smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 350°F. Pneumatic operators shall be installed by the damper manufacturer at the time of damper fabrication. Damper and operator shall be supplied as a single entity

that meets all applicable UL555 and UL555S qualifications for both dampers and operators. Manufacturer shall provide factory-assembled sleeve. Sleeve shall be minimum 21-gauge for dampers where neither width nor heights exceeds 48 inches or 16-gauge where either dimensions equals or exceeds 48 inches.

E. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures of at least 4 inches water gauge in the closed position, and 2000 FPM air velocity in the open position.

F. The damper must be operable while the temperature is above 350°F. The actuator/operator package shall include two damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One switch shall close when the damper is fully open, and the other switch shall close when the damper is fully closed. Position indicator switches shall be capable of interfacing directly with the remote smoke detectors, building fire alarm systems, and remote indicating/control stations (BAS).

G. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated on the Drawings, and shall be furnished and installed by the damper manufacturer as required by the UL rating mentioned above. Motors shall be electric to match the type of temperature control system specified elsewhere in this Specification. Furnish all required relays, wiring and other labor and material necessary to completely interconnect the smoke detector system.

H. Furnish each damper in a square or rectangular configuration. Furnish and install sleeves manufactured by the approved damper manufacturer for each damper. Construct sleeves with square or rectangular to square, rectangular, round, or oval adapters as required. Install dampers in the sleeves in accordance with manufacturer's UL installation instructions. Entire assembly, following installation, shall operate smoothly and be capable of withstanding 6 inch water gauge static pressure.

I. All smoke dampers shall be dynamic type.

J. Completely seal the damper assembly to the building components.

2.07 FLEXIBLE CONNECTIONS

A. Where ducts connect to fans, including roof mounted exhaust fans, or at MRI cryogenic vent connections, flexible connections shall be made using "Flexmaster TL-M" or "Ventglas" fabric that is temperature-resistant, fire-resistant, waterproof, mildew-resistant and practically airtight, weighing approximately thirty ounces (30 oz.) per square yard.

B. Material used outdoors shall be resistant to ultra-violet radiation. There shall be a minimum of one-half inch (1/2-inch) slack in the connections, and a minimum of two and one-half inches (2-1/2 inch) distance between the edges of the ducts. This does not apply to air handling units with internal isolation.

2.08 ACCESS DOORS

A. Furnish and install the ductwork, hinged rectangular, pressure relief, or round "spin-in" access doors to provide access to all fire dampers, mixed air plenums, steam reheat coils (install upstream), automatic dampers, etc.

B. Where ductwork is insulated, access doors shall be double skin doors with one inch (1") of insulation on the door.

C. Where duct size permits, 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).

D. Latches for rectangular doors smaller than 18 inch x 16 inch shall be Ventlok No. 100 or 140.

E. Doors for zone heating coils shall be Ventlok, stamped, insulated access doors, minimum 10 inch x 12 inch, complete with latch and two (2) hinges, or twelve inches (12") in diameter.

F. Round access doors shall be "Inspector Series" spin-in type door as manufactured by Flexmaster USA.

G. Doors for personnel access to ductwork shall be nominal twenty-four inches (24") in diameter. Doors may be fabricated in a local approved sheet metal shop in accordance with SMACNA Standards.

H. Where access doors are installed above a suspended ceiling, this Contractor shall be responsible for the proper location of ceiling access doors.

2.09 GUY WIRE SYSTEM

A. Provide 1/4-inch diameter American Aircraft Steel Cable (plastic coated) with clip for vertical stack off utility fans on roof, with eyebolts for attachment to anchor systems on the roof (refer to details on the plans).

2.10 SCREENS

A. Furnish and install screens on all duct, fan, etc., openings furnished by this Contractor which lead to, or are located outdoors.

B. Screens shall be No. 16 gauge, one-half inch (1/2") mesh in removable galvanized steel frame.

C. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

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 balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing.

D. Provide all dampers furnished by the BAS Provider in strict accordance with manufacturer's written installation instructions and requirements of these Specifications.

E. Provide fire dampers, and combination fire and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

F. Provide backdraft dampers on exhaust fans or exhaust ducts where indicated. Install dampers so that they will open freely.

G. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Cover connections to medium and high pressure fans with leaded vinyl sheet, held in place with metal straps.

H. Provide duct access doors for inspection and cleaning before and after duct mounted filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated on Drawings. Provide minimum 8 x 8 inch (200 x 200 mm) size for hand access, 18 x 18 inch (450 450 mm) size for shoulder access, and as indicated.

I. Provide duct test holes where indicated and where required for testing and balancing purposes.

1. Furnish and install Ventlok No. 699 instrument test holes in the return air duct and in the discharge duct of each fan unit.

2. Install test holes in locations as required to measure pressure drops across each item in the system, e.g. outside air louvers, filters, fans, coils, intermediate points in duct runs, etc.

J. Access doors as specified elsewhere shall be provided for access to all parts of the fire and combination fire and smoke dampers. Doors shall open not less than 90 degrees following installation and shall be insulated type where installed in insulated ducts.

K. Install each fire and combination fire and smoke damper square and true to the building. The installation shall not place pressure on the damper frame, but shall enclose the damper as required by UL555 and UL555S.

3.02 GUY WIRE INSTALLATION

A. Coordinate installation of guy wire anchor supports with roofing contractor.

B. On existing buildings, coordinate with the general contractor and Owner's representative, to assure that any penetrations of the existing roof are made in a way that will not void the existing roof warranty.

3.03 TESTING

A. After each fire damper, smoke damper and combination fire and smoke damper has been installed and sealed in their prescribed openings and prior to installation of ceilings, Contractor shall, as directed by Owner, activate part or all dampers as required to verify "first-time" closure.

B. Activation of damper shall be accomplished by manually operating the resettable link, disconnecting the linkage at the fire damper fusible link, and manually operating the fire/smoke damper through the pneumatic or electronic controls as appropriate.

C. Failure of damper to close properly and smoothly on the first attempt will be cause to replace the entire damper assembly.

D. Coordinate smoke damper system interlock requirements with the fire alarm system.

END OF SECTION

SEQUENCE OF OPERATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. The requirements of the General Conditions, Supplementary Conditions, Division 01 and Drawings apply to all work herein.

1.02 SCOPE

A. The Sequence of Operation is hereby defined to mean the manner in which and methods by which the Building Automation System (BAS) functions. The requirements for each type of operation are specified in this Section.

PART 2 - SEQUENCE OF OPERATION

2.01 GENERAL

A. Start/Stop Control: Heating, ventilating, and air conditioning equipment as listed herein shall be programmed to start and stop at predetermined times for optimal operation of the building. Provide individual start/stop function of the following equipment:

1. All air handling units, and fan powered filter units.
2. All exhaust and ventilating fans, except fans interlocked with air handling units, and thermostatically controlled fans.

B. Smoke Detectors: Most air handling units and fans shall be provided with smoke detectors furnished and installed under Division 28 30 00. Air handling units, supply air ventilation fans, exhaust air fans, and relief air fans (including stair pressurization, except smoke exhaust fans) 2000 CFM and greater will have smoke detectors installed in the discharge supply air ductwork and in the return air path. In general, each air handling unit and fan shall be stopped by the fire alarm system whenever its fire alarm zone is activated.

C. High Limit Thermostats: Provide a high limit thermostat for every air handling unit, supply fan, and exhaust fan, which is not otherwise protected by a smoke detector (refer to Section 28 30 00) and as required by code. Smoke exhaust fans shall not have a high limit thermostat.

D. Current Sensing Relays: Provide current sensing relays, where required to sense proper motor operation (fans, pumps, etc.) and prove air or water flow. The operational set point level shall be adjustable to sense when a belt, fan or pump shaft has broken, such that the current level is below the operational set point and a trouble signal will be initiated. Provide current sensing relays similar to Johnson Controls #CSD-SAE0-1 (set point range adjustable between 1.0 and 135 amps).

E. Automatic Dampers: Provide automatic dampers where indicated on the Drawings. These dampers shall be interlocked with their respective fan units. On a fan unit start signal, the automatic dampers shall open. Duct systems, dampers, and fans shall be protected from fan starting against closed systems. In general, after a time delay of 15 seconds (adjustable) for dampers to fully open, the fan shall start. In lieu of a time delay, certain sequences require the dampers to be proven open by actuation of a damper blade end switch before the fan is allowed to start.

F. Automatic Outside Air Intake Dampers: On a start signal, the outside air intake dampers shall open. On a stop signal, the fan shall stop and the dampers shall close. Dampers shall close on loss of control signal, on loss of electrical power, and whenever the air handling unit fan motor stops for any reason.

G. Fire Safety Sequences: The operation of certain exhaust and ventilating fans, combination fire, smoke and automatic dampers control sequences, etc., will be governed by the fire alarm systems. Refer to Section 28 30 00, Fire Alarm System for operation of these systems under special conditions. The fire safety, fire alarm, and fireman's manual override sequences shall take precedence over all other manual, safety, or automatic functions.

H. Hand-Off-Auto Switch Operation: In general, each motor controller shall be provided with a 120 volt control power transformer and a "HAND-OFF-AUTO" selector switch. When the sequence description requires a motor to be operated by an automatic device such as outside temperature, Building Control and Automation System (BAS), etc., this sequence shall occur only when the selector switch is in the "AUTO" position. The "HAND" position may be used to operate the motor at any time, regardless of the functioning of the automatic device or circuit. All automatic functions such as damper opening, valve actuation, interlocks, etc., shall occur as described whether the motor is started and stopped in the "AUTO" position or manually by use of the "HAND" and "OFF" positions. Safety devices and circuits such as low limit thermostats, high limit thermostats, fire alarm contacts, etc., however, shall operate as described regardless of the position of the H-O-A switch.

I. Control Power Source: In general, all control circuits whenever possible shall originate from respective motor controller control power transformers. Confirm that each control power transformer and control fuse is adequately sized for all relays, coils etc., connected to the circuit. Provide all necessary interlock and circuit isolation relays required to perform the sequence of operation specified. Coordinate all requirements with the Contractor for Division 26.

J. Smoke Block Dampers: All air handling unit system smoke block dampers shall close upon a signal from the fire alarm system and shall open upon removal of the signal.

2.02 CONTROL TYPE 1: VARIABLE VOLUME TERMINAL UNIT (VAV)

A. General: Each of these units consist of a variable volume unit (VAV), primary cold air inlet damper, inlet airflow sensor, hot water reheat coil, and shall be provided with related control systems.

B. Zone Control: A wall mounted space temperature sensor shall provide an input to an ASC which outputs a signal to modulate the primary inlet damper from maximum CFM set point to minimum CFM set point and shall modulate a signal to the hot water reheat coil in sequence as required to maintain space temperature set point. The heating coil control valve shall not begin to open until the primary air inlet damper has closed to its minimum CFM set point.

C. Pressure Independent Operation: A flow cross/flow ring multipoint sensor in the primary air inlet shall through a pressure transducer and the ASC reset the control loop for terminal unit pressure independent operation. System shall employ a three mode control algorithm to eliminate offset.

D. Primary Damper:

1. From full cooling to full heating, the primary air inlet damper shall modulate closed to its minimum set point in response to the room temperature sensor.
2. The primary air inlet damper shall close when the unit fan is off.
3. Communication: The unit shall be capable of transmitting the following information and receiving instructions to change set points in standard binary coded decimal format (DDC).

4. Primary air velocity.
5. Primary air maximum CFM set point.
6. Primary air minimum CFM set point.
7. Temperature at room thermostat.
8. Space temperature set point.

2.04 CONTROL TYPE 2: CONSTANT VOLUME TERMINAL UNIT (CAV)

A. General: Each of these units consist of a constant volume unit (CAV), primary cold air inlet damper, inlet airflow sensor, hot water reheat coil, and shall be provided with related control systems.

B. Zone Control: A wall mounted space temperature sensor shall provide an input to an ASC which outputs a signal to modulate a signal to the hot water control valve controlling the heating coil in sequence as required to maintain space temperature set point. The primary cold air inlet damper shall modulate as required to maintain a constant discharge air volume regardless of variations in the upstream pressure.

C. Pressure Independent Operation: A flow cross/flow ring multipoint sensor in the primary air inlet shall through a pressure transducer and the ASC reset the control loop for terminal unit pressure independent operation. System shall employ a three mode control algorithm to eliminate offset.

D. Primary Damper:

1. From full cooling to full heating, the primary air inlet damper shall modulate closed to its minimum set point in response to the room temperature sensor.
2. The primary air inlet damper shall close when the unit fan is off.
3. The unit shall be capable of transmitting the following information and receiving instructions to change set points in standard binary coded decimal format (DDC):
4. Primary air velocity.
5. Primary air maximum CFM set point.
6. Primary air minimum CFM set point.
7. Temperature at room thermostat.
8. Space temperature set point.

2.06 CONTROL TYPE 3: SMOKE EXHAUST SYSTEM (OPERATING ROOM)

A. The sequence below shall be coordinated with the existing system smoke evacuation sequence.
B. Upon detection of combustive products by a smoke detector within an operating room or upon operation of the manual smoke exhaust system pushbutton switch, the maximum outside air damper of the serving AHU opens fully, the return dampers to the affected operating room close, the motorized damper in the smoke exhaust duct serving the affected operating room opens, and the supply fan continues to operate at design speed. The system continues to operate in this manner until the fire alarm system is reset.
C. If combustive products are detected in the outside air or the supply air and the system is already in a smoke evacuation mode, the supply fan shuts down, outside air dampers close.
D. If combustive products are detected in the outside air and the system is in a normal operating mode, the minimum and maximum outside air dampers closes and air continues to recirculate with the supply fan. If smoke is detected in the suite or by the supply air smoke detector, the supply fan shuts down and the return damper closes.
E. If combustive products are detected by the return air smoke detector while in a normal operating mode, the system would be placed in a smoke evacuation mode as noted above.

2.08 SUBMITTALS

A. Shop drawing submittal shall include the following:

1. Complete control drawings showing all control components, control wiring diagrams, and Fire Alarm System interface.

2. Written control sequences for each control function.

3. Additional information as required by Section 23 05 00.

END OF SECTION