University of South Carolina
Columbia, South Carolina

Project Manual for Career Center at Thomas Cooper Library Renovation-Mechanical

Project Number: BC00450776

April 9, 2014

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Project Number: BC00450776

Project Name: Career Center at TCL-5th Level (Mechanical)

Scope of Work-Mechanical

This is a bid for the mechanical portion of the renovation of level 5 of the Thomas Cooper Library. Work is shown on floor plan sheet M2.5A, air device schedule and general notes sheet M0.0, mechanical details on sheet M5.0 and specification section Division 23 Heating, Ventilating, and Air Conditioning of drawings by RMF Engineering for Quackenbush Architects. Bid is to furnish and install all mechanical to include but not limited to all ductwork, dampers and air devices. Items not included in this work are as follows:

1) There is no demolition in this work
2) Air balancing will be by USC
3) USC will handle any hazardous material should any be encountered.

2011 Edition

SE-311
Invitation for Minor Construction Quotes

SCBO NOTES 2, 4 and 5 APPLY TO THIS INVITATION FOR QUOTES

PROJECT NAME: Career Center at TCL 5th Level (Mechanical)

PROJECT NUMBER: BC00450776 **PROJECT LOCATION:** Columbia, SC

BID SECURITY REQUIRED? Yes ☐ No ☑

PERFORMANCE BOND REQUIRED? Yes ☐ No ☑

PAYMENT BOND REQUIRED? Yes ☐ No ☑ **CONSTRUCTION COST RANGE:** Less than $50K

DESCRIPTION OF PROJECT:
Provide services to furnish & install all mechical to include but not limited to ductwork, dampers & air devices.
Work is shown in Division 23 and drawings M0.0, M1.5A, M2.5A,M5.0.
Small and miniroity business participation is encouraged. It is the bidders responsibility to obtain all bidding documents from the purchasing website at http://purchasing.sc.edu

A/E NAME: Quakenbush Architects **A/E CONTACT:** John Bedell

ADDRESS: 1217 Hampton Street **PHONE:** 803.771.2999 **Fax:**

CITY: Columbia **STATE:** SC **ZIP:** 29201 **E-MAIL:** jbedell@quackenbusharchitects.com

PLANS ON FILE AT: AGC: DODGE: OTHER:

PLANS MAY BE OBTAINED FROM: http://purchasing.sc.edu (See Facilities/Construction Solicitations & Awards)

PLAN DEPOSIT AMOUNT: **IS DEPOSIT REFUNDABLE?** Yes ☐ No ☐

PRE-QUOTE CONFERENCE? ☑ Yes ☐ No **MANDATORY ATTENDANCE?** ☐ Yes ☑ No

DATE: 04/17/2014 **TIME:** 10AM **PLACE:** 743 Greene St, Conf Rm 053, Columbia SC 29208

AGENCY: University of South Carolina

NAME AND TITLE OF AGENCY COORDINATOR: Aimee B. Rish, Procurement Specialist

ADDRESS: 743 Greene Street **PHONE:** 803.777.2261 **Fax:** 803.777.7334

CITY: Columbia **STATE:** SC **ZIP:** 29208 **E-MAIL:** arish@fmc.sc.edu

IFQ CLOSING DATE: 04/28/2014 **TIME:** 2:00PM **LOCATION:** 743 Greene St;Conf Rm 53, Cola SC

IFQ DELIVERY ADDRESSES:

HAND-DELIVERY:
see mail

MAIL SERVICE:
Facilities Center -Attn: A Rish "Bid Enclosed"
743 Greene St
Columbia SC 29208

IS PROJECT WITHIN AGENCY CONSTRUCTION CERTIFICATION? *(Agency MUST check one)* ☑ YES ☐ NO

APPROVED BY: _____ _____
(State Engineer) *(Date)*

SE-331
Quote Form

2011 Edition

Quotes shall be submitted only on SE-331

QUOTE SUBMITTED BY: _____
(Offeror's Name)

QUOTE SUBMITTED TO: University of South Carolina
(Agency Name)

FOR PROJECT: BC00450776 *(Number)* Career Center at TCL-5th Level (Mechanical) *(Name)*

OFFER

1. In response to the Form SE-311, *Request for Minor Construction Quotes*, and in compliance with the *Instructions to Bidders* for the above-named Project, the undersigned **OFFEROR** proposes and agrees, if this Quote is accepted, to enter into a Contract with the **AGENCY** in the form included in the Solicitation Documents, and to perform all Work as specified or indicated in the Solicitation Documents, for the prices and within the time frames indicated in the Solicitation and in accordance with the other terms and conditions stated.

2. Pursuant to Section 11-32-3030(1) of the SC Code of Laws, as amended, **OFFEROR** has submitted Bid Security as follows in the amount and form required by the Solicitation Documents:

☐ Bid Bond with Power of Attorney ☐ Electronic Bid Bond ☐ Cashier's Check
(OFFEROR check one, if Bid Security is required)

3. **OFFEROR** acknowledges the receipt of the following Addenda to the Solicitation documents and has incorporated the effects of said Addenda into its Quote:

ADDENDUM No: _____

4. **OFFEROR** agrees that this Quote, including all bid alternates, if any, may not be revoked or withdrawn after the opening of bids, and shall remain open for acceptance for a period of 60 Days following the Quote Date, or for such longer period of time that **OFFEROR** may agree to in writing upon request of the **AGENCY**.

5. **OFFEROR** agrees that from the compensation to be paid, the **AGENCY** shall retain as Liquidated Damages the amount of for each calendar day the actual construction time required to achieve Substantial Completion exceeds the specified or adjusted Contract Time for Substantial Completion, as provided in the Contract Documents.

6. **OFFEROR** herewith submits its offer to provide all labor, materials, equipment, tools of trades and labor, accessories, appliances, warranties and guarantees, and to pay all royalties, fee, permits, licenses and applicable taxes necessary to complete the following items of construction work:

6.1 BASE BID _____
(enter BASE BID in figures only)

6.2 ALTERNATE NO. 1 _____ **to be ADDED/DEDUCTED from BASE BID.**
(circle one)

6.3 ALTERNATE NO. 2 _____ **to be ADDED/DEDUCTED from BASE BID.**
(circle one)

FEIN/SSN: _____

SC Contractor's License Number: _____

Address: _____

Telephone/Fax _____

E-mail _____

This Quote is hereby submitted on behalf of the Offeror named above.

BY: _____
(Signature of Offeror's Representative)

_____
(Print or Type Name of Offeror's Rpresentative)

ITS: _____

USC SUPPLEMENTAL GENERAL CONDITIONS FOR CONSTRUCTION PROJECTS

1. Contractor's employees shall take all reasonable means not to interrupt the flow of student traffic in building corridors, lobbies and stairs. All necessary and reasonable safety precautions shall be taken to prevent injury to building occupants while transporting materials and equipment through the building to the work area. Providing safe, accessible, plywood pedestrian ways around construction may be required if a suitable alternative route is not available.

2. Fraternization between Contractor's employees and USC students, faculty or staff is strictly prohibited-zero tolerance!

3. USC will not tolerate rude, abusive or degrading behavior on the job site. Heckling and cat-calling directed toward students, faculty or staff or any other person on USC property is strictly prohibited. Any contractor whose employees violate this requirement will be assessed a fine of up to $500 per violation.

4. Contractor's employees must adhere to the University's policy of maintaining a drug-free and smoke-free/tobacco free workplace.

5. Contractor must sign a Contractor Key Receipt/Return form before any keys are issued. Keys must be returned immediately upon the completion of the work. The Contractor will bear the cost of any re-keying necessary due to the loss of or failure to return keys.

6. A welding permit must be issued by the University Fire Marshall before any welding can begin inside a building. Project Manager will coordinate.

7. Contractor must notify the University immediately upon the discovery of suspect material such as those potentially containing asbestos or other such hazardous materials. These materials **must not** be disturbed until approved by the USC Project Manager.

8. At the beginning of the project, the USC Project Manager will establish the Contractor's lay-down area. This area will also be used for the Contractor's work vehicles. No personal vehicles will be allowed in this area, or in any areas surrounding the construction site that are not regular or authorized parking lots. Personal vehicles must be parked in the perimeter parking lots. Parking permits can be obtained at the USC Parking Office located in the Pendleton Street parking garage. The lay down area will be clearly identified to the contractor by the PM, with a sketch or drawing provided to Parking. In turn, the contractor will mark off this area with a sign containing the project name, PM name, Contractor name and contact number, and end date. Where this area is subject to foot traffic, protective barriers will be provided as specified by the PM. The area will be maintained in a neat and orderly fashion. Vehicles parked in the lay down area (or designated parking areas) will be clearly marked or display a CPC furnished placard for identification.

Updated: July 15, 2011

9. Contractor will be responsible for providing its own temporary toilet facilities, unless prior arrangements are made with the USC Project Manager.

10. Use of USC communications facilities (telephones, computers, etc.) by the Contractor is prohibited, unless prior arrangements are made with the USC Project Manager.

11. For all projects over $100,000, including IDC's, an SE-395, Contractor Performance Evaluation, will be completed by the USC Project Manager and reviewed with the GC at the beginning of the project and a copy given to the GC. At the end of the project the form will be completed and a Construction Performance rating will be established.

12. Contractor is responsible for removal of all debris from the site, and is required to provide the necessary dumpsters which will be emptied at least __one____ times per week. Construction waste must not be placed in University dumpsters. THE CONSTRUCTION SITE MUST BE THOROUGHLY CLEANED WITH ALL TRASH PICKED UP AND PROPERLY DISPOSED OF ON A DAILY BASIS AND THE SITE MUST BE LEFT IN A SAFE AND SANITARY CONDITION EACH DAY. THE UNIVERSITY WILL INSPECT JOB SITES REGULARLY AND WILL FINE ANY CONTRACTOR FOUND TO BE IN VIOLATION OF THIS REQUIREMENT AN AMOUNT OF UP TO $1,000 PER VIOLATION.

13. **Contractor must provide all O&M manuals, as-built drawings, and training of USC personnel on new equipment, controls, etc. prior to Substantial Completion. Final payment will not be made until this is completed.**

14. The contractor will comply with all regulations set forth by OSHA and SCDHEC. Contractor must also adhere to USC's internal policies and procedures (available by request). As requested, the contractor will submit all Safety Programs and Certificates of Insurance to the University for review.

15. Tree protection fencing is required to protect existing trees and other landscape features to be preserved within a construction area. The limits of this fence will be evaluated for each situation with the consultant, USC Arborist and USC Project Manager. The tree protection fence shall be 5' high chain link fence unless otherwise approved by USC Project Manager. No entry or materials storage will be allowed inside the tree protection zone. A 4" layer of mulch shall be placed over the tree protection area to maintain moisture in the root zone.

16. Where it is necessary to cross walks, tree root zones (i.e., under canopy) or lawns the following measures shall be taken: For single loads up to 9,000 lbs., a 3/4" minimum plywood base shall be placed over areas impacted. For single loads over 9,000 lbs., two layers of 3/4" plywood is required.

17. For projects requiring heavy loads to cross walks tree root zones or lawns. A construction entry road consisting of 10' X 16' oak logging mates on 12" coarse, chipped, hardwood base. Mulch and logging mats shall be supplemented throughout the project to keep

matting structurally functional.

18. Any damage to existing landscaping (including lawn areas) will be remediated before final payment is made.

19. Orange safety fence to be provided by the contractor. (USC Arborist, Kevin Curtis may be contacted at 777-0033 or 315-0319)

Campus Vehicle Expectations

1. All motorized vehicles on the University campus are expected to travel and park on roadways and/or in parking stalls.

2. All motorized vehicle traffic on USC walkways must first receive the Landscape Manager=s authorization. Violators may be subject to fines and penalties.

3. All motorized vehicles that leak or drip liquids are prohibited from traveling or parking on walks or landscaped areas.

4. Contractors, vendors, and delivery personnel are required to obtain prior parking authorization before parking in a designated space. Violators may be subject to fines and/or penalties. See Item 10 below.

5. Drivers of equipment or motor vehicles that damage university hardscape or landscape will be held personally responsible for damages and restoration expense.

6. Vehicle drivers who park on landscape or drives must be able to produce written evidence of need or emergency requiring parking on same.

7. All vehicles parked on landscape, hardscape, or in the process of service delivery, must display adequate safety devices, i.e. flashing lights, cones, signage, etc.

8. All drivers of equipment and vehicles will be respectful of University landscape, equipment, structures, fixtures and signage.

9. All incidents of property damage will be reported to Parking Services or the Work Management Center.

10. Parking on campus is restricted to spaces designated by Parking Services at the beginning of the project. Once the project manager and contractor agree on how many spaces are needed, the project manager will obtain a placard for each vehicle. This placard must be hung from the mirror of the vehicle, otherwise a ticket will be issued and these tickets cannot be "fixed". Parking spaces are restricted to work vehicles only; no personal vehicles.

Project Name: USC Career Center at TCL 5th Level (Mechanical)
Project Number: BC00450776

University of South Carolina

CONTRACTOR'S ONE YEAR GUARANTEE

STATE OF _____

COUNTY OF _____

WE_____
as Contractor on the above-named project, do hereby guarantee that all work executed under the requirements of the Contract Documents shall be free from defects due to faulty materials and /or workmanship for a period of one (1) year from date of acceptance of the work by the Owner and/or Architect/Engineer; and hereby agree to remedy defects due to faulty materials and/or workmanship, and pay for any damage resulting wherefrom, at no cost to the Owner, provided; however, that the following are excluded from this guarantee;

Defects or failures resulting from abuse by Owner.

Damage caused by fire, tornado, hail, hurricane, acts of God, wars, riots, or civil commotion.

_____
[Name of Contracting Firm]

*By_____

Title_____

*Must be executed by an office of the Contracting Firm.

SWORN TO before me this
_____ day of _____, 2____ (seal)

_____State

My commission expires _____

SECTION 220500 - PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

1.2 SCOPE

A. This section includes the storm, soil, waste, drain, vent and domestic water systems from their source of supply or point of disposal to and including their connection to equipment and fixtures.

B. The requirements of Division 23, Sections "Mechanical and Electrical General Provisions" shall apply to all work specified under this section. Sterilization shall comply with Section 610 of the 2009 International Plumbing Code.

1.3 CODES

A. All plumbing work shall comply with the 2009 International Plumbing Code and the regulations of the South Carolina Department of Health and Environmental Control (DHEC), and the State of South Carolina. Obtain all approvals before starting plumbing work. Request all inspections during the course of work.

B. Installation shall meet the regulations contained in the Safe Drinking Water Act (SDWA) concerning lead and copper concentrations.

C. All residential type faucets, electric water coolers and drinking fountains shall meet the requirements of NSF Standard 61, Section 9.

1.4 EQUIPMENT CONNECTIONS

A. Provide all plumbing connections required by equipment which is provided on this project. Certain items of equipment shall be provided under this section and certain items will be furnished and set under other sections of the specifications. In all cases, provide valved water supplies, waste and vent lines, and, unless noted otherwise, make final connections after equipment is in place.

PART 2 - PRODUCTS

2.1 PIPE, VALVES AND FITTINGS

A. Provide materials as hereinbefore specified in Division 23, Section "Basic Materials and Methods". All floor, wall and ceiling penetrations for piping shall be sealed with appropriate sealant.

B. Unions or flanges shall be provided at all connections to each piece of plumbing equipment and on both sides of valves and other in-line devices that require removal for maintenance. Bronze adaptors shall be used at all copper to flanged or IPS connections.

2.2 PLUMBING FIXTURES

A. Provide all plumbing fixtures indicated on the drawings and as specified herein. All exposed metal parts of all fixtures, including all trim and fittings, shall be brass, chromium plated. Each hot and cold water connection to each fixture shall be provided with a stop valve and all nipples shall be chrome plated red brass. Provide backflow devices on all faucets and fittings requiring same. Devices may be inline type when not provided integral with the faucet. All faucet handles, where possible, shall have color coded "indexes" identifying the service used. All "serrated" or slip hose connection spout outlets shall have Allen wrench operated volume controls to control "splashing" of water as it hits sink bottoms. Water supplies for handicapped lavatories and sinks shall be insulated. Waste line for handicapped lavatories and sinks shall be offset and insulated. Refer to Division 23, Section "Mechanical Insulation" for insulation type and thickness.

B. Water supplies for handicapped water closets shall be roughed-in for flush valve handles to be operated from the accessible side of the water closet. The Contractor shall coordinate and provide flush handles on the accessible side of all handicapped water closets. Provide offset flush connection as required to coordinate with wall mounted grab bars" to all ADA water closets with flush valves.

C. The Contractor shall provide metal supports necessary to adequately and substantially hang and set all fixtures subject to the approval of the Architect. No wood grounds, wood plugs, or expansion bolts shall be permitted for fixture support. Provide carriers where specified below and as required to hang fixtures.

D. Insulate all exposed piping under lavatories and sinks with a white, fitted/molded antimicrobial undersink pipe cover equal to Truebro Lav Guard 2. Cover shall have internal, E-Z Tear-To-Fit trim feature for square, clean trimming (internal ribs) and built-in, concealed E-Z Grip fasteners (no cable-tie fasteners allowed).

E. Water-Conserving Fixtures: Plumbing fixtures and fittings shall use in aggregate at least 30% less water than the water use baseline calculated for the building after meeting the Energy Policy Act of 1992 fixture performance requirements. Flow and flush rates shall not exceed the following:

1. Toilets: no more than 1.3 gallons per flush and have documented bowl evacuation capability per MaP testing of at least 400 grams.
2. Urinals: no more than 0.5 gallons per flush or use.
3. Lavatory Faucets: 0.5 gpm with automatic faucet controls.
4. Showerheads: no more than 1.5 gpm.

F. Acceptable Manufacturers

1. Fixture shall be American Standard, Crane or Kohler, equal to American Standard or other manufacturer of the types listed below.
2. Flush valves shall be Zurn, Sloan, Delany or Cambridge Brass, equal to Sloan of the types listed below.
3. Faucets shall be Sloan, Kohler, Chicago Faucet, T & S Brass, Crane, Eljer or American Standard equal to Sloan of the types listed below.
4. Drinking fountains shall be Elkay, Oasis or Halsey Taylor equal to Elkay of the types listed below.
5. Toilet seats shall be Bemis (Church), Beneke, Sperzel equal to Church of the types listed below.

G. Fixtures:

1. P-1 Kitchen Sink:

Fixture:	American Standard 20SB.251900.073, 20 gauge stainless steel, single bowl undermount sink, nominal dimensions 24 ¾ ”x18 ¾ ”x8”
Faucet:	American Standard 4275.550, two handle kitchen faucet brass construction with all brass inlet shanks and coupling nuts. Brass gooseneck swivel spout. Shall also feature ¼ turn washerless ceramic disc valve cartridges that are reversible for use on either hot or cold side.
Strainer:	McGuire 1518 Heavy duty forged brass basket strainer with brass basket. Furnished with 1 ½”x8” tailpiece, brass lock and coupling nuts.
Trap:	McGuire 8912CNC Heavy cast brass 1 1/2 x 1 1/2" adjustable trap with no cleanout plug and 12 inch center to end. Furnished with slip nuts, seamless tubular brass wall bend and steel shallow flange.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING

A. Interior Drainage Systems:

1. Soil, waste, vent, and drain piping for sanitary and storm drainage, shall be of the sizes noted, and shall be run as indicated. Pipes must be run in straight lines and have a uniform grade between elevations noted. No branch drain shall have a grade less than that indicated for the main drain to which it is connected. Where elevations are not given, horizontal pipes shall have a uniform grade of 1/4 inch per foot where possible but in no case less than 1/8 inch per foot and shall be installed to the inverts shown. All piping shall be adequately supported as specified in Division 23, Section "Mechanical and Electrical General Provisions". All main vertical soil and waste stacks shall be extended as vents full size to approximately 18 inches above the roof of the building. Two (2) or more vent lines shall be connected together where practicable and extended as one (1) pipe through the roof. Vent pipes in roof spaces shall be run as close as possible to the underside of the roof without forming traps in pipes. Vent pipes may be connected to other vent pipes or to main vent stacks provided the connections are at least four (4) feet above the floor on which the fixtures are located so that no vent pipe can be used as a waste. Openings in roof for vent pipes shall be flashed and made watertight. Use vent stack flashing sleeves where applicable. Handicapped plumbing fixtures shall be rough-in to suit the specific mounting of the fixture. Waste lines shall be offset for lavatories and sinks to accommodate wheelchair type strainers and traps shall be insulated.
2. Changes in direction shall be made by appropriate use of forty-five (45) degree wyes, 1/2 wyes, or long sweep 1/4, 1/6, 1/8, or 1/16 bends. Sanitary tees or short quarter bends may be used on vertical stacks of drainage lines where change in direction of flow is from horizontal to vertical; except use long turn tee wyes when two (2) fixtures have common drain. Straight tees, elbows, and crosses may be used on vent lines. Make no change in direction of flow greater than ninety (90) degrees. Where different sizes of drainage pipes or pipes and fittings are to be connected, use standard increasers and reducers of proper size. Reduction of size in horizontal drainage piping in direction of flow is prohibited.
3. Drilling and tapping of drains, soil, waste, or vent piping, and use of saddle hubs and bands are prohibited.
4. Connect piping to fixtures or equipment by couplings or unions so that devices may be replaced with no disturbance to piping.

B. Water Piping Systems:

1. Water piping shall be complete from service connection to all fixtures, equipment, outlets, etc. Sizes of pipes shall be shown or as specified.
2. Chromium plated piping shall be threaded and made up carefully, and not more than one (1) full turn of thread shall be exposed beyond any fitting.
3. Ends of pipes or tubing and recesses of fittings to be bronzed or soldered shall be thoroughly cleaned. Joints shall be assembled without binding. Brazing material or solder shall penetrate fully and shall fill the joint completely.
4. All brass and copper pipe and tubing shall be free from cuts, dents or other surface

damage at the time of final inspection. Damaged pipe or tubing shall be removed and replaced with new pipe or tubing.

5. Horizontal runs of brass and copper pipe and tubing over fifty (50) feet in length shall be anchored to wall or floor construction. Anchors shall be located near the midpoints of the runs so as to force the expansion equally to the ends or in a direction where expansion can take place without excessive strain. Swing joints, offsets, expansion joints, etc., shall be provided where necessary to accommodate expansion of piping, which will be approximately two (2) inches in 100 feet of brass or copper hot water piping.
6. Where non-ferrous metal piping and zinc-coated metal piping are jointed, dielectric (insulating) couplings, fittings or unions shall be provided.
7. Where pipe sizes shown or specified differ from the connection sizes of meters, pumps, fixtures, outlets, etc., reducing fittings shall be installed.
8. Water supplies for wall hung lavatories shall be roughed in as high as possible and still permit connections to the faucet. Water supplies shall be insulated for handicapped fixtures and rough-in shall be on accessible side of fixture for flush valves and flush handles.

C. All rough-in plumbing shall be sealed off with test plugs, caps, etc., until fixtures are ready to be installed.

3.2 TRAPS

A. Each fixture, floor drain and piece of equipment connected to the sanitary system shall be equipped with a trap.

B. Provide traps for storm water lines where required by code.

C. Each trap shall be placed as close to the fixture as possible and no fixture shall be double trapped.

D. All traps on bell and spigot pipe shall be extra heavy cast iron and all traps on threaded pipe shall be galvanized cast iron recessed drainage type.

END OF SECTION 220500

SECTION 230530 – BASIC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

1.2 SCOPE

A. This section includes requirements for items of equipment, materials and procedures which are common to more than one section of Division 21, 22 and 23 and which are general in nature and use. This section applies to all sections of Divisions 21, 22 and 23.

B. The requirements of Division 23, Section "Mechanical and Electrical General Provisions" shall apply to all work specified under this section.

C. This section specifies the color schemes for painting exposed and insulated piping in the mechanical rooms. Refer to Division 9 for painting specifications.

1.3 SHOP DRAWINGS

A. Submit shop drawings for all items of materials specified in this section in accordance with the General Requirements.

1.4 TESTS AND ADJUSTMENTS

A. The Contractor shall furnish labor, instruments, equipment, and materials required to perform tests prescribed in the sections describing the various systems. All tests shall be performed in the presence of the Owner and/or the Architect. Forty-eight (48) hours prior notice shall be given to the Owner and Architect for all tests. A written test report shall be submitted following all tests and before systems are insulated.

B. Replace or repair defects found during inspection or tests with new materials. Caulking of welded joints, screwed joints, cracks, or holes is not acceptable. Correct leaks in screwed fittings by remaking joints. Cut out and reweld. Repeat tests after defects have been eliminated.

C. Where reasonable doubt exists as to a system's ability to comply with contract requirements,

perform any reasonable test required by the Architect.

D. Make static pressure tests and prove to the satisfaction of the Architect the piping is tight before pipes are concealed. Tests shall be provided as hereinafter specified.

E. Use test instruments tested for accuracy by an approved laboratory or by the instrument manufacturer, and furnish certificates showing degree of accuracy to the Architect when requested. Make calibration histories for each instrument available for examination.

F. Where gauges, thermometers and other instruments which are to be left permanently installed are used for tests, do not install until just prior to the tests to avoid possible changes in calibration.

1.5 REFERENCES AND DEFINITIONS

A. Unless otherwise specifically indicated, the term, and requirements of, "domestic" water systems shall universally apply to all potable, HVAC make-up and industrial laboratory water systems.

PART 2 - PRODUCTS

2.1 HANGERS:

A. See Division 23, Section "Mechanical and Electrical General Provisions" for general requirements.

B. Hangers and accessories shall be Anvil International, Carpenter-Patterson, Michigan, B-Line, or Basic Engineering of the types specified in Division 23, Section "Mechanical and Electrical General Provisions".

C. It shall be the responsibility of the Contractor to provide an adequate pipe suspension system in accordance with recognized engineering practices, using standard, commercially accepted pipe hangers and suspension equipment.

D. The Contractor shall engage a qualified professional engineer to design an engineered pipe hanger and support system for all pipe systems of this Contract. Contractor shall perform calculations to ensure that the pipe support system being provided is adequate for the service. For all pipe hangers, supports, anchors, guides, etc., the Contractor shall submit a pipe hanger assembly drawing in accordance with the recommendations provided by MSS SP-89. Provide proposed equipment manufacturer, manufacturer's model number and size, construction, finish, quantities and/or lengths. Utilize columns shown on Contract Drawings for the location plan. Indicate pipe system, line size, insulation thickness, and Contract Drawing for which the plan view of the pipe hanger location can be found.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing

engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.

E. All brackets used for supporting piping shall be provided by the Contractor and shall be of welded steel construction with a design safety factor of not less than five.

F. The design of all hangers and supports shall conform to the latest requirements of ANSI/ASME B31.1 or ANSI/B31.9 and Manufacturers' Standardization Society (MSS) Standard Practice SP-58, SP-69 and SP-89, unless otherwise made more stringent below.

1. Hangers for steel pipe, except as noted otherwise, shall be spaced at least every ten (10) feet.
2. Hangers for cast iron pipe shall be provided at each joint.
3. Hangers for copper pipe shall be placed at least every eight (8) feet, except pipes 3/4 inch and smaller shall have hangers at six (6) foot intervals.
4. Plastic and polypropylene piping systems 1 ¼" and smaller shall be provided with continuous pipe support using light gauge sheetmetal angles strapped to pipes.
5. Hangers shall be placed within one (1) foot of each horizontal and vertical elbow.

G. Where concentrated loads of valves, fittings and similar items occur, closer hanger spacing will be necessary.

H. Generally, hangers shall be clevis type, standard weight for lines 2-1/2 inch and larger.

I. Vibration hangers shall be provided as hereinafter specified in Division 23, Section "Mechanical Vibration, Sound and Seismic Controls".

J. Pipe Shields

1. On insulated piping 2" and larger, provide Pipe Shields, Inc. Model No. A3000 and A5000 for use on warm systems and Model No. A4000 and A6000 for use on cold systems. Contractor shall select appropriate shield for support application.
2. On insulated piping smaller than 2", provide insulation protection shield equal to Anvil International Figure 167. Shield shall comply with Manufacturers Standardization Society (MSS) SP-58 (Type 40).

K. Hangers in direct contact with copper piping systems shall be copper plated.

L. All hangers shall be prime painted for interior locations and galvanized coated for exterior locations.

M. Hangers shall be provided with seismic restraints as required by IBC 2009 and ASCE 05-07.

2.2 IDENTIFICATION, VALVE TAGS AND CHARTS

A. A complete identification system shall be provided for all mechanical and electrical components which conform to the requirements published in ASME A13.1, NFPA 13 and the Fuel Gas

Code.

B. Product Data and Samples: In accordance with Division 1 Section "Submittal Procedures", submit the following:

1. Manufacturer's technical product data and installation instructions for each type of identification device specified. Include a list of all piping systems indicating a proposed nomenclature where a manufacturer's standard pre-printed nomenclature does not match up exactly with what is specified.
2. Samples of each color, lettering style, and other graphic representation required for:

    a. Brass valve identification tag.
    b. Pipe contents and identification markers.
    c. Valve Schedules: For each piping system. Reproduce on standard-size bond paper. Tabulate valve number, piping system, system abbreviation as shown on tag, room or space location of valve, and variations for identification. Mark valves intended for emergency shut-off and similar special uses. Besides mounted copies, furnish copies from maintenance manuals specified in Division 1.
    d. Plastic equipment identification plates.
    e. Paint colors for piping systems.
    f. Stencils.

C. All control devices, i.e.; panels, switches, starters, pushbutton stations, relays, temperature controls, etc., shall be clearly identified as to their function and the equipment controlled. All equipment such as pumps, fans, heaters, etc., shall be marked to clearly identify equipment and space or duty they serve. Mechanical equipment shall be identified using engraved laminated black and white phenolic legend plates. Letters shall be minimum 3/4 inch high white on surrounding black. Plates shall be mounted by means of sheet metal screws. Submit nameplate list for approval.

D. Piping shall be identified with colored, prerolled, semirigid plastic labels as manufactured by Seton or approved equal. Labels shall be Seton "Set mark" system and shall be set around pipes with a field installed high strength cement compound applied along their longitudinal edge. Labels shall be placed around the piping or insulation every twenty (20) feet and with one (1) label on each pipe in rooms smaller than ten (10) feet. Provide labels on branch lines not more than 5 ft from main header. Provide labels on lines that penetrate walls or floors on each side of penetration not more than 5 ft from penetration. A label shall be placed at every major valve and at least six (6) feet from exit or entrance to an item of equipment. On exterior piping, utilize stencils to paint contrasting letters identifying pipe contents and direction of flow. Letter size and color shall comply with the requirements of adhesive pipe labels.

E. For supply and exhaust air terminal units located above the ceiling, in addition to a label on the device, labels are to be permanently affixed to the ceiling grid framing as near to the item as possible using epoxy glue. Where hard ceilings are used, the label is to be affixed to the frame of the access panel for the unit. Labels are to be black core white or beige Bakelite. The lettering is to be 3/8" inches high. The minimum label size is 3/4" wide by 1" long. Terminal units shall be identified as indicated on the mechanical drawings and ATC graphics. The thermostat that controls each air terminal unit shall be identified with an identical but appropriately sized label.

F. For fire, smoke and fire/smoke dampers located above the ceiling, labels are to be permanently affixed to the ceiling grid framing as near to the item as possible using epoxy glue. Where hard ceilings are used, the label is to be affixed to the frame of the access panel for the damper. Labels are to be black core white or beige Bakelite. The lettering is to be 3/8" inches high. The minimum label size is 3/4" wide by 1" long. Dampers shall be identified as "Fire Damper", "Smoke Damper" or "Fire/Smoke Damper".

G. Labels shall have minimum 3/4 inch high black letters for pipes one (1) inch and larger, and 1/2 inch letters for smaller pipes. All labels shall have flow arrows. Color coding and stencil designations shall be as follows:

Service	Color	Stencil Designation
Potable Cold Water	Green	Potable Cold Water
Potable Hot Water	Green	Potable Hot Water
Potable Hot Water Recirc	Green	Potable Hot Water Recirc.
Sanitary	Brown	Sanitary Sewer
Steam	Orange	Steam (Designate Pressure)
Steam Condensate	Orange	Steam Condensate

H. All valves, except as specified below, shall be provided with colored plastic valve tags with stamped-in numbers. Tags shall be secured to valve wheels with a metal chain. Stop valves on individual fixtures or equipment where their function is obvious, or where the fixture of equipment is immediately adjacent, need not be so equipped. Care shall be exercised in scheduling and selecting valve numbers to be indicated on a drawing. Drawing shall show locations, details of arrangements, identity, and function of all service and control valves. One (1) copy of each drawing and schedule shall be mounted and framed under plastic protection where directed. Blueprints are not acceptable. A copy of each drawing and schedule shall also be included as a part of the operations and maintenance manuals. Valve tags shall be Seton or approved equal minimum 1-1/2 inch round tags with white characters describing system and valve designation.

I. Use color scheme indicated below for painting exposed and insulated piping in the mechanical rooms. Colors for piping not identified below shall be as indicated by Owner. Exterior non-insulated piping shall be painted with two coats of rust inhibitive paint. Colors shall be approved by the Owner after a sample is provided for each service. Do not paint aluminum jackets. Do not paint exposed copper or galvanized piping.

Service	Color
Potable Water	Green
Sanitary	Brown
Storm Water	Brown
Condensate Drain, Drain	Brown
Heating Water	Yellow
Steam	Orange
Steam Condensate	Orange

J. Identify fire protection systems (sprinkler and fire alarm) as hereinafter specified as required by NFPA Standards

2.3 PIPE, FITTINGS AND JOINTS

A. General: Items are referred to by type and shall conform to the latest editions of standards listed below:

B. Provide pipe and fittings for fire protection as hereinafter specified in Division 21, Sections "Fire Protection."

C. All piping shall be new domestic pipe material, manufactured in the United States of America (USA) and be suitable for the specific use indicated on drawings and in the specifications.

D. Piping Material:

Service	Piping	Fittings	Joints
1. Sanitary drainage:			
a. Underground:	A	I	a
b. Above ground within building	J	VIII	i
c. Vent piping	J	VIII	i
2. Cold Water:			
a. Above ground - 4" and larger	F	III	e
b. Above ground - 3" and smaller	F	III	e
c. Underground - 3-1/2" and larger	K	IX	j
d. Underground - 3" and smaller	E	III	f
3. Domestic hot water, tempered water and hot water recirc:	F	III	e
4. Heating water supply and return:			
a. 2-1/2" and larger	C	VII	b
b. 2" and smaller	C	IV	c

	c. 2" and smaller (optional)	F	III	e
5.	Steam and steam relief:			
	a. 2-1/2" and larger	C	VII	b
	b. 2" and smaller	C	XII	c
6.	Steam Condensate:			
	a. 2-1/2" and larger	D	VII	b
	b. 2" and smaller	D	XII	c

E. Piping Assembly:

Type		Designation
1.	Cast iron hub and spigot pipe, service weight ASTM A74. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International.	A
2.	Copper drainage tubing, drain, waste, and vent, DWV, ASTM B306	B
3.	Black steel pipe, ASTM A53/106 Grade B Seamless ANSI Schedule 40	C
4.	Black steel pipe, ASTM A53/106 Grade B Seamless ANSI Schedule 80	D
5.	Seamless copper water tube, ASTM B88, Type K, soft	E
6.	Seamless copper water tube, ASTM B88, Type L, hard	F
7.	Seamless copper water tube, ASTM B819 Type L, hard, prepared and labeled for oxygen service and sealed when delivered to the site	G

H

8. Corrugated and perforated black polyethylene drain pipe ASTM F-405 with three (3) rows of perforations and snap-lock ends

J

9. Cast iron soil pipe, service weight No-Hub, ASTM A-888. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International.

K

10. Ductile iron water pipe, outside coated, AWWA C104/A21.4 cement mortar-lined, ANSI/AWWA C151/A 21.51 pipe

L

11. Black steel pipe ASTM A53/106 Grade B Seamless ANSI Schedule 40 with "X-Tru-Coat" Polyethylene or polypropylene coating (25 to 60 mils thickness)

M

12. Galvanized steel pipe ASTM A53/106, Grade B seamless ANSI Schedule 40

N

13. Enfield flame retardant polypropylene acid resistant drainage pipe, ASTM D635, Schedule 40

P

14. Polypropylene (PP) pipe by George Fischer, Asahi, or Orion, equal to George Fischer PPro-Seal, suitable for use in reverse osmosis/deionized (RO/DI) water systems. Natural virgin copolymer polypropylene with no added plasticizers, pigments or re-grind that is manufactured to schedule 80 wall thickness and is compliant with US Food and Drug Administration regulations 21.CFR 177.1520 Sections A1, B & C and conforms to ASTM D4101. Pipe shall be manufactured to the dimensions and tolerances of ASTM D1785. All pipes shall be packaged in polybags at the point of manufacturing to preserve pipe cleanliness.

Q

15. Plenumline FR-PVDF flame retardant polyvinylidene fluoride (PVDF) acid resistant drainage pipe, ASTM F 1673, Schedule 40, meeting the requirements of ASTM E84 and UL723

F. Fitting Materials:

Type — Designation

I

1. Cast iron soil pipe fittings, service weight, ASTM A74

II

2. Wrought copper and bronze drainage fittings, ANSI A16.29

III

3. Wrought copper solder joint fittings, 150 pound ANSI B16.22

IV

4. Black malleable iron screwed fittings, 150 pound, ANSI B16.3 for less than seventy-five (75) pounds per square inch and 300 pounds for seventy-five (75) pounds per square inch or more

V

5. Black malleable iron grooved fittings, ASTM A47, Victaulic Style 07, Zero Flex. Galvanized fittings shall be used for domestic water.

VI

6. Corrugated polyethylene snap-lock drain fittings for snap-together assembly

VII

7. Steel butt-welding fittings ANSI B16.9 using long-turn ells, ANSI B16.5 weld neck or slip on flanges & Bonney Forge Weldolets and Threadolets. Wall thickness to match pipe.

VIII

8. Cast iron soil pipe fittings, No Hub, ASTM A-888

IX

9. Cast iron pressure fittings AWWA Class D, 250 pounds per square inch

X

10. Steel butt-welding fittings ANSI B16.9 using long-turn ells with field applied "X-Tru-Coat" coating in accordance with manufacturer's recommendations

XI

11. Galvanized malleable cast iron screwed fittings, ANSI B16.3, 150 pounds for less than seventy-five (75) pounds per square inch and 300 pounds for seventy five (75) pounds per square inch or more. Provide drainage fittings for drain pipe.

XII

12. Black Cast iron screwed fittings, ANSI B16.4, 125 pound for less than seventy-five (75) pounds per square inch and 250 pounds for seventy-five (75) pounds per square inch or more

XIII

13. Forged steel socket-welding fittings, ANSI B16.11, Class 3000, Schedule 40.

XIV

14. Enfield mechanical joints and adapters. Connections containing EVA components are prohibited.

XVI

15. Polypropylene (PP) fittings by George Fischer, Asahi, or Orion, equal to George Fischer PPro-Seal, suitable for use in reverse osmosis/deionized (RO/DI) water systems. Natural virgin copolymer polypropylene with no added plasticizers, pigments or re-grind that is manufactured to schedule 80 wall thickness and is compliant with US Food and Drug Administration regulations 21.CFR 177.1520 Sections A1, B & C and conforms to ASTM D4101. Pipe shall be manufactured to the dimensions and tolerances of ASTM D1785. All fittings shall be packaged in polybags at the point of manufacturing to preserve pipe cleanliness.

XVII

16. Plenumline acid waste fittings and adapters. Fittings shall be third party certified to ASTM F 1673 and ASTM E84, and IAPMO approved. Connections containing EVA components are prohibited, meeting the requirements of ASTM E84 and UL723

G. Joint Materials:

Type		Designation
1.	Premolded rubber gaskets Tyler Pipe Industries, TY-Seal or Multiple Seal, ASTM C564	a
2.	Welded: Mechanical Contractors Association of America, Inc. Guidelines for Quality Piping Installation (1995), Section 2.1.O	b
3.	Threaded: American Standard for Pipe Threads, ANSI B2.1	c
4.	Mechanical: Grooved pipe joints: Victaulic Style 07, Zero Flex. Roll grooving shall be prohibited	d
5.	Soldered: ASTM B32 tin-antimony 95-5	e
6.	Brazed: Silver alloy brazing equal to Silfos and Easy-Flo by Handy and Harman. The use of flux is prohibited	f
7.	Brazed: Silver alloy brazing equal to Silfos and Easy-Flo by Handy and Harman. The use of flux is prohibited	g
8.	Tongue and groove joint sealed with mortar	h

i

9. No-Hub neoprene gasket and stainless steel corrugated shield, Tyler No-Hub coupling

j

10. Mechanical: Specification for Mechanical Joint or cast iron pressure pipe and fittings, ANSI A21.10

k

11. Enfield mechanical joints and adapters. Connections containing EVA components are prohibited.

m

12. Butt-welded joint construction with an approved welding device, certified personnel and meeting the requirements of ASTM F1290/ASTM D2657 Section 9. All equipment should utilize electronically controlled heating elements for accurate welding temperatures. Tools should also incorporate planing units to face ends prior to heating. Butt-fusion equipment supplied shall weld joints based on force and/or pressure and not mechanical stops.

n

13. Plenumline mechanical joints and adapters meeting the requirements of ASTM E84 and UL723, XVII. Connections containing EVA components are prohibited

H. Pre-Insulated Direct Buried Piping System

1. Refer to Division 23, Section "Underground Distribution Piping".

2.4 VALVES

A. General:

1. Valves shall be provided where indicated on the drawings and as herein specified.
2. Valves shall be placed in such manner as to be easily accessible for hand wheel operation and stuffing maintenance.
3. Install shut-off valves in piping where shown or where listed below:

    a. To isolate all items of equipment.
    b. To isolate motorized flow control valves.
    c. To isolate branch lines and riser at mains.

4. Valve pipe connections shall be screw, solder or weld flange as required to be consistent with other parts of the piping system.
5. Where piping or equipment may subsequently need to be removed, provide valves with bodies having integral flanges or full lugs drilled and tapped to hold valve in place so that downstream piping or equipment can be disconnected and replaced with blank-off plate while valve is still in service.
6. Valves over ten (10) feet above standing level and above six (6) inches in size shall have

chain wheel with chain extending to within six (6) feet of standing level. All wheel operated valves shall have an indicator to show the position of the disc or plug.

7. Where valves specified are not available in the pipe size noted on the drawing, the next larger size valve shall be provided.
8. Valves shall be provided for fire protection systems as specified in Division 21, Section "Fire Protection."

B. Balancing Valves:

1. Provide balancing valves where indicated and required to balance water flow through the piping system.
2. Balancing valves, 1 1/4 inches and larger, for systems piping shall be DeZurik as follows: PEC, flanged above two (2) inches with Buna filled PTFE U-ring seal and isobutene-isoprene plug facing, suitable for 250 degrees Fahrenheit continuous operation. Valves in chilled water and tower water systems may have seal and plug facing suitable for 180 degrees Fahrenheit. Valves six (6) inches and smaller shall have lever actuators and valves eight (8) inches and larger shall have gear operators. All actuators shall have adjustable memory stops.
3. Balancing valves one (1) inch and smaller shall be Armstrong Model CBV or as manufactured by TA Hydronics or approved equal.

C. Butterfly Valves:

1. Butterfly valves may be used in lieu of gate valves in chilled water, glycol water, condenser water and heating water systems size 2-1/2 inches and over.
2. Butterfly valves shall be Nibco, Centerline, DeZurik, Posi-Seal, or Jamesbury equal to Nibco Fig. No. 2000 lug body type, installed with welding neck companion flanges.
3. Valves shall have semi-steel or ductile iron lug body for flanged connection with alignment bolts, holes or guides, Type 416 stainless steel one (1) piece stem, upper and lower brass bushings, EPDM or nitrile (Buna-N) rubber liner, and aluminum bronze disc. Provide minimum two (2) inch extension neck on valves for insulated piping.
4. Pressure ratings shall be 150 pounds per square inch (psi) body; dead end bubble tight shut off for 200 pounds per square inch (psi) differential in either direction.
5. Actuators for valves six (6) inches and smaller shall be lever type with locking trigger with ten (10) position notched quadrant. Actuators on valves eight (8) inches and larger shall be heavy duty gear operators. All actuators shall have adjustable memory stops.
6. Butterfly valves shall not be used for steam, feedwater or condensate service.

D. Ball Valves:

1. Ball valves shall be used in all water systems size two (2) inches and smaller.
2. Ball valves shall be Nibco, Jamesbury, Apollo or Watts.
3. Two (2) piece ball valves sizes one (1) inch and smaller may be used for domestic water systems where replacement of internal parts is not critical. Valves shall be equal to Nibco Figure No. 585-70-66, bronze body, full port, stainless steel ball and stem (ASTM A-276, Type 316), TFE seat, blowout proof stem, extended stem for insulation thickness, and suitable for 150 pounds per square inch saturated steam service.
4. Three (3) piece ball valves sizes 1/2 inch to two (2) inch shall be used for all water piping systems to accommodate replacement of internal parts. Valves shall be equal to Nibco

Figure No. 595-Y-66, swing out design, bronze body, full port, stainless steel ball, and stainless steel stem (ASTM A-276 Type 316), reinforced TFE seats. Body bolts and nuts shall be zinc dichromate plated steel and valve shall be suitable for 150 pounds per square inch saturated steam service. Valves shall be threaded or soldered to suit piping systems which they are installed.

5. Three (3) piece ball valves sizes 1/2 inch to four (4) inch shall be used for all medical gas piping systems to accommodate replacement of internal parts. Valves shall be equal to Nibco Figure No. 595-Y-66, swing out design, bronze body, full port, stainless steel ball, and stainless steel stem (ASTM A-276 Type 316), reinforced TFE seats. Body bolts and nuts shall be zinc dichromate plated steel and valve shall be suitable for 150 pounds per square inch saturated steam service. Valves shall be threaded or soldered to suit piping systems which they are installed. All valves shall be serviceable in the line and supplied clean and prepared for oxygen service. Valves shall be packaged in a polyethylene bag to keep them clean on the job site.
6. Three (3) piece ball valves size 1/2 inch to two (2) inch shall be used for all steam and condensate piping systems to accommodate replacement of internal parts. Valves shall be equal to Nibco Figure No. 590-CS-R-66, stainless steel trim (A-276 type 316) with threaded or socket weld ends to suit system wherein installed.
7. Valves shall be equipped with lever handle with extended stem for insulation thickness which shall indicate position of ball orifice and have stops for fully open and closed position. Construction shall be such that power actuator can be used. Ball opening shall be full pipe size.
8. Valve shall be suitable for flow in either direction and must be leak proof at all pressures up to 150 pounds per square inch gauge (psig) and temperatures from minus twenty (-20) degrees Fahrenheit to 350 degrees Fahrenheit in open or shut position.

E. Drain Valves:

1. Drain valves shall be ball type as hereinbefore specified with hose end adapter and shall be provided at low points of all piping systems, and where indicated, 3/4 inch minimum.

F. Gas Valves:

1. Shut-off valves for natural gas service shall be ball type Jamesbury Clincher Type 2000 or approved equal for sizes up to two (2) inch. Valve shall have screwed ends, brass body, and 316 stainless steel trim. Valves shall meet UL Guide Designation YRPV for gas shut-off valves.
2. Shut-off valves for natural gas service shall be ball type Jamesbury Series 5150 ANSI Class 150 or approved equal for sizes greater than two (2) inches. Valve shall be flanged ends, ductile iron body, and 316 stainless steel trim. Valves shall meet UL Guide Designation YRPV for gas shut-off valves.

G. Valve Schedule:

1. Unless otherwise specified, valves shall be Nibco, Stockham, or Crane equal to the Nibco figure numbers indicated below:

a. Domestic Hot, Cold, Tempered and Recirculated Water Systems:

Globe - Solder end	S-211-Y
Check - Solder end	S-413-Y
Gate - Flanged end	F-619

b. Chilled Water, Glycol Water, and Condenser Water:

Gate - 2-1/2" and over	F-619
Globe - 2-1/2" and over	F-718-B
Globe - 2" and under	T-211-B
Check - 2-1/2" and over	F-918-B
Check - 2" and under	T-413-B

c. Blowdown:

Quick Opening	Everlasting Series 4000 Meeting ASME/ANSI Code

d. Steam Supply and Steam Condensate Return:

Gate - 2-1/2" and over	F-637-33
Gate 2" and under	T-124
Globe - 2-1/2" and over	F-768-B
Globe - 2" and under	T-235-Y

e. Condensate Return Only:

Check - 2-1/2" and over	F-918-B
Check - 2" and under	T-413-B

f. Heating Water:

Gate - 2-1/2" and over	F-619
Globe 2-1/2" and over	F-718-B
Globe - 2" and under	T-211-B
Globe - Solder end	S-211-Y
Check - 2-1/2" and over	F-918-B
Check - 2" and under	T-413-B
Check - Solder end	S-413-B

g. Pumped Discharge:

Check - 2-1/2" and over	F-918-BL&W with lever and weight

2.5 PIPING SPECIALTIES

A. Strainers shall be Mueller Steam Specialty Company, Inc., or approved equal, No. 351 for two (2) inch and smaller, No. 758 (125 lbs.) or No. 725 (250 lbs.) for 2-1/2 inch and larger. Basket strainers shall be Mueller Steam Specialty Company, Inc. or approved equal, No. 185. Provide valved blow-down connections on each strainer consisting of a ball valve set between two (2) short nipples. Blow-down valve shall be full size of strainer blow-down connection. Steam and condensate strainers shall be laid parallel to the floor to prevent the accumulation of condensate in the strainer body. Screens shall be stainless steel with perforations as follows:

Steam Service	3/64 inch perforations

1. Contractor shall provide coarse construction strainers in each strainer or inline cone strainers in the piping system during equipment start-up periods. A list of construction strainers with their proposed location shall be submitted to the Architect for approval. After systems have been flushed clean and are fully operational construction strainers shall be removed and turned over to the Owner for accounting. Final strainer elements shall be installed after all construction strainers have been accounted for.

2.6 TEST PLUGS

A. Pressure and temperature test plugs where indicated or required shall be 1/4 inch npt fittings, suitable to receive either a 1/8 inch outside diameter (OD) temperature or pressure probe. Fittings shall be solid brass with Nordel valve core, fitted with a color coded marked cap with gasket. The entire assembly shall be rated at 1000 pounds per square inch gauge (psig). Plugs shall be manufactured by Peterson Equipment Company, Inc., Richardson, Texas, or Sisco P/T plugs.

2.7 STEAM SYSTEM SPECIALTIES

A. Steam System Strainers:

1. Provide Y Type strainers in compliance with Fluid Control Institute Standard 73-1, full size of connecting pipe. Provide integral blowdown connection.
2. Low & Medium Pressure Steam and Condensate Return:

   a. Strainers shall be rated for 125 psig saturated steam.
   b. Strainers 2 inches and larger shall be flanged, cast iron body. Strainers smaller than 2-inches shall be cast iron or bronze with screwed connections.
   c. Strainer screens shall be type 304 stainless steel, free area not less than 2-1/2 times pipe area, with 20 mesh perforations.
   d. Strainers shall be Spirax/Sarco type IT, CI-125 or F-125, or equal by Watts or Armstrong.

3. High Pressure Steam:

a. Strainers shall be rated for 250 psig saturated steam.
b. Strainers 2 inches and larger shall be flanged cast iron. Strainers smaller than 2-inches shall be cast iron, or bronze body with screwed connections.
c. Strainer screens shall be type 304 stainless steel, free area not less than 2-1/2 times pipe area, with 20 mesh perforations.
d. Strainers shall be Spirax / Sarco type IT, CI-250 or F-250, or equal by Watts or Armstrong.

B. Steam Traps:

1. Each type trap shall be the product of a single manufacturer. All trap bodies shall be constructed to permit ease of removal and service of working parts without disturbing connecting piping. Floats and linkages shall provide sufficient force to open trap valve over full operating pressure range available to the system. Unless otherwise indicated on the drawings, traps shall be sized for capacities indicated at minimum pressure drop.
2. Steam Traps on Low Pressure Steam (15 psig and below):

a. Equipment or Process (with modulating control valve): Use Float and Thermostatic (F&T) type rated for 15 psi working pressure. Each trap shall be sized using 1 psi differential pressure at 2 times scheduled flow rate of equipment, based on a condensate leg of 18 inches at trap inlet and gravity flow to the main return line or receiver. Condensate may not be lifted to the return line unless otherwise approved by the Engineer. Traps shall be Spirax/Sarco UFT14 float & thermostatic steam trap with universal strainer connector with blowdown (parallel connection).
b. Main Line drips: Use balanced pressure thermostatic type rated for 15 psi working pressure. Main line drip traps shall be selected using 70 percent of design differential pressure at required flow. Provide trap sets at all low points and at 200 foot intervals on the horizontal main lines. Condensate may not be lifted to the return line unless otherwise approved by the Engineer. Traps shall be Spirax/Sarco UBP32 thermostatic steam trap with universal strainer connector with blowdown (bolt-on trap).

3. Steam Traps on Medium or High Pressure Steam (over 15 psig):

a. Equipment or Process (with modulating control valve): Use Float and Thermostatic (F&T) type rated for working pressure. Traps on equipment using 15 to 30 psig steam shall be sized for 3 times scheduled flow rate of equipment at 2 psig differential pressure. Traps on equipment using 30 psig steam and above shall be sized for 2 times scheduled flow rate of equipment at 5 psig differential pressure. Condensate may not be lifted to the return line unless otherwise approved by the Engineer. Traps shall be Spirax/Sarco UFT14 float & thermostatic steam trap with universal strainer connector with blowdown (parallel connection).
b. Main Line drips: Use Thermodynamic type on 15 psig and above. Traps shall be sized as indicated on plans. Main line drip traps shall be selected using 70 percent of design differential pressure. Provide drip trap sets at all low points and natural drainage points such as, ends of mains, bottoms of risers, and ahead of pressure regulators, control valves, isolation valves, expansion joints. On straight runs of

pipe with no natural drainage points, install drip legs at 200 foot intervals on the horizontal main lines. Condensate may be lifted to the return line. Traps shall be Spirax/Sarco UTD52L thermodynamic steam trap with universal strainer connector with blowdown (bolt-on trap).

4. Float and Thermostatic (F&T) traps shall comply with ASTM A126, cast iron body and bolted cover, with replaceable stainless steel float, lever and valve assembly. Thermostatic air vent shall be balanced pressure, stainless steel or bronze bellows with stainless steel valve and seat. Float and thermostatic trap shall not be installed in a manner to lift condensate up to a return line. F & T trap shall be Spirax/Sarco FT-15 to FT-200 or equal by Hoffman Specialty or Armstrong.
5. Balanced pressure traps shall be maintenance-free and tamper-proof design of all stainless steel construction with forged body and drawn cover completely sealed against leakage. Operating element to be a solidly liquid-filled thermostatic capsule which self adjusts to all pressures to 435 psig. Trap shall vent air freely and withstand waterhammer, freezing and superheat. Balanced pressure trap shall be Spirax/Sarco BP32 or equal by Hoffman Specialty or Armstrong.
6. Thermodynamic traps with integral strainers shall be stainless steel body, disc , insulating cap and integral strainer with blowdown connection, rated for 600 psig. Trap shall be Spirax/Sarco TD42L or equal by Hoffman Specialty or Armstrong.
7. Universal connector (bolt-on) steam traps shall consist of stainless steel pipeline connector with integral strainer & blowdown which when installed remains in the line permanently. Stainless steel trap shall be attached to the connector by two bolts to enable simple and rapid installation and replacement. Bolting pattern on connector shall be universal among manufacturers and shall be capable of accepting thermodynamic, balanced pressure thermostatic, inverted bucket, or float & thermostatic steam traps. Universal traps shall be Spirax Sarco UTD52, UBP32, UFT14 or equal.

C. Combination Vacuum Breaker/Air Vent: Cast iron body, balanced pressure bellows, stainless steel (renewable) valve and seat, rated 125 psig working pressure, 1/2-inch screwed connections. Vacuum breaker shall be stainless steel construction, including the body, threaded cap, valve and valve seat. Air vent shall be balanced pressure type that responds to steam pressure-temperature curve and vents air at any pressure. Combination vacuum breaker/balanced pressure thermostatic air vent shall be Spirax/Sarco VB-VS, or equal by Watson-McDaniel or Armstrong.

D. Unions, Flanges and Couplings

1. Use unions for pipe 2 inches and smaller. 150 psig galvanized malleable iron, threaded.
2. Use flanges for pipe 2 ½" inches and larger. 150 psig forged steel, slip on.
3. Gaskets: 1/16 inch thick, non-asbestos graphite fiber.
4. Dielectric connections shall be union with galvanized or plated steel threaded end, copper solder and, water impercious isolation barrier.

E. Steam pressure regulating valves shall be Spence Regulator Type ED or approved equal. Regulators shall have the capacity as indicated on the drawings.

F. Relief valves for steam systems sizes two (2) inches and less shall be Spirax Sarco, ASME Standard 6000 Series or approved equal. Relief valves for steam systems sizes 2.5 inches and

larger shall be Lonergan, ASME Standard D Series or approved equal.

G. Noise suppressor for steam pressure reducing stations shall be Spence ANSI Class 150 with welded steel components, stainless steel acoustic material, and 500 degrees Fahrenheit temperature rating. Suppressor shall have 150 pound flat faced flanges and drain connection in bottom.

H. Flash tank shall be Spirax Sarco flash recovery vessels or approved equal, ASME Stamped and approved. Tank capacity and size shall be as indicated on the drawings.

2.8 DIELECTRIC FITTINGS

A. General: Provide assembly or fitting with insulating material isolating joining of dissimilar metals, to prevent galvanic action and stop corrosion.

B. Description: Combination of copper alloy and ferrous; threaded, soldered, plain end, or weld neck types matching piping system materials.

C. Insulating Material: Suitable for system fluid, pressure, and temperature.

D. Dielectric Unions: Factory-fabricated, union assembly, for 250 psig minimum working pressure at 180 deg. F.

E. Dielectric Flange Insulating Kits: Field assembled, companion flange assembly, full face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers. Provide Class 150 or Class 300 flanges to match system pipe requirements.

F. Dielectric Couplings: Galvanized steel coupling with inert and non-corrosive, thermoplastic lining, threaded with 300 psig minimum working pressure at 225 deg. F.

G. Dielectric Nipples: Electroplated steel nipple with inert and non-corrosive, thermoplastic lining, threaded with 300 psig minimum working pressure at 225 deg. F.

2.9 FLEXIBLE CONNECTORS

A. General: Provide stainless steel braided flexible connectors with design pressure and temperature rating meeting or exceeding the test pressures and operating temperatures of the systems in which they are installed. Pipe sizes 2-inch and smaller shall be socket welded or threaded matching system requirements. Pipe sizes above 2-inch shall be Class 150 or Class 300 flanged matching system requirements.

B. Stainless steel hose / Steel pipe, flexible connectors: Corrugated, stainless steel inner tubing covered with stainless steel single wire braid. Include steel nipples or steel flanges welded to hose. Minimum length shall be three times pipe diameter up to 4-inch pipe size and two times pipe diameter up to 18-inch pipe size.

2.10 PIPE ANCHORS

A. All pipe lines shall be anchored where specified herein, indicated on drawings and where required to prevent uncontrolled movement. Anchors shall be constructed of steel sections and plates, assembled by bolting or welding and secured to the building structure by means of bolts, clamps or welding. Anchors shall prevent both axial and lateral movement of the lines. Anchor vertical pipes by means of clamps welded to pipe and secured to wall or floor construction. Submit details of anchors for approval.

B. Anchor piping adjacent to flexible pipe connectors to prevent connector from expanding against its restraining bolts and also to keep the pipe on both sides of the connector in alignment.

2.11 EXPANSION

A. All piping shall be so installed that it will in no way be distorted or strained by expansion or contraction. Except as noted, all expansion and contraction shall be taken up by means of swing joints, loops, bends or long offsets. Swing joints made up with at least three (3) elbows shall be provided in branches from mains in runouts. Size loops for the total pipe expansion without cold springing, but field cold spring 1/2 the pipe on expansion corrected for ambient temperature.

B. Where expansion joints are indicated or required, select joints with a traverse of 150 percent of the pipe expansion from an ambient of forty (40) degrees Fahrenheit to the maximum system operating temperature.

C. Expansion joints two (2) inches and larger shall have flanged ends, except when installed in copper piping systems.

D. All expansion joints shall be suitable for minimum operating pressure and temperature of 150 pounds per square inch (psi) and 300 degrees Fahrenheit respectively.

E. Expansion joints shall be of the following types:

1. Corrugated Type - Flexonics "Low-Corr" joints for pipes three (3) inches and larger. Flexonics Model H or HB for pipes smaller than three (3) inches.
2. Slip Type - Flexonics "Slip Pakt" with anchor base.

F. Submit, for approval, manufacturers' shop drawings of each expansion joint provided depicting length of pipe, location of anchors and guides, calculated expansion offset and type of joint employed.

2.12 PIPE GUIDES

A. Install pipe guides where indicated on drawings or where required for proper installation of expansion loop. Limit use of guides with expansion loop to points shown or where required to prevent buckling of pipe whether indicated or not.

B. Do not use pipe guides as pipe supports.

C. Provide factory made cast semi-steel or other heavy fabricated steel consisting of a bolted two (2)-section outer cylinder and base with a two (2)-section guiding spider welded or bolted tight to the pipe, of sufficient size to clear pipe insulation and long enough to prevent over-travel of spider in cylinder. Furnish a guide sleeve of a length not less than the length of pipe expansion plus the spider length.

D. When installed in cooling systems, guides must permit the application of thermal insulation.

2.13 MISCELLANEOUS MATERIALS FOR SUPPORTS, HANGERS, ANCHORS AND GUIDES

A. The Contractor shall provide all miscellaneous materials required to properly install all supports, hangers, anchors and guides, including:

1. Steel Plates, Shapes and Bars: Provide products complying with ASTM A36.
2. Cement Grout: Portland Cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.
3. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.

PART 3 - EXECUTION

3.1 CLEANING, FLUSHING, INSPECTING

A. General: Clean exterior surfaces of piping systems of superfluous materials, and prepare for application of specified coatings (if any.) Clean interior of pipe by mechanical means to remove welding slag, metal filings, dirt, and debris. Flush out piping systems to the satisfaction of the Owner before proceeding with required tests. Inspect each run of each system for completion of joints, supports, and accessory items.

1. Inspect Power Piping in accordance with procedures of ASME B31.1.

B. The Contractor shall submit a detailed pipe flushing plan detailing the efforts to be taken to ensure a completely clean piping system. Any damage to existing or new equipment or components shall be repaired or replaced at the Contractor's expense to the satisfaction of the Owner.

C. The Contractor shall clean and flush all installed piping systems with a clean water solution with additives formulated to assist in the removal of welding slag, metal filings, oil, and grease. Flushing operations shall maintain a minimum velocity of six feet per second for a minimum four hour time frame. Repeat flushing operations to the satisfaction of the Owner and until flushing water is completely clear. System pumps may be utilized for flushing operations with fine mesh start-up screens. Clean screens often and replace with final system screens at

completion of flushing operations. Provide temporary equipment bypasses for all components where metal slag and filings are prone to collect (such as chillers, heat exchangers, and boilers.) The Contractor shall provide all temporary equipment and piping necessary to complete the flushing operations. Cooling tower basins shall be drained, cleaned of all mud and dirt, and sump screens cleaned. Cooling tower basins shall be checked and reflushed weekly during site construction activities that create airborne dust and particles.

D. Refill and vent water systems being sure to add water after venting to completely fill system.

E. Disinfect new or repaired water mains and water service piping in accordance with AWWA A601 and section 610 of the 2006 International Plumbing Code.

F. Provide water treatment services as indicated in other Division 23 specification Sections.

3.2 PIPING INSTALLATION

A. Install piping without undue stress or strain in locations shown and run parallel to the lines of the building, except to grade them as specified in neat and workmanlike manner using a minimum of fittings. Provide such fittings, valves and accessories as may be required to meet the conditions of installation. Contractor shall inform himself fully regarding any peculiarities and limitations of space available for installation of material under each section of specifications. Install piping to suit necessities of clearance with ducts, conduits, and other work, and so as not to interfere with any passages or doorways and allow sufficient head room at all places. Use proper reducing fittings for changing piping sizes.

B. Cut pipes accurately to measurements established in the field in a neat and workmanlike manner without damage or without forcing or springing. Perform cutting by means of an approved type of mechanical cutter of the wheel type where practicable. Ream pipe after cutting to remove all burrs.

C. Because of the small scale of the drawings, it is not possible to indicate all offsets, fittings and accessories that may be required. Carefully investigate the architectural and structural conditions affecting the work, and arrange such work accordingly, providing such fittings, and accessories as may be required to meet such conditions. Drawings (plans, schematics, and diagrams) indicate the general location arrangement and restrictions of the piping systems. Location and arrangement of piping layout shall take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated on the Contract Drawings unless deviations to layout are approved on the Coordination Drawings. The Contract Drawings are diagrammatic in nature and are not welding fit-up documents. The Contractor is responsible for a complete installation. Refer to individual system specifications for requirements for coordination drawing submittals.

D. Install at low points of gas piping and at the foot of each riser and each drip, a "T" fitting and six (6) inch long capped drip pocket of same size and riser or drip. Grade horizontal gas pipe to prevent traps. Pipe all green gas vents to the exterior as required by Code. Make all joints with graphite and oil and in accordance with National Fuel Gas Code requirements.

E. Install unions and flanges where shown and on each side of all pieces of equipment and other

similar items, and in such a manner that the unions can be readily disconnected. Do not place any union or flange in a location which will be inaccessible after completion of the project unless so shown on drawings or specified.

1. Unions in steel pipe 2 1/2 inches and smaller, shall be 250 pound malleable iron, brass seat type. Use 150 pound forged steel flanges for piping three (3) inches and larger. Gaskets shall be 1/8 inch thick.
2. Unions in copper pipe two (2) inches and smaller shall be wrought copper with red bronze ring nut. Use 150 pound ASME copper flanges for piping 2 1/2 inches and larger. Use dielectric unions or couplings where nonferrous metal is joined to ferrous metal.

F. Use reducing fittings, eccentric where required to prevent pocketing of air and water or both, to make changes to pipe sizes.

G. HVAC piping shall be installed plumb, level, and square with low point drains and high point vents. Steam, condensate, drain and sanitary waste and vent piping shall be sloped per code.

H. Contractor shall fully coordinate the installation of all piping systems with all other trades including sheet metal, electrical, sprinkler, ceiling systems, etc.

3.3 JOINTS

A. Steel Pipe Joints:

1. Threaded Pipe Joints, 2" and Smaller: Thread pipe with tapered pipe threads in accordance with ANSI B1.20.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint lubricant or sealant suitable for the service for which the pipe is intended on the male threads at each joint and tighten joint to leave not more than 3 threads exposed. Align threads at point of assembly. Tighten joint with wrench. Do not use pipe or pipe fittings with threads that are damaged or corroded. Do not use pipe sections that have cracked or open welds. Comply with the provided pipe material classification requirements for allowance of threaded pipe within each service type. Threaded pipe will not be allowed for high temperature hot water service.
2. Pipe Larger Than 2":

    a. Weld Pipe joints in accordance with ASME Code for Building Services Piping, 31.9. Bevel weld end to end. Sleeve welds shall not be permitted.
    b. Install flanges on all valves, apparatus, and equipment. Weld pipe flanges to pipe ends in accordance with ASME Code for Building Services Piping. Clean flange faces and install gaskets. Tighten bolts gradually and uniformly using a torque wrench to torque specified by manufacturer or flange and sequence flange bolts, to provide uniform compression of gaskets. Use suitable lubricants on bolt threads.

B. Non-Ferrous Pipe Joints:

1. Brazed and Soldered Joints: For copper tube and fitting joints, braze joints in accordance with ANSI B31.31.0 – Standard Code for Pressure Piping, Power Piping and ANSI B9.1

– Standard Safety Code for Mechanical Refrigeration.

2. Thoroughly clean tube surface and inside surface of the cup of the fittings, using very fine emory cloth, prior to making soldered or brazed joints. Wipe tube and fittings clean and apply flux. Flux shall not be used as the sole means for cleaning tube and fitting surfaces.

C. Weld pipe joints in accordance with ASME Code for Building Services Piping, B31.9. Weld piping in accordance with recognized industry practice and as follows:

1. Weld pipe joints only when ambient temperature is above 0 degree F.
2. Bevel pipe ends at a 37.5 degree angle, smooth rough cuts, and clean to remove slag, metal particles, and dirt.
3. Use pipe clamps or tack-weld joints with 1" long welds; 4 welds for pipe sizes to 10", 8 welds for pipe sixes 12" to 20".
4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes, and non-metallic inclusions.
5. Do not weld out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.

D. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

E. Hubless Cast-Iron Joints: Comply with coupling manufacturer's installation instructions.

3.4 WORKMANSHIP

A. Cut pipes accurately to measurements established at structure. Install pipes without springing or forcing.

B. Clear windows, doors, and other openings with all pipes and ductwork.

C. Arrange pipes to permit expansion and contractions without misalignment or damage.

D. During construction all openings in piping and equipment shall be closed with caps or plugs to keep out all foreign matter and to prevent leakage.

E. All piping in finished spaces shall be run concealed unless otherwise indicated.

3.5 WELDING

A. Refer to Division 23, Section "Mechanical and Electrical General Provisions".

3.6 SLEEVES AND PLATES

A. Sleeves shall be provided by the trade installing the pipes for which sleeves are to be used. The sleeves shall be carefully located in advance of the construction of walls and floors where new construction is involved. All cutting and patching necessary to set sleeves which are not placed prior to construction shall be the responsibility of the trade providing the sleeves.

B. Sleeves shall be provided for all piping passing through all floor slabs and concrete, plaster, gypsum, or masonry wall construction.

C. Where pipe motion due to expansion and contraction will occur, make sleeves of sufficient diameter to permit free movement of pipe. Where sleeves pass insulated pipes, the sleeves shall be large enough to pass the pipe and the insulation. Check floor and wall construction to determine proper length for various locations; make actual lengths to suit the following:

1. Terminate sleeves flush with wall.
2. Terminate sleeves two (2) inches above finished floors.

D. Submit for approval shop drawings showing size, type, and location of all sleeves and penetrations through poured concrete walls. See Architectural Drawings for extent and location of such walls.

E. All pipe sleeves shall be constructed of Schedule 40 steel pipe unless otherwise indicated on the drawings.

F. See drawings for additional sleeve requirements.

G. Fasten sleeves securely in floors and walls so that they will not become displaced when concrete is poured or when other construction is built around them. Take precautions to prevent concrete, plaster or other materials from being forced into space between pipe and sleeve during construction. Caulk the annular space with elastic caulk compound or as noted to make tight.

H. Where watertight sleeves are indicated, provide Link Seal rubber seals, as manufactured by Thunderline Corporation, between pipes and sleeves, or provide sleeves as detailed.

3.7 STEAM SYSTEMS

A. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves require eccentric reducers to connect to pipe sizes shown on the drawing.

B. Provide full line size strainers as indicated and ahead of all steam traps, pressure regulating/reducing valves, and temperature control/regulating valves unless integral strainer is provided. Provide each strainer with a valved blow-off, full size of blow-off connection. Strainers installed in steam piping systems shall be oriented in the side position.

C. Install steam traps with union or flanged connection on both ends of trap with shut-off valves,

inlet strainer and outlet check valve. Install steam traps in accessible locations as close as possible to connected equipment, but not more than 48" from equipment. Provide dirt leg with blow down as recommended by manufacturer. Install drip traps close to drip leg. Sized drip legs at vertical risers same size as pipe and extend beyond rise. Size drip legs at other locations same diameter as main, up to 5". In steam mains 6" and larger, dirt leg size can be reduced, but in no case less than 4" NPS.

D. Install steam pressure gauges with siphons and isolation valves both upstream and downstream of pressure reducing valves, heat exchangers, condensate return pumps, and at other locations indicated on the drawings.

E. Install premanufactured accessories and equipment in accordance with the manufacturer's instructions and recommendations.

3.8 TESTS

A. The following tests shall be conducted by the Contractor and all piping shall be proven tight in the presence of the Architect or his representative. These tests shall be conducted before any insulation is installed and any insulation installed prior to tests shall be removed. Provide all equipment and labor required. Tests shall be at least four (4) hours in duration, after all piping has been proven tight. Piping may be tested in sections as approved by the Architect. Tests shall be as specified herein and a written test report shall be submitted to the Architect within two (2) days following each individual test. All test reports shall be included in the operation and maintenance manuals.

B. The domestic water piping shall be hydrostatically tested to 150 pounds per square inch gauge (psig). All openings in the water piping shall be plugged; the system, or portion thereof, filled with water, and tested with a pump to a pressure of 150 pounds per square inch gauge (psig). Domestic water system piping shall be disinfected after tests in accordance with Baltimore City and Maryland State Health Department Requirements.

C. The sanitary and miscellaneous drain systems shall be hydrostatically tested. Tests shall be as required by code and as a minimum shall comprise of the plugging of all openings in the lines, filling the system (or portion thereof), with water until all joints are proven tight. Piping shall be tested with a minimum head of ten (10) feet of water.

D. All heating water, chilled water, glycol water, condenser water, and steam piping shall be hydrostatically tested to 1-1/2 times the system working pressure or a minimum of 100 pounds per square inch gauge (psig), whichever is greater.

1. Underground piping systems shall be hydrostatically tested before insulation is applied at field joints, and shall be proved tight at a pressure of 1-1/2 times the working pressure, but not less than 150 pounds per square inch gauge (psig). Duration of test shall be four (4) hours, with no leakage.

3.9 STERILIZATION

A. Domestic water system piping shall be disinfected in accordance with State of South Carolina Health Department requirements and Section 610 of the 2006 International Plumbing Code. A written test report shall be submitted to the Owner and Architect within five (5) days following the sterilization process and before occupancy is granted. All written reports shall be included in the operation and maintenance manuals.

B. After final testing for leaks, all new domestic water lines shall be thoroughly flushed by Contractor to remove foreign material. Before placing the systems in service, Contractor shall engage a qualified water service Contractor to sterilize the new water lines. Sterilization shall include as a minimum the following procedure:

1. Through a 3/4" hose connection in the main entering the building, pump in sufficient sodium hypochlorite to produce a free available chlorine residual of not less than 200 parts per million. The Contractor shall provide plumbing connections and power for pumping chlorine into the system.
2. Proceed upstream from the point of chlorine application opening all faucets and taps until chlorine is detected. Close faucets and taps when chlorine is evident.
3. When chlorinated water has been brought to every faucet and tap with a minimum concentration of 200 parts per million chlorine, retain this water in the system for three (3) hours. CAUTION: Over-concentration of chlorine and more than three (3) hours of retention may result in damage to piping system which shall be replaced by the Contractor at no additional cost.
4. At the end of the retention period, no less than 100 parts per million of chlorine shall be present at the extreme end of the system.
5. Proceed to open all faucets and taps and thoroughly flush all new lines until the chlorine residual in the water is less than 1.0 parts per million.
6. Obtain representative water samples, at least two (2), from the system for analysis by a recognized bacteriological laboratory.
7. If the samples tested for coliform organisms is negative, a letter and laboratory report shall be submitted by the water service organization to the Contractor, certifying successful completion of the sterilization.
8. If any samples tested indicate the presence of coliform organism, the entire sterilization procedure shall be repeated.

3.10 MOLD AND CONDENSATION PREVENTION

A. Piping Systems: Cold piping systems (such as cold water) shall not be operated prior to insulation and vapor barrier installation in order to prevent condensation on the piping.

B. Air Systems: Air handling systems shall not be operated at supply air temperatures below fifty (50) degrees F and all supply air ductwork shall be insulated prior to operation. Coils shall be insulated to prevent condensation when heating valve is closed. Air systems shall not be operated in portions of the building not yet fully enclosed, where systems can be exposed to warm, humid air conditions.

C. Room thermostats shall not be set lower than sixty-eight (68) degrees F. Programmable

thermostats shall be set to prevent lower temperature setting from the exterior of the thermostat by room occupants.

D. Contractor shall notify the Architect immediately if signs of condensation or mold are discovered.

END OF SECTION 230530

SECTION 230548 - MECHANICAL VIBRATION, SOUND AND SEISMIC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

B. The 2009 International Building Code and SEI/ASCE 7-05 Standard apply to all work associated with the seismic installation of all new mechanical and electrical equipment. Refer to Architectural and Structural drawings for seismic loads and additional seismic information.

1.2 SCOPE

A. This section includes requirements for items of equipment, materials and procedures which are common to more than one section of Division 22 and 23. This section applies to all sections of Divisions 22 and 23.

1.3 SUMMARY

A. This Section includes the following:

1. Elastomeric hangers.
2. Spring hangers.
3. Spring hangers with vertical-limit stops.
4. Thrust limits.
5. Pipe riser resilient supports.
6. Resilient pipe guides.
7. Restraining cables.
8. Certification of seismic restraint designs and installation supervision.
9. Certification of seismic attachment of housekeeping pads.

B. Work includes vibration control devices, materials, and related items for mechanical and electrical systems. Perform all work as shown on the drawings and as specified herein to provide complete vibration isolation systems in proper working order.

C. The requirements of Division 15, Section "Mechanical and Electrical General Provisions" shall apply to work specified under this section.

1.4 DEFINITIONS

A. A_v: Effective peak velocity related acceleration coefficient.

B. OSHPD: Office of Statewide Health Planning & Development for the State of California. OSHPD assigns a unique anchorage preapproval "R" number to each seismic restraint it tests. The number describes a specific device applied as tested.

C. Life Safety Systems:

1. All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems.
2. All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers and all flowpaths to fire protection and/or emergency lighting systems.
3. All medical and life support systems.
4. Fresh air relief systems on emergency control sequence including air handlers, conduit, duct, dampers, etc.
5. All life safety equipment has an asterisk on the equipment schedule.

D. Positive Attachment: A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, fire protection, electrical conduit, bus duct, or cable trays, or any other equipment are not acceptable on this project as seismic anchor points.

E. Transverse Bracing: Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.

F. Longitudinal Bracing: Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

G. Failure: For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8" and/or horizontal permanent deformation greater that 1/4".

1.5 SUBMITTALS

A. Product Data: Include load deflection curves for each vibration isolation device.

B. Shop Drawings: Signed and sealed by the manufacturer's qualified professional engineer. Before ordering any products, submit shop drawings of the items listed below. The shop drawings must be complete when submitted, be based on equipment actually purchased and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection of the submittal. Include the following:

1. Product Description: A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.
2. Selection Data: Detailed selection data for each vibration isolator supporting equipment, including:

    a. Equipment identification mark;
    b. Isolator type;
    c. Actual load;
    d. Static deflection expected under the actual load
    e. Specified minimum static deflection.

3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases. Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by the manufacturer's registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.
4. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
6. Seismic-Restraint Details: Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
7. Submittals for Interlocking Snubbers: Include load deflection curves up to 1/2-inch deflection in x, y, and z planes.
8. Seismic restraint calculations.
9. Provide Approved Agencies Certificate of Compliance meeting Seismic Category D for all components. Tests shall include anchorage, structural and on line capability from analytical or shaker test method.

C. Submission of samples may be requested for each type of vibration isolation device. After approval, samples will be returned for installation at the job if requested. All costs associated with submission of samples shall be borne by the Contractor.

D. Welding certificates.

E. Manufacturer Seismic Qualification Certification: Submit certification that all specified equipment will withstand seismic forces identified in "Performance Requirements" Article above. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6 MANUFACTURER RESPONSIBILITIES

A. Manufacturer of vibration isolation and seismic restraint equipment shall have the following responsibilities:

1. Determine vibration isolation and seismic restraint sizes and locations.
2. Provide piping and equipment isolation systems and seismic restraints as scheduled or specified.
3. Guarantee specified isolation system deflection.
4. Provide installation instructions, drawings and field supervision to assure proper installation and performance.
5. Provide certification by a licensed engineer employed by the manufacturer that all mounts and restraints meet the project requirements for seismic loading.

B. Substitution of internally isolated mechanical equipment in lieu of the specified isolation of this Section must be approved for individual equipment units and is acceptable only if above acceleration loads are certified in writing by the equipment manufacturer and stamped and sealed by a licensed civil or structural engineer.

1.7 RELATED WORK

A. Supplementary Steel

1. Provide any incidental materials and supplementary support steel for all equipment, piping, ductwork, roof mounted equipment, etc., such as mounting brackets, attachments and other accessories, that may be needed to meet the requirements stated herein, even if not expressly specified or shown on the drawings, at no additional cost.

B. Attachments

1. Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

1.8 QUALITY ASSURANCE

A. Seismic-restraint devices shall have horizontal and vertical load testing and analysis performed according to OSHPD and shall bear anchorage preapproval "R" number, from OSHPD or

another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer. Testing and calculations must include both shear and tensile loads and 1 test or analysis at 45 degrees to the weakest mode.

B. Seismic restraints for mechanical systems shall comply with 2009 IBC and ASCE 7-05.

C. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel."

D. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specifications.

E. Should any rotating or electrical equipment cause excessive noise or vibration when properly installed on the specified isolators, the Contractor shall be responsible for rebalancing, realignment, or other reme¬dial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

F. Upon completion of the work, the Architect shall inspect the installation and shall inform the installing contractor of any further work that must be completed. Make all adjustments as directed by the Architect that result from the final inspection. This work shall be done before vibration isolation systems are accepted.

G. The contractor shall provide a quality assurance plan prepared by a registered design professional for all mechanical, plumbing and electrical equipment and systems. The plan shall include the provisions of the 2009 International Building Code, per section 1705.2 and 1705.3. The plan shall be submitted to the Architect for review and approval. The contractor shall coordinate the requirements of the plan with the Owner and shall cooperate with the Owner's Seismic Quality Assurance coordinator.

1.9 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Seismic Snubber Units: Furnish replacement neoprene inserts for all snubbers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 SEISMIC-RESTRAINT DEVICES

A. Manufacturers:

1. Amber/Booth Company, Inc.
2. B-Line Systems, Inc.
3. California Dynamics Corp.
4. Kinetics Noise Control, Inc.
5. Loos & Co., Inc.; Cableware Technology Division.
6. Mason Industries, Inc.
7. TOLCO Incorporated.
8. Unistrut Diversified Products Co.; Wayne Manufacturing Division.
9. Vibration Eliminator Co., Inc.
10. Vibration Isolation Co., Inc.
11. Vibration Mountings & Controls/Korfund.

B. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 40, plus or minus 5, with a flat washer face.

C. Seismic Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of 40, plus or minus 5.

D. Restraining Cables: Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement.

E. Anchor Bolts: Seismic-rated, drill-in, and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488/E 488M.

F. General Requirements:

1. Equipment, piping, ductwork and conduit shall be braced and supported in accordance with International Building Code, 2009 - Chapter 16.
2. This Contractor shall provide the services of a professionally registered Seismic consultant to perform duties indicated below. The Contractor shall submit with his bid, the hourly billing rate for their Seismic consultant to provide additional services beyond the specified scope..

G. Mechanical Equipment:

1. All equipment bases and mounting tabs shall be provided integral to the equipment and designed to distribute Seismic loads without failure. Equipment bases mounting tabs shall be certified by the manufacturer to be in accordance with the requirements of this specification.
2. The size, type and quantity of anchors and fasteners required to anchor the equipment will be provided in accordance with the Seismic consultant.
3. Equipment submittals shall include Seismic anchoring details.

H. HVAC Ductwork:

1. Attachments and supports for HVAC ductwork systems shall be designed to meet the force and displacement provisions of SEI/ASCE 7-05 Standard.

I. Piping

1. Attachments and supports for piping systems shall be designed to meet the force and displacement provisions of SEI/ASCE 7-05 Standard.

J. Mechanical Equipment, Attachments and Supports

1. Attachments and supports for mechanical equipment shall be designed to meet the force and displacement provisions of SEI/ASCE 7-05 Standard.

K. The Seismic details indicated on the drawings are not intended to limit the Contractor. Alternated methods of support, attachment and bracing must be designed by the Seismic Consultant and submitted to the Architect for review.

L. Sprinkler and standpipe system piping shall be supported and braced in accordance with NFPA 13 and NFPA 14.

2.3 RESILIENT PENETRATION SLEEVE/SEAL

A. Resilient penetration sleeve/seals shall be field-fabricated from a pipe or sheet metal section that is 1/2 inch to 3/4 inch larger than the penetrating element in all directions around the element, and shall be used to provide a sleeve through the construction penetrated. The sleeve shall extend one (1) inch beyond the penetrated construction on each side. The space between the sleeve and the penetrating element shall be packed with glass fiber or mineral wool to within 1/4 inch of the ends of the sleeve. The remaining 1/4 inch space on each end shall be filled with acoustical sealant to form an airtight seal. The penetrating element shall be able to pass through

the sleeve without contacting the sleeve. Alternatively, prefabricated sleeves accomplishing the same result are acceptable.

2.4 RESILIENT LATERAL SUPPORTS

A. These units shall either be a standard product of the vibration isolation mounting manufacturer, or be custom fabricated from standard components. These units shall incorporate neoprene isolation elements that are specifically designed to provide resilient lateral bracing of ducts or pipes.

2.5 FLEXIBLE DUCT CONNECTIONS

A. Flexible duct connections shall be made from coated fabric. The clear space between connected parts shall be a minimum of three (3) inches and the connection shall have a minimum of 1.5 inches of slack material.

2.6 GROMMETS:

A. Grommets shall be specially formed to prevent bolts from directly contacting the isolator base plate, and shall be sized so that they will be loaded within the manufacturer's recommended load range.

B. Grommets shall either be custom made by combining a neoprene washer and sleeve, or a manufactured product:

2.7 ACOUSTICAL SEALANT:

A. Sealants for acoustical purposes as described in this specification shall be silicone or a nonsetting sealants.

2.8 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be electrogalvanized. Hot-dip galvanized metal components for exterior use.
3. Baked enamel for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION:

A. General:

1. Refer to the PRODUCTS section of this specification for vibration isolation devices identified on the drawings or specified herein.
2. The static deflections of all isolators specified herein are the minimum acceptable deflections for the mounts under actual load. Isolators selected solely on the basis of rated deflection are not acceptable and will be disapproved.

B. Pipes:

1. All chilled water, heating water, reheat water, preheat water, steam, and drain piping that is connected to vibration-isolated equipment shall be isolated from the building structure at their first three support points.
2. Piping shall be isolated from the building structure by means of vibration isolators, resilient lateral supports, and resilient penetration sleeve/seals.
3. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than 1/2 inch, spring neoprene isolators shall be used. When the required static deflection is less than or equal to 1/2 inch, neoprene isolators shall be used. All other pipe support isolators within the specified limits shall be either neoprene achieving at least 1/4 inch static deflection.
4. Where lateral support of pipes is required within the specified limits, this shall be accomplished by use of resilient lateral supports.
5. Pipes within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
6. Provide flexible pipe connections as called for under Major Equipment above and wherever shown on the drawings.
7. All pipe risers within mechanical rooms over three (3) inches in diameter shall be isolated under each pipe riser floor support with either two layers of 3/4 inch thick, maximum 50 durometer neoprene pads or with load bearing plates or neoprene mounts with a minimum 0.2 inch static deflection.

C. Ductwork:

1. All sheet metal ducts and air plenums that are connected to vibration-isolated equipment shall be isolated from the building structure at their first three support points by neoprene isolators. All isolators shall achieve 0.1 inch minimum static deflection.
2. Ducts within the specified limits that penetrate the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.
3. Flexible duct connections shall be provided as called for above under Major Equipment and wherever shown on the drawings.

3.3 INSTALLATION

A. Install thrust limits at centerline of thrust, symmetrical on either side of equipment.

B. General:

1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.
2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.
3. In all cases, isolated electrical equipment shall be positioned so that it is free standing and does not come in rigid contact with the building structure or other systems.
4. Isolators:

a. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.
b. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft unless this is not possible because of physical constraints.
c. Locate isolators to provide stable support for equipment, without excess rocking. Consideration shall be given to the location of the center of gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called for herein.
d. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
e. Hanger rods for vibration-isolated support shall be connected to structural beams or joists, not the floor slab between beams and joists. Provide suitable intermediate support members as necessary.
f. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360 degrees about the rod axis without contacting any object.
g. Parallel running pipes may be hung together on a trapeze that is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and unisolated pipes on the same trapeze.
h. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
i. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.
j. The installed and operating heights of equipment vibration-isolated with floor spring and neoprene travel limited isolators or roof isolators or with roof curb or roof rail isolation bases shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide 1/4 inch clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.
k. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.
l. Roof isolators shall be installed in strict accordance with the manufacturer's instructions.

5. Flexible Duct Connections:

a. Sheet metal ducts and plenum openings shall be squarely aligned with the fan discharge, fan intake, or adjacent duct section prior to installation of the flexible connection, so that the clear length is approximately equal all the way around the perimeter. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.

6. Flexible Pipe Connections:

a. Install flexible pipe connections in strict accordance with the manufacturer's instructions.

7. Thrust Restraints:

a. Thrust restraints shall be attached on each side of the fan at the vertical centerline of thrust. The two rods of the thrust restraint shall be parallel to the thrust force. This may require custom brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.

8. Grommets:

a. Where grommets are required at hold down bolts of isolators, bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers shall be galvanized.

9. Resilient Penetration Sleeve/Seals:

a. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.

10. Flexible Electrical Connections:

a. Type C connections shall be installed in a grossly slack "U" shape or a 360 degree loop.
b. Rigid conduit on the isolated-equipment side of the flexible connection, and the flexible connection itself, shall not be tied to the building construction or other rigid structures.

C. Install seismic snubbers on isolated equipment. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

D. Install restraining cables at each trapeze and individual pipe hanger. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.

E. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers. At trapeze anchor locations, shackle piping to trapeze. Requirements apply equally to hanging equipment. Do not weld angles to rods.

F. Install resilient bolt isolation washers on equipment anchor bolts.

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. Isolator seismic-restraint clearance.
2. Isolator deflection.
3. Snubber minimum clearances.
4. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
5. Air-Mounting System Operational Test: Test the compressed-air leveling system. Remove malfunctioning units, replace with new units, and retest.
6. Test and adjust air-mounting system controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 ADJUSTING

A. Adjust isolators after piping systems have been filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop.

D. Adjust air spring leveling mechanism.

E. Adjust active height of spring isolators.

F. Adjust snubbers according to manufacturer's written recommendations.

G. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

H. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

3.6 CLEANING

A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 1.

3.8 SEISMIC INSTALLATION INSPECTION

A. On completion of installation of all vibration isolation and seismic restraint devices herein specified, a representative of the isolation materials manufacturer shall inspect the completed system and report in writing any installation errors, improperly selected isolation or restraint devices, or other faults that could affect the performance of the system. Contractor shall submit a report to the Architect, including the manufacturer's representative's final report, indicating all isolation reported as properly installed or requiring correction, and include a report by the Contractor on steps taken to properly complete the isolation work.

B. All special inspections must be performed in accordance with IBC 2009 and as specified herein.

C. Continuous inspection: The full-time observation of work by an approved special inspector pursuant to IBC 2009 section 1704. The following pieces of equipment require these inspections:

1. All equipment using combustible or toxic energy sources.
2. All electric motors, transformers, switchgear unit substations and motor control centers.
3. Reciprocating and rotating type machinery.
4. Pipe, 3" & larger.
5. Tanks, heat exchangers & pressure vessels.

D. Periodic inspection: intermittent observation of work by an approved special inspector of the following pieces of equipment in compliance with IBC 2009 section 1704.

1. Isolator units for seismic isolation systems.
2. All flammable, combustible and highly toxic piping and their associated mechanical systems.
3. All ductwork containing hazardous materials.
4. All electrical components for standby or emergency power systems.

END OF SECTION 15070

SECTION 230593 - TESTING AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and General Requirements, apply to work specified in this Section.

1.2 SUMMARY

A. This Section includes TAB to produce design objectives for the following:

1. Air Systems:

    a. Constant-volume air systems.

2. Steam systems.
3. HVAC equipment quantitative-performance settings.
4. Existing systems TAB.
5. Verifying that automatic control devices are functioning properly.
6. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.

C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report Forms: Test data sheets for recording test data in logical order.

I. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

J. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

K. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.

L. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

M. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

N. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

O. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

P. TAB: Testing, adjusting, and balancing.

Q. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

R. Test: A procedure to determine quantitative performance of a system or equipment.

S. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 QUALIFICATIONS

A. Work included in this section must be performed by an independent testing and balancing agency and an approved member of the Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB) who shall provide a complete and comprehensive total system balance process to test, adjust, and balance the air and water systems for this project. Submit the name of the air balance firm for approval within thirty (30) days after award of contract. See Section 15000 for approved Contractors.

B. If the Contractor fails to submit the name of an acceptable agency within the specified time, the (Architect/Engineer) will select a firm to accomplish the work, and the selection shall be binding at no additional cost to the Owner.

C. All work shall be performed under direct supervision of a qualified engineer. All instruments

used shall be accurately calibrated and maintained in good working order. If requested, calibration tests of equipment to be used shall be performed in the presence of the (Architect/Engineer).

D. Submit for review and approval within ten (10) working days after the notice to proceed, the names of the personnel who will be responsible for the work and those who will actually perform the testing and balancing and their qualification, which shall demonstrate that they have balanced and tested systems of comparable size and complexity.

1.5 SUBMITTALS

A. Qualification Data: Submit evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Submit Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Submit TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. Certified TAB Reports: Submit reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Warranties specified in this Section.

1.6 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.

B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda Items: Include at least the following:

a. Submittal distribution requirements.
b. The Contract Documents examination report.
c. TAB plan.
d. Work schedule and Project-site access requirements.
e. Coordination and cooperation of trades and subcontractors.
f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems and NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification."

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by the instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.7 PROJECT CONDITIONS

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

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.8 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.9 WARRANTY

A. National Project Performance Guarantee: If AABC standards are used, provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air

Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:

B. Special Guarantee: If NEBB standards are used, provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.

C. Guarantee includes the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

1.10 TEST PROCEDURE

A. System may be tested in sections when approved by the (Architect/Engineer).

B. When testing and balancing involve the building temperature control systems, cooperate with the temperature control subcontractor to achieve the desired results.

C. At the time of final inspection, recheck in the presence and at the request of the (Architect/Engineer) not to exceed ten (10) percent of the previously recorded readings from the certified report selected at random from the log by the (Architect/Engineer).

D. Permanently mark the settings of valves, dampers, and other adjustment devices so that adjustment can be restored if disturbed at any time. Do not permanently mark devices before final acceptance.

E. Perform all tests in accordance with AABC standard procedures. Any deviation from same must be approved by the (Architect/Engineer).

F. Should the basic system or any of its components fail to meet contract requirements, and thereby make the testing and balancing work invalid, notify the (Architect/Engineer) and stop all tests until such time that the failure is corrected.

PART 2 - PRODUCTS

2.1 TEST INSTRUMENTS

A. Use instruments of equal or better quality than those described in the technical portions of Associated Air Balance Council--"National Standards for Testing and Balancing Heating, Ventilating and Air Conditioning Systems, Fifth Edition 1989.

B. Instruments used for balancing air and water systems must have been calibrated within a period

of six (6) months prior to balancing.

C. List in the report types, serial numbers, and dates of calibration of all instruments used in the final air and water balance tests.

D. Instrumentation shall include, as a minimum, the following items of equipment:

1. Pressure gauges and fittings.
2. Dry bulb and wet bulb thermostats.
3. Contact pyrometer.
4. Portable flow meter and, if required, orifice plates.
5. Pitot tube and manometers.
6. Alnor Velometer with attachments.
7. Amprobe.
8. Tachometer.
9. Special wrenches and tools.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine project record documents described in Division 1 Section "Project Record Documents."

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce the performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201,

"Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine strainers for clean screens and proper perforations.

M. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

N. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

O. Examine system pumps to ensure absence of entrained air in the suction piping.

P. Examine equipment for installation and for properly operating safety interlocks and controls.

Q. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices are operated by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at design values.

9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

R. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated design conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. All air distribution systems including supply, return, outdoor air and exhaust ductwork shall be tested and balanced.

B. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

C. Prepare schematic diagrams of systems' "as-built" duct layouts.

D. For variable-air-volume systems, develop a plan to simulate diversity.

E. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

F. Check the airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

G. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

H. Verify that motor starters are equipped with properly sized thermal protection.

I. Check dampers for proper position to achieve desired airflow path.

J. Check for airflow blockages.

K. Check condensate drains for proper connections and functioning.

L. Check for proper sealing of air-handling unit components.

M. Check for proper sealing of air duct system.

N. Where the system cannot be properly balanced or equipment tested due to system deficiencies such as inability to properly adjust fan speeds, improperly sized motors, excessively noisy equipment, malfunctioning controls, excessively out of balance air distribution system branch runs, and similar items, furnish to the (Architect/Engineer) in writing a list of the deficiencies prior to the submission of the test report.

O. Verify operation of each room thermostat serving variable air volume terminal units over full range of heating and cooling to insure proper sequence of control of the variable air volume operator and reheat coil valve.

P. Field test maximum and minimum air volumes of all variable air volume terminal units and record final settings. Check factory settings of regulators and controllers before tests. Reset to the scheduled air volumes if required.

Q. Air Outlets and Inlets: Adjust total to within plus or minus 10 percent of design to space. Adjust individual outlets and inlets in space to within plus or minus 10 percent of design.

R. Work in conjunction with the Automatic Temperature Control Contractor and Architect to establish maximum and minimum settings on all variable air volume fans.

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by the fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
b. Measure static pressure directly at the fan outlet or through the flexible connection.
c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers under final balanced conditions.
4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

a. Where sufficient space in submains and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submains and branch ducts to design airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR STEAM SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check the setting and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record the final setting.

D. Check the settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.7 GENERAL PROCEDURES FOR EQUIPMENT

A. Conduct performance tests only after the air and water systems have been balanced and the proper flow rates established.

B. Test and record capacity of heat transfer equipment including all coils. Air side and water side capacities must agree within five (5) percent of each other. Include the manufacturer's rated capacity at the test operating conditions with the report. Perform tests where possible at design conditions. If tests are not performed under design conditions, interpolate results to determine capacity at full load operating conditions.

C. Calculate efficiency of pumps and fans by recognized methods using test data.

D. Test refrigeration equipment to determine heat extracted from or heat added to the building by the equipment and the heat ejected from the device. Record date, time and outside weather conditions including ambient dry bulb, wet bulb, wind speed and direction, cloud cover, rain, and any special conditions pertinent to the test.

3.8 PROCEDURES FOR HEAT-TRANSFER COILS

A. Steam Coils: Measure the following data for each coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Air pressure drop.
4. Inlet steam pressure.

3.9 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan, speed, filter, and coil face velocity.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
4. Air balance each air outlet.

3.10 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water-flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.11 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.12 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and

balancing engineer.

1. Include a list of the instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to the certified field report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to the form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB firm who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents, including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms, including the following:

    a. Settings for outside-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings, including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outside, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch
f. Make and model number.
g. Face area in sq. ft..
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data: (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outside-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft.
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

3.13 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
2. Randomly check the following for each system:

a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Measure sound levels at two locations.
e. Measure space pressure of at least 10 percent of locations.
f. Verify that balancing devices are marked with final balance position.
g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
2. TAB firm test and balance engineer shall conduct the inspection in the presence of Architect.
3. Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report

and balancing device settings to include all changes and resubmit the final report.

7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.14 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspections, and adjusting during near-peak summer and winter conditions.

END OF SECTION 15990

SECTION 230700 – MECHANICAL SYSTEMS INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

1.2 SCOPE

A. Work included in this section is the thermal insulating done in the field, on the Division 21, 22 and 23 systems as specified herein.

B. Work excluded in this Section are the following:

1. Thermal building insulation.
2. Sound absorbing duct lining.

C. The requirements of Division 23, Section "Mechanical and Electrical General Provisions" shall apply to the work specified under this Section.

1.3 DEFINITIONS

A. The k factor means the number of British thermal units of heat transmitted per (sq. ft.) (Fahrenheit temperature difference) through a material with flat, parallel sides one (1) inch apart. The material shall be tested and rated according to ASTM Test Method C-177.

B. Unless otherwise specified, the term "concealed", as used in this specification, shall include all items hidden from normal sight. This includes items within furred spaces, pipe and duct shafts, above suspended ceilings and within return air plenums.

C. Unless otherwise specified, the work "exposed" shall refer to all work other than "concealed" work.

D. Unless otherwise specified, the term "exterior", as used in this specification, shall include all items being or situated outside. Items located within a crawl space shall be considered exterior.

E. Unless otherwise specified, the term "conditioned", as used in this specification, shall be a heated or cooled space, or both, within a building and, where required, provided with humidification or dehumidification means, so as to be capable of maintaining a space condition falling within the comfort envelope set forth in ASHRAE 55.

1.4 SUBMITTALS

A. Provide shop drawings in accordance with Division 23, Sections "Mechanical and Electrical General Provisions" and the General Requirements which shall include all insulation, jackets, finishes, corner beads, pump covers, etc. Shop drawings shall additionally describe each system or component to be insulated, insulation type and thickness, and method of installation.

B. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

1.5 MOCK-UPS

A. Mockups: Before installing insulation of any type, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups according to the following requirements, using materials indicated for the completed Work:

1. Include the following mockups:

a. One 10-foot section of 2" straight pipe and duct run.
b. One 90-degree pipe and duct elbow.
c. One pipe and duct tee fitting.
d. One 2" valve.
e. Four support hangers, including hanger shield and insert.

2. Build mockups with cutaway sections to allow observation of application details for insulation materials, mastics, attachments, and jackets.
3. Build mockups in the location indicated or, if not indicated, as directed by Architect.
4. Notify Architect seven (7) days in advance of dates and times when mockups will be constructed.
5. Obtain Architect's approval of mockups before starting insulation application.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields.

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 GENERAL

A. All insulating materials, including adhesives, jackets and coatings, to be used on the project must be delivered to the building in the manufacturer's unopened container and must bear the manufacturer's stamp or label giving name of manufacturer, brand and description of material.

B. After the necessary tests have been conducted to prove the water and air systems tight, all piping, ductwork and equipment to be insulated shall be thoroughly cleaned and then covered. Insulation materials shall be the product of Owens Corning, CSG, Schuller or Armacell equal to the products specified herein.

C. All Insulation shall have ASTM E84 flame spread/smoke developed indices of ≤25/50 for use in air plenums of commercial buildings.

2.2 TYPES OF INSULATION

A. Type I - Pipe Insulation:

1. Provide heavy density fiberglass pipe insulation with vapor barrier jacket. The k factor shall not be more than 0.23 at seventy-five (75) degrees Fahrenheit mean temperature. Insulation shall be equal to Johns Manville Micro-Lok meeting ASTM C 547 with FSK jacket.

B. Type II - Pipe Insulation:

1. Provide closed cell elastomeric tubular insulation with built-in vapor barrier. The k factor shall not be more than 0.25 at seventy-five (75) degrees Fahrenheit mean temperature. Insulation shall be equal to Armacell AP Armaflex or AP Armaflex SS. The use of polyethylene, polyolefin or engineered polymer insulation is prohibited.

C. Type IV - Duct Insulation:

1. Provide blanket type lightweight fiberglass duct insulation with vapor barrier facing. The compressed k-factor shall not exceed 0.27 at seventy-five (75) degrees Fahrenheit mean temperature and a minimum installed R-Value of 6.0 (hr•ft2•°F)/Btu. Insulation shall be equal to Johns Manville flexible fiberglass blanket Microlite XG Formaldehyde-free Type 100 meeting ASTM C 553 with factory-applied FSK facing.

D. Type V - Duct and Equipment Insulation:

1. Provide board type fiberglass insulation with vapor barrier facing. The k factor shall not exceed 0.22 at seventy-five (75) degrees Fahrenheit mean temperature, and the density shall not be less than 6.0 pounds per cubic foot (pcf). Insulation shall be equal to Johns Manville 817 Spin-Glas meeting ASTM C 612 with FSK facing.

E. Type VI - Equipment Insulation:

1. Provide board type fiberglass insulation, unfaced. The k factor shall not exceed 0.23 at seventy-five (75) degrees Fahrenheit mean temperature and the density shall not be less than 3.0 pounds per cubic foot (pcf). Insulation shall be equal to Johns Manville 814 Series Spin-Glas meeting ASTM C 612.

F. Type VII - Equipment or Exterior Duct Insulation:

1. Provide flexible elastomeric thermal sheet insulation with built-in vapor barrier. The k factor shall not exceed 0.27 at seventy-five (75) degrees Fahrenheit mean temperature. Insulation shall be equal to Armacell AP Armaflex or AP Armaflex SA.

G. Type IX - Equipment Insulation:

1. Provide flexible board type fiberglass insulation, unfaced. The k factor shall not exceed 0.28 at 150 degrees Fahrenheit mean temperature. Insulation shall be equal to Johns Manville pipe and tank insulation.

H. Type XI – Fire Barrier Insulation

1. Provide patented inorganic blanket encapsulated with scrim reinforced foil insulation with k-factor of 0.21. Wrap shall be rated as a shaft alternative per UL 1978. Insulation shall be equal to 3M Fire Barrier Insulation 15A.

I. Type XII – Piping Insulation

1. Provide rigid closed-cell polyisocyanurate thermal insulation with vapor retarder over pipe insulation and 0.030 inch thick PVC (polyvinylchloride) rolled jacketing. The insulation shall have a density of 2 lb/ft^3, the k factor shall not be more than 0.18 (aged 6-months) at seventy-five (75) degrees Fahrenheit mean temperature and the minimum R-value of 5.6 $hr*ft^2*F/BTU$ (aged 6-months). Polyisocyanurate pipe insulation shall be manufactured by Dyplast, Dow Chemical Company, Elliott Company, or Duna USA equal to Dyplast dP-ISO-C1.

2.3 ADHESIVES, SEALERS AND COATINGS

A. The vapor barrier on all insulation systems shall be maintained at all times. Any penetration into the vapor barrier shall be sealed vapor tight. All joints, fittings etc shall be sealed vapor tight.

B. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated. They shall not corrode, soften or otherwise attach such material in either the wet or dry state and must be suitable for the service temperatures.

C. Any cement, sealer or coating used shall be resistant to vermin and mold and shall be durable. It shall not discolor on aging; and where applied on the final surface of the insulation, it shall be light in color and be capable of being painted.

D. For indoor applications:

1. Use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Adhesives, coatings and compounds shall be equal to the following:

1. Vapor barrier adhesive for sealing joints on pipe and duct insulation - Foster 85-75.
2. Adhesive for installing canvas jackets - Foster 30-36.
3. Adhesive for installing duct insulation - Foster 85-20 and 81-91.
4. Adhesive for installing cellular-glass insulation - Foster Brand 81-84.
5. Adhesive for installing elatomeric insulation - Foster Brand 85-75, Armaflex 520.
6. Adhesive for installing mineral-fiber insulation - Foster Brand 85-60/85-70, Childers CP-127.
7. Adhesive for ASJ, FSK and PVDC jackets - Foster Brand 85-50, Childers CP-82.
8. Joint sealants for cellular-glass insulation - Foster Brand 30-45, Childers CP-76.
9. FSK and metal jacket flashing sealants - Foster Brand 95-44, Childers CP-76.
10. ASJ, vinyl, PVDC, and PVC jacket flashing sealants - Childers Brand CP-76
11. Two coats of WB Armaflex finish or glass mesh with mastic for all Armaflex located outside.

2.4 FABRIC JACKETS

A. All exposed piping, ductwork, and equipment in addition to the insulation jackets specified, shall be covered with an additional UL listed jacket of eight (8) ounce canvas. This shall be in addition to the insulation jackets specified.

2.5 PAINTING

A. All piping and insulation in the mechanical rooms shall be painted. Refer to Division 23 Section "Basic Materials and Methods" and Division 9 for more information.

2.6 FITTING AND VALVE COVERS

A. Pipe fittings and valves shall be insulated with one (1) piece pre-molded high impact PVC insulated fitting covers with factory precut insulation inserts and accessories. Fittings shall have edges of one (1) piece cover sealed with vapor barrier pressure sensitive tape. Fitting covers shall be 25/50 rated to meet meet fire and smoke safety requirements of federal, state and local building codes. Manufacturers shall be Knauf (Proto), Johns Manville (Zeston), Thomas Insulation or equal to Proto Fitting Cover System.

2.7 METALLIC COMPONENTS

A. Staples shall be outward clinching type of 304 or 316 stainless steel.

B. Bands shall be galvanized steel, aluminum, brass, or nickel-copper alloy, of 3/4 inch nominal width. The band thickness, exclusive of coating, shall be not less than 0.005 inch for steel and nickel copper alloy, 0.007 inch for aluminum, and 0.01 inch for brass.

C. Wire shall be fourteen (14) gauge, nickel-copper alloy or copper clad steel, or sixteen (16) gauge, soft annealed, galvanized steel.

D. Wire netting used for exposed surfaces of insulation that is to be cement finished shall be twenty-two (22 gauge, one (1) inch galvanized mesh, with continuous twenty-six (26) gauge galvanized steel corner beads having 2-1/2 inch wings.

E. Protect external corners on insulation of ducts and equipment exposed in occupied spaces by corner beads two (2) inches by two (2) inches, .016 inch thick aluminum adhered to heavy duty Kraft paper.

F. All exterior piping and ductwork shall be additionally covered with a sixteen (16) mil embossed aluminum weatherproof jacket. Jacketing shall be ITW's Lock-On (Childers) type with an integrally bonded polysurlyn moisture retarder over the entire surface in contact with the insulation. Jackets are to be fabricated with continuous modified Pittsburg Z-lock on the longitudinal seam and each butted section of jacketing shall be joined and sealed with factory fabricated butt strap and sealant. Fittings shall be insulated and weatherproofed using similar materials.

2.8 INSULATION SCHEDULE:

A. Insulation materials furnished must meet the minimum thickness requirements of National Voluntary Consensus Standard 90.1 (current accepted edition), "Energy Efficient Design of New Buildings" of the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE).

	Service	Type	Thickness
B.	Domestic Water Pipe (Hot, Cold, Tempered, & Recirc.,)	I	1"
	Optional sizes 1" and smaller	I	½"
C.	Domestic Water Piping Concealed in Walls and Cabinet Enclosures	II	½"
D.	Air Conditioning Condensate	I	1"
	Optional	II	½"
E.	Steam and Condensate		
	1. 1 ½" or smaller	I	1 1/2"
	2. 2" and larger	I	2"
F.	Air Conditioning Supply and Outdoor Air Ductwork		
	1. Concealed	IV	2"

2.	Exposed or in Shafts	V	2"
3.	Air Device Bodies	V	1"

G. Air Conditioning Return Ductwork

1.	Concealed (shafts only)	IV	2"
2.	Exposed	V	1"

PART 3 - EXECUTION

3.1 GENERAL:

A. All insulation shall be installed by skilled workmen regularly engaged in this type of work.

B. Insulation shall be continuous at all hangers, hanger rods, supports, sleeves and openings. Continuous vapor barrier must be provided for all cold surfaces. Insulation shall be sealed where it terminates because of a valve, union, flange, etc.

C. Provide continuous insulation and jacketing when passing thru interior wall, floor, and ceiling construction.

1. At Through Penetration Firestops: Coordinate insulation densities with the requirements of approved firestop system being installed.
2. Insulation densities required by approved firestop system may vary with the densities specified in this Section. When this occurs use the higher density insulation.

D. Do not intermix different insulation materials on individual runs of piping or ductwork.

E. Arrange to permit expansion and contraction without causing damage to insulation or surface.

F. Actual insulation thickness must be at least equal to the minimum specified in the schedule at all locations including supports in contact with cold surfaces. Where the manufacturer's rated or nominal thickness is less than the minimum specified, a thicker material or more layers will be requested so that the stated minimum thickness will be attained or exceeded.

G. Install insulation materials in a first class manner with smooth and even surfaces. Scrap pieces of insulation shall not be used where a full length section will fit.

H. Unless otherwise specified herein, the application of all insulation materials, accessories and finishes shall be in accordance with the manufacturer's published recommendations.

I. Insulation materials shall not be applied until all surfaces to be covered are clean and dry; all foreign material, such as rust, scale, dirt, etc., has been removed, and where specified, surfaces have been painted. Insulation shall be clean and dry when installed and during the application

of any finish. The insulation on pipe fittings, valves and pipe joints shall not be installed before the piping is tested and approved.

J. Omit insulation of the following unless directed otherwise.

1. Brass or copper pipe specified to be chrome plated.
2. Traps and pressure reducing valves, relief piping from safety valves, and unions, flanges and expansion joints on heating water system.
3. All fire protection piping.
4. Existing adjacent insulation.
5. ASME stamps, manufacturer's nameplates.
6. Access plates on fan housings.
7. Cleanouts or handholes.
8. Components within factory preinsulated HVAC equipment.
9. Factory - preinsulated flexible ductwork and HVAC equipment.
10. Vibration - isolating connections.

K. Replace and repair insulation disturbed by testing and balancing procedures required under Division 23, Section "Testing and Balancing".

L. Repair existing insulation on piping, ductwork, and equipment, that is damaged by the contractor's work with a material similar to the existing insulation. Insulation vapor barrier and appearance shall be returned to its original condition.

3.2 PIPE INSULATION

A. High density pipe saddles shall be provided at all points of support as hereinbefore specified.

B. Insulate all valves and strainers. Use premolded covers and factory precut insulation where applicable. Unions and flanges shall not be insulated except on cold services.

C. Insulate valves up to and including bonnets, except for cold water valves which shall be insulated over packing nuts in a manner to permit removal for adjustment and repacking.

D. Insulate strainers in a manner to permit removal of the basket without disturbing the insulation of the strainer. Obtain Architect's approval of installation method.

E. Insulate all exposed piping under lavatories and sinks with a white, fitted/molded antimicrobial undersink pipe cover equal to Truebro Lav Guard 2. Cover shall have internal, E-Z Tear-To-Fit trim feature for square, clean trimming (internal ribs) and built-in, concealed E-Z Grip fasteners (no cable-tie fasteners allowed).

F. Application - Type I Insulation:

1. Insulate all pipes in a neat and workmanlike manner. Seal all longitudinal laps of jackets and staple every six (6) inches. Where the piping operates below ambient temperature, the staples shall be coated with vapor barrier adhesive. All butt joints shall be wrapped with a three (3) inch minimum wide strip of jacketing material securely sealed in place.

2. Insulate valves and fittings with pre-cut blanket type fiberglass insulation and PVC covers as specified. Insulation shall be of the same thickness as that on adjoining pipe. The ends of the insulation shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe covering tufted and tucked, fully insulating the pipe fitting. The one (1) piece PVC fitting cover shall then be secured by stapling, tack fastening, banding or taping the ends to the adjacent pipe covering. Chilled water supply and return piping and cold water systems piping shall be insulated as above and have all seam edges of the cover sealed with ZESTON vapor barrier adhesive mastic. The circumferential edges of cover shall be wrapped with ZESTON vapor barrier pressure sensitive color matching tape. The tape shall extend over the adjacent pipe insulation and overlap itself at least two (2) inches on the downward side.
3. Where fittings are operating above ambient they may, in lieu of the proceeding paragraph, be covered with a three (3) hour, hydraulic setting, combination insulating and finishing cement having k factor not greater than 0.87 at a mean temperature of 200 degrees Fahrenheit. The thickness of this cement shall be such that the surface is substantially flush with the pipe covering. Where the insulation terminates at a fitting that is not covered, the end of the insulation shall be beveled off with this same cement. All fittings insulated in this manner shall be covered by a fabric jacket as specified, which shall be cemented down with lagging adhesive.
4. Where expansion joints are required to be insulated, they shall be covered with readily removable sections of insulation of same composition and thickness as provided for adjacent piping.

G. Application - Type II Insulation:

1. The material shall be slit lengthwise to permit installation or slipped over pipe before connections are made. Self-seal insulation may also be installed.
2. All joints and seams must be thoroughly bonded, both mechanically and hermetically, by the adhesive recommended by the insulation manufacturer. Also, the manufacturer's recommendations shall be followed as to the adhesive to use where the insulation needs bonding to metal or other material used for any surface treatment where a finish coat of paint is required.
3. All penetrations of the insulation must be thoroughly sealed so that the insulation itself will form a complete vapor barrier. Insulation shall run continuous at hangers and supports to form a complete vapor barrier. Wherever the insulation terminates, the edges shall be sealed to the metal.
4. Insulation shall be extended to stop valves under plumbing fixtures and/or within cabinets. Water and waste lines serving handicap plumbing fixtures shall be insulated and painted to match adjacent surface.

H. Application -Type XII Insulation:

1. Insulation shall be fabricated in required shapes from bun stock in accordance with ASTM C-450 "Standard Practice for Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments" and C-585 "Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System)". Insulation shall be factory fabricated by a qualified fabricator from bun stock.

2. Fittings, such as valves, valve stations, flanges, 90° and 45° elbows, and tees shall be two piece flycut or routed as the preferred fabrication method. For diameters too large for flycutting or routing, the pieces shall be fabricated in two halves with each half made up of mitered sections. Both methods shall be in accordance with ASTM C-450 and ASTM C-585.
3. Adhesives, Joint Sealers and Mastics

    a. Solvent based adhesives, joint sealers and mastics may be used in contact with ISO-C1 insulation. Mastics shall remain flexible at the lowest expected ambient temperature.
    b. Joint sealers for sealing joints of insulation shall be vapor retarder type, moisture and water resistant, non hardening, and flexible with a service temperature range from -275°F to +200°F.
    c. A vapor retarder type joint sealer shall be applied on insulation longitudinal joints and butt joints to prevent moisture and moisture vapor infiltration. Such joint sealers are Fosters 95-50 sealer or approved equal. Please consult joint sealer manufacturer for recommended products
    d. Solvent or water adhesives may be used to attach the vapor barrier to the outer surface of the ISO-C1. Refer to the vapor barrier installation guidelines. Consult adhesive manufacturer's literature for instructions on handling adhesives including required operating temperatures. Potential adhesives for use in this application include:

        1) Childers CP 88 adhesive (solvent based)
        2) Foster 81-05 adhesive (solvent based)
        3) Foster 85-50 adhesive (water based)
        4) Foster 85-60 adhesive (water based)

4. Vapor Retarder

    a. The Vapor Retarder be factory or field applied to the outer surface of the pipe insulation. A double layer vapor retarder design shall be used for cryogenic and LNG applications, with the secondary vapor retarder applied between the outer most foam insulation layer and the next inner layer of foam insulation. Refer to Figure 2 in Appendix B for details.
    b. Vapor retarder shall have a maximum permeance of 0.01 perm and shall be equivalent to Venture Wrap or Venture Clad products or Insulrap 50 Laminated Vapor Retarder for Pipe Insulation. Refer to ASTM standards C-755 and C-1136 for information on selection and specification of vapor retarders. Refer to product literature and installation guidelines from the vapor retarder manufacturer for recommended application instructions.
    c. Elbows and fittings shall be wrapped with vapor retarder tape with a 50% overlap.
    d. For other laminated membrane type vapor retarders, consult manufacturer's literature and installation guidelines.

5. Installation

    a. Dyplast recommends insulation shall be fabricated with shiplap or tongue and groove longitudinal joints and shiplap ends.

b. Install pre-fabricated insulation fittings on elbows, tees, and valves. Insulation shall be the same thickness as pipe sections and fabricated with shiplap ends and shiplap or tongue and groove longitudinal joints.
c. Insulation shall be secured to the pipe with 3/4" wide fiber reinforced tape.
d. Insulation shall be secured with fiber reinforced tape prior to installation of the vapor retarder material when vapor retarder is field applied.
e. Outer layer insulation and vapor retarder shall be secured with fiber reinforced tape. Use a 25% circumferential overlap on 12" centers when vapor retarder is factory applied to insulation. Fiber tape shall be applied to the exterior of the insulation/vapor retarder system.
f. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor retarder must be continuous. All fasteners and bands shall be neatly aligned and overall work must be of high quality appearance and workmanship.
g. Vapor stops shall be used on either side of valves frequently removed for servicing, valve stations left exposed, or odd fittings, elbows, tees, etc. where the chance of moisture infiltration is high.
h. The vapor retarder shall have a maximum permeance of 0.01 perm and shall be equivalent to Venture wrap or Venture Clad products or Insulrap 50 Laminated Vapor Retarder.
i. Vapor Retarder Film should be cut to length longitudinally and wrapped around the circumference of the pipe with lap joint and installed facing downward avoiding the placement of the joint at the top or bottom of the pipe. Lap joint to be sealed using liquid adhesive. Butt joints shall be covered with Vapor Retarder Tape. Spiral wrap configuration can be used in lieu of the above installation. Spiral wrapping will require adhesive placed on one edge of the vapor retarder as it is wrapped over the previous layer.
j. Elbows and fittings shall be wrapped with Vapor Retarder Tape or covered with a mastic type vapor retarder product. Vapor Retarder Tape is to be wrapped in a spiral configuration. If using mastic type vapor retarder at fittings and elbows, form mastic so that fitting covers can be applied true and tight.
k. On factory applied Vapor Retarder Film, lap joint to be sealed with SSL tape. All vapor retarder surfaces should be cleaned and free of dust, grease, oil, etc before application of the SSL tape to ensure good adhesion between the tape and vapor retarder. Refer to Figure 7 in Appendix. For other types of factory applied vapor retarders, consult manufacturer's recommendations on installation.
l. Before jacketing can be installed on a portion of the piping, the vapor retarder system on that portion must be complete and continuous.

3.3 DUCT INSULATION

A. Provide accessories as required to prevent distortion and sagging of duct insulation. Provide welded pins, adhesive clips and wire ties as recommended by the manufacturer and directed by the Architect.

B. Insulation shall cover all standing seams and metal surfaces. Provide corner beading on all exposed ducts.

C. Staples shall be sealed to maintain vapor barrier.

D. Neatly cut insulation at dampers, temperature control sensors, and controllers. Butter exposed edges with approved mastic coating.

E. Use 24" minimum length Type V board type insulation , of specified thickness, on the bottoms of ducts at each trapeze hanger location.

F. Application - Type IV Insulation:

1. Insulation shall be cut slightly longer than perimeter of duct to insure full thickness at corners. All insulation shall be applied with edges tightly stitched with staples. Provide vapor barrier mastic sealer at seam. The insulation shall be additionally secured to the bottom of all square ducts eighteen (18) inches or wider by means of welded pins and speed clips. The protruding ends of the pins shall be cut off flush after the speed clips have been applied. The vapor barrier facing shall be thoroughly sealed where the pins have pierced through with a tape of the same material by applying a vapor barrier adhesive to both surfaces as recommended by the manufacturer.
2. All hanger rods, support members, joints and penetrations of the vapor barrier shall be sealed with full thickness insulation and vapor barrier mastic sealer. All cuts or tears shall be sealed with strips of the aluminum foil tape and vapor barrier adhesive.

G. Application - Type V Insulation:

1. All insulation shall be applied with edges tightly butted. Insulation shall be impaled on pins welded to the duct and secured with speed clips. Spacing of pins shall be as required to hold insulation firmly in place but not less than one (1) pin per square foot, and pins shall be placed within three (3) inches of each corner of insulation. All joints and penetrations of the vapor barrier shall be sealed with a three (3) inch wide strip of the same material, applied with Foster 85-75, or to both surfaces as recommended by the adhesive and vapor barrier mastic sealer manufacturer.
2. If, through space or size restriction or other causes, the welded pin method is impossible, the insulation shall be secured to the duct with adhesive such as Foster 81-91 or equal. The adhesive shall cover the entire surface of the sheet metal when applied to underside of horizontal duct but may be applied in strips or spots for application to top and sides with a minimum of fifty (50) percent coverage.

3.4 FABRIC JACKET

A. Apply jacket to insulated breeching and equipment. Onto the dry cement surface apply a brush coat of Foster Sealfas 30-36 at the rate of sixty (60) to seventy (70) square feet per gallon. Embed into wet coating the canvas jacket, smoothed out to avoid wrinkles and overlap all seams a minimum of two (2) inches. Apply a second brush coat of Sealfas 30-36 to the entire surface at the rate of sixty (60) to seventy (70) square feet per gallon.

B. Where jacket is to be installed on piping, apply Foster 30-36 adhesive to the canvas jacket by dipping to completely wet and saturate the canvas. While wet, position on the pipe insulation and pull tight, bond, lap and smooth out all wrinkles. Finish with a sealer coat of adhesive.

END OF SECTION 230700

SECTION 233110 – AIR DISTRIBUTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The drawings and general provisions of the Contract, including General and Supplementary Conditions, General Requirements and all other Specification Sections apply to the work specified in this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e.: more expensive) requirement shall govern.

1.2 SCOPE

A. This section includes the air distribution systems including those devices distributing the air to the spaces, and those items which collect, filter, control, and convey air.

B. Fans which are not an integral part of a factory fabricated air handling unit are included under this section.

C. The requirements of Division 23, Section "Mechanical and Electrical General Provisions" shall apply to the work specified under this section.

D. Except for duct pressure tests, all testing and balancing of the air distribution systems shall be performed under Division 23, Section "Testing and Balancing" of the Specifications.

PART 2 - PRODUCTS

2.1 AIR DEVICES

A. Provide air devices of the minimum sizes and quantities indicated and of the types specified. Contractor shall carefully study the drawings and the field conditions to ascertain the air device requirements as to suitability, location, air capacity, required accessories, border and finish. Devices shall be selected to provide draft-free air distribution over entire area served and sound rating shall not exceed Noise Criteria (NC) 25.

B. Border types shall be compatible with Architectural ceiling type for the room for which the air device is located. All devices shall have plaster frames when installed in plaster or drywall construction.

C. Margins shall be as indicated or directed to suit field conditions.

D. Provide Titus, Kreuger, Price, Metalaire, Nailor or Tuttle & Bailey air devices in accordance with the schedule below and on the drawings.

E. Air Device Schedule:

Device	Type	Finish	Basis of Design
Ceiling Supply Diffuser	A	#26 white	Titus/TDCA
Ceiling Supply Diffuser	B	#26 white	Titus/TDC-AA
Return Register	C	#26 white	Titus/PAR

1. Type A: Ceiling diffusers shall be Titus Model TDCA (steel) or prior approved equal for adjustable discharge pattern. These diffusers shall consist of an outer frame assembly of the sizes and mounting types shown on the plans and outlet schedule. A square or rectangular inlet shall be an integral part of the frame assembly and a transition piece shall be available to facilitate attachment of round duct. An inner core assembly consisting of fixed deflection louvers shall be available in one-, two-, three- or four-way horizontal discharge patterns. Diffuser shall include adjustable vanes to provide full vertical projection as well as horizontal projection. The inner core assembly must be removable in the field without tools for easy installation, cleaning or damper adjustment.

    a. The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
    b. Opposed blade volume damper shall not be provided. Throw Reducing Vanes (TRV) must be available to deflect a horizontal discharge airstream from each side of the TDC diffuser into diverging airstreams.
    c. The manufacturer shall provide published performance data for the diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

2. Type B: Ceiling diffusers shall be Titus Model TDC-AA (aluminum) or prior approved equal for fixed, horizontal discharge pattern. These diffusers shall consist of an outer frame assembly of the sizes and mounting types shown on the plans and outlet schedule. A square or rectangular inlet shall be an integral part of the frame assembly and a transition piece shall be available to facilitate attachment of round duct. An inner core assembly consisting of fixed deflection louvers shall be available in one-, two-, three- or four-way horizontal discharge patterns. The inner core assembly must be removable in the field without tools for easy installation, cleaning or damper adjustment.

    a. The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
    b. Opposed blade volume damper shall not be provided. Throw Reducing Vanes (TRV) must be available to deflect a horizontal discharge airstream from each side of the TDC diffuser into diverging airstreams.
    c. The manufacturer shall provide published performance data for the diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

3. Type C: Perforated ceiling diffusers shall be Titus Model PAR (steel, flush face) or approved equal for return. Diffusers shall have a perforated face with 3/16-inch diameter holes on ¼-inch staggered centers and no less than 51 percent free area. Perforated face shall be steel. The backpan shall be one piece stamped heavy gauge steel of the sizes and mounting types shown on the plans and outlet schedule. The diffuser neck shall have 1 1/8-inch depth for easy duct connection. Diffusers must discharge a uniform horizontal blanket of air into the room and protect ceiling against smudging. Pattern controllers in the supply models shall be mounted on the back of the perforated face and must be field adjustable to allow the discharged air to enter the room in either vertical or one-, two-, three- or four-way horizontal jets. The perforated face must be easily unlatchable from the backpan to facilitate option of the face for pattern controller adjustment.

    a. The finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
    b. Opposed blade volume damper shall not be provided.
    c. The manufacturer shall provide published performance data for the perforated diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

2.2 FIRE, FIRE/SMOKE, AND SMOKE DAMPERS

A. Provide where indicated on the plans, fire dampers constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have 1-1/2 hour fire protection rating, 212 degrees Fahrenheit fusible link, and shall include a UL label in accordance with established UL labeling procedures and shall have Static Rating for HVAC systems that shut down automatically in a fire or smoke emergency or Dynamic Rating for HVAC systems that remain operational during a fire or smoke emergency. Three (3) hour dampers shall be installed where required by wall or floor rating. Damper Manufacturer's literature submitted for approval prior to installation shall include comprehensive performance data developed from testing in accordance with AMCA Standard 500 and shall illustrate pressure drops for all sizes or dampers required at all anticipated air flow rates. Fire dampers shall be equipped for vertical or horizontal installation as required by the locations indicated on the drawings. Fire dampers shall be installed in wall and floor openings utilizing steel sleeves, angles, other materials, and practices required to provide an installation equivalent to that utilized by the manufacturer when dampers were tested at UL. Fire damper installation shall also meet all requirements of the authority having jurisdiction. Installation shall be in accordance with the damper manufacturer's instructions. Fire dampers shall be Ruskin, Pottorff , United Enertech or approved equal to Ruskin Type IBD, DIBD, FD of the following styles:

1. Low Pressure Rectangular Ducts - Style B.
2. Low Pressure Round Ducts - Style CR.
3. Medium Pressure Rectangular Ducts - Style C.
4. Medium Pressure Round Ducts - Style CR.
5. Medium Pressure Oval Ducts - Style CO.

6. Dampers for grilles, diffusers, registers, etc. - Thinline.

B. Fire damper assembly shall include fire damper and damper enclosure wall sleeve complete with duct attachment flanges, as detailed. Provide an access door at each fire damper located so as to permit easy maintenance of damper and fusible link. All fire dampers shall be installed in accordance with NFPA Requirements and the manufacturer's printed instructions.

C. Provide at locations shown on plans, combination fire/smoke dampers meeting or exceeding the following specifications. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under UL Standard 555, and shall further be classified by Underwriters Laboratories as Leakage Rated Damper for Use in Smoke Control Systems under the latest version of UL555S, and bear a UL label attesting to same and shall have Dynamic Rating. Damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers required by this specification. Testing and UL qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be no higher than leakage Class I. Fire/Smoke dampers shall be Ruskin, Pottorff, United Enertech or approved equal to Ruskin Type FSD 37, FSD-60.

1. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close) under HVAC system operating conditions, with pressures of at least four (4) inch water gauge in the closed position, and at least 2000 feet per minute air velocity in the open position. Pressures of at least six (6) inch or eight (8) inch water gauge shall have velocity levels of 3000 or 4000 feet per minute respectively.
2. In addition to the leakage ratings already specified herein, the combination fire/smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 350 degrees Fahrenheit. Appropriate electric operators shall be installed by the damper manufacturer at time of damper fabrication; damper and operator shall be supplied as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and operators.
3. Each combination fire/smoke damper shall be equipped with a fusible link which shall melt at 212 degrees Fahrenheit causing damper to close and lock in a closed position. Damper shall be Ruskin Model FSD 37 or FSD60.
4. Each combination fire/smoke damper shall be furnished with factory sleeve of length and gauge required for satisfactory installation, and with damper operator factory installed on exterior of sleeve and properly linked to damper operating shaft. Smoke dampers shall be provided with a pneumatic operator and be controlled under Division 23, Section "Automatic Temperature Controls".
5. Operators shall be of the spring-return fail safe type that will close damper upon power interruption or control air failure. Damper operators shall be UL listed as Fire Damper Operators, and shall bear the appropriate UL Operator label.
6. All wiring or piping material and labor required to interconnect the combination fire/smoke dampers with detection and/or control systems shall be under Division 23.
7. Duct smoke detectors shall be supplied by Division 26 and installed under Division 23 in accordance with NFPA and the manufacturer's recommendations.

D. Provide at locations shown on plans smoke dampers similar to fire/smoke dampers specified hereinbefore equal to Ruskin, Pottorff United Enertech or approved equal to Ruskin Type SD60 and having a Dynamic Rating.

E. Submit samples for approval to the Architect of all fire, fire/smoke, and smoke damper

assemblies for low pressure and medium pressure duct systems. Dampers shall not be installed prior to receiving written approval of submitted samples.

F. Fire, smoke and/or fire/smoke dampers in stainless steel duct systems shall be of stainless steel construction.

2.3 DUCTWORK

A. General:

1. The Duct Manual as herein referenced shall mean the "HVAC Duct Construction Standards – Metal & Flexible", 3rd Edition, 2005 as published by the Sheet Metal and Air Conditioning Contractors National Association, Inc.
2. Unless noted otherwise, ductwork shall be constructed of prime, first quality galvanized steel of gauges as called for in the Duct Manual. Reinforce all ducts to prevent buckling, breathing, vibrations, or unnecessary noise. Such reinforcing shall be as recommended in Duct Manual, plus any additional reinforcing as required to meet job conditions. Longitudinal and cross joints, elbows, transitions, etc., shall be furnished as specified in Duct Manual, including recommended duct supports to suit job conditions.
3. All uninsulated rectangular ductwork shall be crossbroken on all four (4) sides of each panel section. All vertical and horizontal sheet metal barriers, duct offsets and elbows, as well as the panels of straight sections of ducts, shall be crossbroken. Crossbreaking shall be applied between the standing seams or reinforcing angles. The center of the crossbreak shall be of the required height to assure each panel section being rigid, to prevent vibrations and "breathing".
4. Ductwork and ductwork fittings for acid fume hood exhaust system shall be acid resistant fiberglass reinforced plastic ductwork.
5. Ductwork and ductwork fittings for fume hood, radio isotope, BL-3, glasswash, and tunnel/cagewash exhaust systems shall be fully welded type 304 stainless steel of gauges as called for in the Duct Manual.
6. Ductwork from kitchen exhaust hood to perimeter of kitchen shall be constructed of minimum 18 gauge stainless steel or 16 gauge black iron all welded construction with fully welded joints, and installed in accordance with the South Carolina State Health Department and the State Fire Marshals requirements. Kitchen hood exhaust ductwork from perimeter of kitchen to the exhaust fan shall be preengineered UL listed kitchen hood exhaust ductwork system with integral two (2) hour fire rating as specified herein. Provide access doors and fire rating around ductwork as required by code.
7. Dryer exhaust ductwork for clothes dryers shall terminate on the outside of the building with a hooded wall vent with integral backdraft damper. Screens shall not be installed at the duct termination. Ducts shall not be connected or installed with sheet metal screws or other fasteners that will obstruct flow. Dryer exhaust shall be provided in accordance with the dryer manufacturers written instructions.
8. Supply air ductwork from air handling units to the air terminal units shall be "medium pressure" ductwork. Supply ductwork from air terminal units to air devices shall be "low pressure" ductwork.
9. Laboratory exhaust air ductwork shall be "medium pressure" ductwork.
10. Outdoor air, ventilation air, return air, relief air and non-laboratory exhaust air ductwork shall be low pressure ductwork.

11. Exposed circular low pressure supply ductwork shall be provided with grip finish and painted. Refer to Division 9 specifications. Color shall be by Architect.
12. Duct cleaning and acceptable level of contaminants allowed in the HVAC system, otherwise known as the Duct Cleanliness Level, shall be equal to Level C - Advanced in accordance with SMACNA Duct Cleanliness for New Construction, 2000 Edition.

B. Low Pressure Ductwork (0" to 2" Water Gauge):

1. Ductwork shall conform to requirements and details, unless specified or indicated otherwise in the SMACNA "HVAC Duct Construction Standards – Metal & Flexible", 3rd Edition, 2005. A copy of the duct manual shall be secured by the Contractor and shall be kept at the project for convenient reference.
2. Concealed circular low pressure supply and exhaust ductwork shall be United McGill low pressure spiral ductwork and fittings, equal to United Uni-seal spiral lockseam duct.
3. Exposed circular low pressure supply ductwork shall be acoustically insulated double-wall spiral ductwork and fittings. Double wall duct shall be constructed of a paintable outer shell, a 1" thick layer of fiberglass insulation and an inner metal liner. Insulation shall have a thermal conductivity "K" factor of .27 BTU/hr/sq. ft./ºF or less. Double-wall spiral ductwork shall be United ACOUSTI-k27 spiral lockseam duct, Semco Industries SL95P, Lindab Safe, United Sheet Metal spiral pipe, or approved equal.
4. Flexible duct connections where indicated shall be "Ventglass" duct fabric as manufactured by Ventfabrics, Inc.
5. Low pressure ductwork shall conform to the requirements and details contained in the Duct Manual and shall be constructed to the requirements for two (2) inches water gauge. Construction shall conform to the following:

a.	Material gauges (galvanized steel) & general construction	-	Tables 1-5, 1-10 thru 1-13 Seal Class B
b.	Longitudinal seams	-	Fig. #1-5, Types L-1, L-3 & L-4
c.	Corner Closures	-	Fig. #1-13 & # 1-14
d.	Hangers	-	Fig. #4-1 & 4-4 & Tables 4-1 & 4-2
e.	Radius Elbows	-	Fig. #2-2, Type RE-1 and RE-3
f.	Vaned Elbows (Applied to Square elbows)	-	Fig. #2-2 Type Re-2 & Figs. #2-3 & #2-4, double thickness vanes only
g.	Transitions & Offsets	-	Fig #2-9
h.	Branch connections	-	Fig. #2-8, 45° only

i. Volume dampers, up to 12" deep - Fig. #2-14, Figs. A&B w/Ventlok #555 quadrant

j. Volume dampers, over 12" deep - Fig. #2-15, Fig. A w/Ventlok #555 quadrant

k. Access doors - Cesco #HADF-10 hinged one (1) side w/Ventlok #100 latch, insulated, one (1) inch thick

6. Duct sizes indicated on the drawings are air side sizes. Where duct lining is indicated, increase sheet metal sizes accordingly to compensate for thickness of lining.
7. Seal all transverse joints in all low pressure supply ductwork with mineral impregnated woven fiber tape as manufactured by Hardcast, Inc.
8. Provide stand-offs on volume dampers installed in all insulated ductwork.
9. Flexible ductwork for connection to air devices shall be Casco Silent Flex II or FlexMaster Type 6B. Flexible duct shall have a minimum R-6 insulation, comply with NFPA Standard 90A and shall be U.L. listed as Class 1 Air Duct & Connector, Standard 181.

C. Medium Pressure Ductwork (Medium - Over 2" and up to 6" Water Gauge):

1. Medium pressure ductwork consists of rectangular, flat-oval, and circular types as indicated on the drawings.
2. Submit samples of medium pressure ductwork for approval as directed. Samples shall include longitudinal seams, transverse joints and reinforcement and others as requested. No ductwork shall be fabricated until duct construction samples are approved in writing by the Architect.
3. All medium pressure duct systems shall be leak tested in strict conformance with "HVAC Air Duct Leakage Test Manual", 1985. Tests shall be witnessed by the balance subcontractor as hereinafter specified.
4. Medium pressure ductwork shall conform to the requirements and details contained in the Duct Manual and shall be constructed to the requirements for six (6) inches water gauge. Construction shall conform to the following:

a. Reinforcement & Gauge - Tables #1-7, 1-10 thru 1-13

b. Transverse Joints - Figs. #1-4 Type T-21, #1-10, #1-12, #1-14, #1-15, Type T-21, and T-22, #1-16, #3-2 Type RT-1 and 2

c. Longitudinal Joints - Fig. #1-5 Type L-1 and L-3

d.	Vanes and Vane Runners	-	Fig. #2-3
e.	Branch Connections	-	Figs. #2-7 and 2-8
f.	Transitions	-	Figs #2-9
g.	Offsets	-	Figs. #2-9 Type 3
h.	Supporting Systems	-	Figs. #4-16, #4-17, #6-4, and Tables #4-1, #4-2 and #4-3
i.	Riser Supports	-	Fig. #4-6
j.	Volume and Floor	-	High Velocity Air Foil Type, Ultra-Low Leakage when closed, Ruskin CD-50 suitable for DDC operator provided under Division 23, Section "Automatic Temperature Controls".
k.	Supply and Exhaust Fan Isolation Dampers	-	High Velocity Air Foil Isolation Dampers Type, Ruskin OD102 fan outlet damper with silicone rubber blade seals, stainless steel jamb seals and bearings with integral shaft seals. Damper shall be suitable for DDC operator provided under Division 23, Section "Automatic Temperature Controls".
l.	Duct Sealants	-	See Section 1 Basic Duct Construction Duct Sealing Commentary
m.	Access Doors	-	CESCO #HADF-10 with cam latches, neoprene gasketing and insulated, one (1) inch thick.
n.	Acoustical Liner	-	In conformance w/SMACNA Standard
o.	Welded Galvanized	-	Coated with two (2) coats of corrosion Resistant aluminum paint.

PART 3 - EXECUTION

3.1 AIR DEVICES

A. Install air devices in accordance with the manufacturer's latest published installation instruction to insure against incorrect air pattern, drafts, and dirt smudging.

B. Construct, and install sheet metal duct or plenum connections to air devices in accordance with terminal manufacturer's recommendations.

C. Make modifications to the duct systems as required to accommodate actual sizes of air devices furnished, e.g., transformations and collar sizes without additional cost.

D. Make joints between each devices and its components, connecting duct, or the mounting surface airtight, using gasket or its equivalent.

E. Align exposed butt edges of linear diffusers using slots and keys strips or with other concealed means.

3.2 DUCTWORK

A. Install hangers, supports, and their attachments, generally in conformance with SMACNA standard referred to in this section of the specifications and applicable portions of article "Piping, Conduit and Supports", of Division 23, Section "Mechanical and Electrical General Provisions".

B. Furnish hangers capable of withstanding five (5) times the weight of the load imposed on them without damage to duct or any adjacent construction.

C. Neatly erect ducts and plenums of sizes and arrangements shown and detailed and as required to carry out intent of specifications and drawings. Work must meet approval of the Architectin all its parts and details.

D. Sizes shown are air side sizes. Where ducts are shown as lined, dimensions shall be increased to reflect that thickness of the lining.

E. Install ductwork in such a manner as to meet the recommendations of NFPA Standard 90A.

F. Provide each air outlet with a collar adequately stiffened, fastened, and made suitable for securing air device thereto. Make field changes in ductwork, such as those required to accommodate the sizes of factory fabricated equipment actually furnished, i.e., coils, air filters, fans, damper and air terminal units and similar items, without additional cost. Provide duct flanges to match those of connecting factory fabricated equipment. When necessary, relocate and modify ductwork to avoid obstructions such as structural members, piping and conduit, in a manner acceptable to the (Architect/Engineer).

G. Construct and install all ductwork in accordance with the SMACNA Standards specified.

Coordinate the installation of all duct systems with all other trades including plumbing, electrical, sprinkler, ceiling systems, etc.

H. All open end return air ducts shall be provided with 1/2" galvanized wire mesh screen.

I. Leak Testing of Ductwork:

1. When deemed necessary by the Architect, test low pressure ductwork for leaks by sealing openings and pressurizing system to that static pressure which the system will operate. Use test methods approved by SMACNA and Architect. Seal all joints. Leakage shall not exceed three (3) percent of air flow specified at the system's nominal static pressure.
2. Medium pressure ductwork shall be pressure tested as hereinbefore defined.

J. Duct smoke detectors shall be installed where indicated on the electrical drawings. Duct smoke detectors shall be installed upstream of the associated smoke damper and within 6'-0" of the damper in as straight a section of ductwork as possible.

END OF SECTION 233110

SECTION 238120 – HEATING AND AIR CONDITIONING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes electric baseboard radiation heaters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details and dimensions of custom-fabricated enclosures.
4. Indicate location and size of each field connection.
5. Indicate location and arrangement of piping valves and specialties.
6. Indicate location and arrangement of integral controls.
7. Include enclosure joints, corner pieces, access doors, and other accessories.
8. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

D. Color Samples for Initial Selection: For heaters with factory-applied color finishes.

E. Color Samples for Verification: For each type of exposed finish.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members, including wall construction, to which radiation heaters will be attached.
2. Method of attaching radiation heaters to building structure.
3. Penetrations of fire-rated wall and floor assemblies.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 ELECTRIC BASEBOARD RADIATION HEATERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Cadet.
2. Chromalox.
3. Indeeco.
4. Markel Products Company; TPI Corporation.
5. Marley Engineered Products.
6. Ouellet Canada Inc.
7. Qmark; Marley Engineered Products.

C. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.

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

D. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.

1. Volts: 208
2. Phase: Single
3. Hertz: 60
4. Heat Output: 250 W/ft

E. Enclosures: Minimum 0.0329-inch thick steel, removable front cover.

1. Full-height back.
2. Full-length damper.
3. End panel.
4. End caps.

5. Inside and outside corners.
6. Joiner pieces to snap together.
7. Enclosure Height: 7.25 inches.
8. Enclosure Depth: 2.875 inches.
9. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.
10. Element Brackets: Primed and painted steel to support front panel and element.

F. Rust-Resistant Enclosures: Minimum 0.040-inch thick ASTM A 653/A 653M, G60 galvanized-steel, removable front cover.

1. Full-height back.
2. Full-length damper.
3. End panel.
4. End caps.
5. Inside and outside corners.
6. Joiner pieces to snap together.
7. Enclosure Height: 7.25 inches.
8. Enclosure Depth: 2.875 inches.
9. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.
10. Element Brackets: Primed and painted steel to support front panel and element.

G. Unit Controls: Remote line-voltage thermostat.

H. Accessories:

1. Filler sections without a heating element matching the adjacent enclosure.
2. Straight-blade-type receptacles complying with DSCC W-C-596G/GEN, NEMA WD 1, NEMA WD 6, and UL 498; in color selected by Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive radiation heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before installation of finned-tube radiation heaters.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ELECTRIC BASEBOARD RADIATION HEATER INSTALLATION

A. Install units level and plumb.

B. Install enclosure continuously around corners, using outside and inside corner fittings.

C. Join sections with splice plates and filler pieces to provide continuous enclosure.

D. Install enclosure continuously from wall to wall.

E. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.

F. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

3.3 CONNECTIONS

A. Ground electric finned-tube radiation heaters according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238120