

University of South Carolina
Columbia, South Carolina

Project Manual for Coker 7th Floor
Renovation – Plumbing

Project Number: BC00433273

January 16, 2014

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SE-311

Invitation for Minor Construction Quotes

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

PROJECT NAME: Coker 7th Floor Renovation -Plumbing

PROJECT NUMBER: BC00433273 PROJECT LOCATION: Columbia, SC

BID SECURITY REQUIRED? Yes No

PERFORMANCE BOND REQUIRED? Yes No

PAYMENT BOND REQUIRED? Yes No CONSTRUCTION COST RANGE: <\$50K

DESCRIPTION OF PROJECT:

Provide services to include furnishing all labor, tools & equipment to install all plumbing to include but not limited to all fixtures, piping, and all items shown on specs & drawings: Sections 15010 through 15950 & sheets P0.0,P1.6,P1.7,P2.7 & P3.7. Small and minority business participation is encouraged. It's the bidders responsibility to obtain all bidding documents from the purchasing website. <http://purchasing.sc.edu>

A/E NAME: Quackenbush 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: Purchasing website: <http://purchasing.sc.edu>

PLAN DEPOSIT AMOUNT: na IS DEPOSIT REFUNDABLE? Yes No

PRE-QUOTE CONFERENCE? Yes No MANDATORY ATTENDANCE? Yes No

DATE: 1/27/2014 TIME: 10:30am PLACE: 743 Greene St, Conf Rm 53, Columbia, SC

AGENCY: University of South Carolina

NAME AND TITLE OF AGENCY COORDINATOR: Hatice Hikmet

ADDRESS: 743 Greene Street PHONE: 803.777.9994 Fax: 803.777.7334

CITY: Columbia STATE: sc ZIP: 29208 E-MAIL: hikmeth@mailbox.sc.edu

IFQ CLOSING DATE: 2/3/2014 TIME: 1pm LOCATION: 743 Greene St, Rm53, Columbia, SC

IFQ DELIVERY ADDRESSES:

HAND-DELIVERY:

see mail

MAIL SERVICE:

University of South Carolina
743 Greene St
Columbia, SC 29208

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

APPROVED BY: _____

(State Engineer)

(Date)

Scope of work - Plumbing

This is a bid for the plumbing portion of the renovation of the 7th floor Coker Pharmacy side. Work is shown on sheets P0.0, P1.6, P1.7, P2.7, and P3.7 and described in division 15 – Mechanical sections 15010 through 15950 of the specifications. Bid is to furnish all labor, tools and equipment to install all Plumbing to include but not limited to all fixtures, piping, and all other items shown on these documents with the following exceptions.

- 1) All demolition of existing sinks is by USC. All piping which cannot be re-used will be removed by this contractor.
- 2) Any insulation containing hazardous material will be removed by USC
- 3) The removal and repair of ceilings required to perform this work will be by USC.
- 4) All materials to perform this work is by will be furnish by USC.

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: BC00433273 Coker 7th Floor Renovation -Plumbing
(Number) (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 Representative)

ITS: _____

SE-331

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. Fraternalization 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.

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 mats on 12" coarse, chipped, hardwood base. Mulch and logging mats shall be supplemented throughout the project to keep

Updated: July 15, 2011

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: Coker 7th Floor Renovation –Plumbing
Project Number: BC00433273

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 15010 - GENERAL MECHANICAL

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Work under Division 15 shall include furnishing of all labor, accessories, tools, equipment and material required to completely execute installation of the entire heating, ventilating and air conditioning systems, plumbing systems and fire protection systems as shown on the drawings and as specified. Work shall include but not be limited to the furnishing, unloading, handling distribution, setting, supporting and installation of all components required for the mechanical systems.
- B. Mechanical specification Sections 15000 through 15299 generally apply to all mechanical trades. Sections 15300 through 15399 apply generally to fire protection work. Sections 15400 through 15499 apply generally to plumbing work. Sections 15500 through 15999 apply generally to HVAC work.
- C. Drawings shall not be scaled. Refer to architectural and structural drawings for building construction and dimensions and to room finish schedule on architectural drawings for material, finish and construction method of walls, floor and ceiling in order to insure proper rough-in and installation of work.

1.02 REFERENCES

- A. FM P7825 - Approval Guide; Factory Mutual; 1995.
- B. NEMA MG 1 - Motors and Generators; 1993 (and Revision 1).
- C. NFPA 70 - National Electrical Code; 2005
- D. SSPC-Paint 15 - Steel Joist Shop Paint; Steel Structures Painting Council; Part of Painting Manual, Vol 2.
- E. ASME American Society of Mechanical Engineers
- F. ASTM American Society for Testing Materials
- G. NEMA National Electrical Manufacturers Association
- H. NFPA National Fire Protection Association
- I. OSHA Occupational Safety and Health Act
- J. SMACNA Sheet Metal and Air Conditioning Contractors National Association, Inc.
- K. IBC International Building Code
- L. IMC International Mechanical Code
- M. IPC International Plumbing Code
- N. IFC International Fire Code
- O. IECC - International Energy Conservation Code - 2003 Edition
- P. ASHRAE 90.1-2001 Edition

1.03 Interpretation of Contract Documents:

- A. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any item, in the drawings or specifications or both, carries with it the instruction to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.
- B. It shall be understood that the specifications and drawings are complimentary and are to be taken together for a complete interpretation of the work.
- C. No exclusions from, or limitations in, the language used in the drawings or specifications shall be interpreted as meaning that the appurtenances or accessories necessary to complete any required system or item of equipment are to be omitted
- D. The drawings of necessity utilize symbols and schematic diagrams to indicate various items of work. Neither of these have any dimensional significance nor do they delineate every item required for the intended installations. The work shall be installed in accordance with the diagrammatic intent expressed on the drawings, and in conformity with the dimensions indicated on final architectural and structural working drawings and on equipment shop drawings.
- E. No interpretation shall be made from the limitations of symbols and diagrams that any elements necessary for complete work are excluded.
- F. Certain details appear on the drawings which are specific with regard to the dimensioning and positioning of the work. These details are intended only for the purpose of establishing general feasibility. They do not obviate field coordination for the intended work.
- G. Information as to the general construction shall be derived from structural and architectural drawings and specifications only.
- H. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.

1.04 PERFORMANCE REQUIREMENTS

- A. Work shall be installed to conform with any City or State law, regulation, code, ordinance, ruling or Fire Underwriters requirement applicable to this class of work.
- B. All installations for construction purposes shall conform with the Department of Labor "Safety and Health Regulations for Construction".
- C. All equipment with electrical components shall bear the UL label.

1.05 SUBMITTALS

- A. See Section 01300 - Administrative Requirements for submittal procedures.

1.06 WARRANTY

- A. Correct defective Work within a five year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.01 Materials and Manufacturers:

- A. Equipment and materials installed under this contract shall be new and without blemish or defect.
- B. Each major component of equipment shall have the manufacturer's name, address, model

number and rating on a plate securely affixed in a conspicuous place. The nameplate of a distributing agent will not be acceptable. ASME Code Ratings, UL label, or other data which is die-stamped into the surface of the equipment shall be stamped in a location easily visible.

- C. In all cases the contractor shall be completely responsible for changes in dimension of other than first named manufacturer equipment, electrical changes, etc. required for proper function and final performance. Item shall comply with all requirements herein set forth and as required to perform as designed.

2.02 Electrical Equipment

- A. In general motor starters and adjustable frequency drives are furnished under Division 15. However, if integral controls and electrical components are specified with the equipment and are factory installed they shall be furnished under Division 15. Refer to the specific equipment specifications to determine if included under Division 15.
- B. Within 60 days of award of contract, the person responsible for work in this division shall verify that the appropriate number of contacts have been provided in the starters or drives and if a control power transformer is required that it has been provided to control the equipment as described in the drawings or specifications.

2.03 Specified Materials:

- A. Throughout the drawings and specifications, equipment and systems have been selected and are referenced by name, manufacturer, model number, etc. These references are not intended to limit competition. Products by other listed manufacturers will be acceptable.
- B. If a listed manufacturer other than the basis of design is used, it is the contractor's responsibility for changes in dimension, structural, electrical changes, etc. required for proper installation, function and final performance.

2.04 Substitution of Specified Materials:

- A. Throughout the drawings and specifications, equipment and systems have been selected and are referenced by name, manufacturer, model number, etc. These references are not intended to limit competition and in most cases materials and methods of construction equal to that specified will be accepted provided prior approval of any substitute item is obtained from the Architect/Engineer. Only products by the listed manufacturers will be acceptable. Contractors and other manufacturers may submit requests to be listed as an acceptable manufacturer on the specified item by submitting documentation in accordance with the requirements of Section 1600. All bidders will be notified by addendum of any approved substitutions. Under no circumstances will any substitutes be accepted after that date; and any item installed on the job which has not been approved in accordance with the noted procedure shall be removed and replaced with the appropriate approved item at the contractor's expense.
- B. In all cases the contractor shall be completely responsible for changes in dimension of other than first named manufacturer equipment, electrical changes, etc. required for proper function and final performance. Item shall comply with all requirements herein set forth and as required to perform as designed.

PART 3 EXECUTION

3.01 Protection of Equipment:

- A. Protect all materials and equipment from damage during storage at the site and throughout the

construction period.

- B. Protection from damage from rain, dirt, sun and ground water shall be accomplished by storing the equipment on elevated supports and covering them on all sides with protective rigid or flexible water proof coverings securely fastened.
- C. Piping shall be protected by storing it on elevated supports and capping the ends with suitable material to prevent dirt accumulation in the piping.

3.02 COORDINATION OF WORK

- A. All work shall be coordinated to avoid conflict with other contractors.
- B. The contractor shall be responsible for checking to insure that the equipment to be installed will fit in the space shown on the drawings. If there is a conflict, the contractor shall notify the Engineer before bid. By submitting a bid the contractor assures that the equipment to be installed will fit or that provisions have been included in the bid to move the equipment to a location where it can be installed without conflict.
- C. The Contractor shall review and coordinate the casework and millwork shop drawings to determine the location of sinks, range hoods, refrigerators, lab equipment, etc., and rough-in and install any and all items shown on the plans.

3.03 Contiguous Work:

- A. If any part of the Contractor's work is dependent for its proper execution or for its subsequent efficiency or appearance on the character or conditions of contiguous work not executed by him, this contractor shall examine and measure such contiguous work and report to the Architect in writing any imperfection therein, or conditions that render it unsuitable for the reception of this work. Should the contractor proceed without making such written report, he shall be held to have accepted such work and the existing conditions and he shall be responsible.

3.04 Certificates of Inspection and Approval:

- A. Upon completion of work, furnish to the Owner certificates of inspection or approval from the authorities having jurisdiction if certificates of inspection or approval are required by law or regulation.

3.05 Equipment Pads:

3.06 Sleeves and Openings:

- A. Furnish, locate, install, and fireproof all sleeves and openings required for installation of the work.

3.07 Access to Equipment and Valves:

- A. All control devices, specialties, valves and removable panels on equipment shall be so located as to provide easy access for inspection and maintenance, including removal of any interior components.
- B. Should any work, such as piping, ducts, conduit, etc. be installed without due regard to the accessibility of devices installed by other contractors, the installation shall be relocated, offset or rerouted without cost to the Owner.

3.08 Cutting and Patching:

- A. Perform all cutting and patching required for installation of the work.

3.09 Welding:

- A. Welders shall be qualified as prescribed by Section IX of the ASME Boiler Code. All weld joints shall conform to ANSI/ASME B-31.1.

3.10 Project Closeout:

- A. Maintenance Manuals: At the end of construction, furnish to the Architect three (3) bound and indexed sets of maintenance and operating instructions, parts lists, electrical wiring diagrams, balance data, and manufacturer's literature sufficient for operation and complete maintenance of all equipment by the Owner.
- B. Approved submittals and shop drawings may be included in the Maintenance Manuals instead of being separately furnished, if desired.
- C. It is intended that the documentation provided in maintenance manuals, along with as-built drawings, shall be complete and detailed enough to permit and facilitate troubleshooting, engineering analysis, and design work for future changes, without extensive field investigations and testing. Manuals shall be prepared so as to explain system operation and equipment to those not acquainted with the job.
- D. Manuals shall be durably bound and clearly identified on the front cover (and on the spine of thick volumes). Identification shall include the building or project name, applicable trade (such as HVAC, Plumbing, Fire Protection, etc.), approximate date of completion (month and year) and contractor's name.
- E. Manuals shall be organized into well defined and easy to locate sections, with index tabs or separators to divide the sections. A complete table of contents shall be provided at the front indicating the section or page number for each system, subsystem, or supplier/manufacturer.
- F. Manuals shall include complete information and diagrams on all controls, indicators, sensors, and signal sources. Control diagrams are to show the locations of components and major equipment by room number or other identification when room numbers are not applicable. Locations of out-of-sight components, such as duct mounted sensors, flow switches, etc. should be clearly indicated. Control diagrams must include identification of components by make and model number, operating ranges, recommended set points, reset schedules, and other job-specific data useful for troubleshooting, calibration and maintenance. Complete narrative descriptions of operating sequences of control systems and subsystems shall be included on the prints adjacent to the corresponding schematics. Catalog data and cuts shall be clearly marked to indicate model numbers, sizes, capacities, operating points, and other characteristics of each item used. This should include accessories or special features provided. Where various sizes or variations of a series or model are used, documents should clearly show which are used where. Where quantities are appropriate, schedule of usage should be provided. Maintenance literature shall include complete information for identifying and ordering replacement parts, such as illustrated parts breakdowns.
- G. Maintenance manuals must include complete balance data on all systems.

3.11 Instructions to Owner:

- A. Contractor shall conduct a maintenance and operational instruction session for the Owner. Where highly technical or complex equipment is supplied, such as chillers and control systems,

manufacturer's representatives, controls subcontractors, and other appropriate personnel who are particularly qualified, shall conduct training sessions pertaining to their equipment, or systems. Such training shall be scheduled with the Owner in advance.

3.12 Spare Filters:

- A. Spare filters shall be delivered to Owner's representative.

3.13 Warranties:

- A. This Contractor warrants the mechanical systems to be free of defects in materials and workmanship for a period of one year after date of final payment. The effective dates of this warranty apply to all components of the mechanical systems regardless of any equipment manufacturer's warranties which may expire at an earlier date. Any system malfunctions, or any previously undiscovered non-compliance with the plans and specifications, during the warranty period shall be repaired at no cost to the Owner.
- B. Deliver to Owner all warranties, guarantees, etc. and obtain written receipts.

END OF SECTION

SECTION 15065 - MOTORS AND CONTROLLERS FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Motor Controllers
- B. Manual Disconnect Switches

1.02 REFERENCE STANDARDS

- A. NEMA MG 1 - Motors and Generators; National Electrical Manufacturers Association; 2009, Revision 1 - 2010.
- B. NFPA 70 - National Electrical Code; National Fire Protection Association; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Spare parts lists
 - 2. Operating instructions
 - 3. Maintenance instructions, including preventative and corrective maintenance.
 - 4. Copies of warranties
 - 5. Wiring diagrams
 - 6. Shop drawings and product data

1.04 QUALITY ASSURANCE

- A. Conform to NFPA 70.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.06 WARRANTY

- A. See Section 01780 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for motors larger than 20 horsepower.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Lincoln Motors: www.lincolnmotors.com.
- B. A. O. Smith Electrical Products Company: www.aosmithmotors.com.
- C. Reliance Electric/Rockwell Automation: www.reliance.com.
- D. Substitutions: See Section 01600 - Product Requirements.

2.02 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Construction:
 - 1. Open drip-proof type except where specifically noted otherwise.
 - 2. Design for continuous operation in 40 degrees C environment.
 - 3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
- B. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.
- C. Wiring Terminations:
 - 1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
 - 2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.03 APPLICATIONS

2.04 MOTOR CONTROLLERS:

- A. Division 15000 Contractors shall provide motor controls and controllers for all items installed under this division of the specifications except for the following equipment:
 - 1. Controllers to be installed in motor control centers.
 - 2. Single speed wall switches for 120 volt and 277 volt fan motors. These are shown on mechanical drawings to indicate location only.
 - 3. Fractional horsepower fans interlocked with light switches.
- B. Unless indicated otherwise, starters shall be magnetic starters.
- C. Branch-circuit protective devices shall not be permitted to serve as controllers on any motors provided under this division of the specifications.
- D. All motor controllers that are specified to be furnished by Division 15000 Contractors shall be turned over to Electrical Contractor for installation by Electrical Contractor unless otherwise specified.
- E. Division 15000 Contractors shall provide motor controls and controllers packaged and pre-wired with equipment where specified or shown on drawings and schedules.
- F. Each controller shall be capable of starting and stopping the motor it controls and shall be capable of interrupting the locked-rotor current of the motor.
- G. Each controller shall have a horsepower rating not lower than the horsepower rating of the motor it controls.
- H. All motor controllers shall be furnished with an identification label designating service for which controller is used. Plate shall be firmly attached to controller or wall mounted adjacent to controller.
- I. All indoor controller enclosures shall be NEMA Type 1 unless specified otherwise. All controller enclosures directly exposed to weather shall be NEMA Type 3R.

2.05 MAGNETIC STARTERS:

- A. Unless otherwise indicated on the drawings, magnetic motor starters shall be full voltage and horsepower rated, across-the-line with 120 volt, 60 Hz control for motors up to and including 25 horsepower. Magnetic starters for motors above 25 horsepower shall be reduced voltage type and shall conform to all requirements of the supplying utility company. Each magnetic starter shall be provided with green "run" pilot light and red "Stop" pilot light.
- B. Pilot lights shall be provided with factory furnished legend plates indicating "Stop", "Run", etc. Pilot lights shall be provided with interlocks controlled by the starter operating coil.
- C. Thermal overloads shall be externally resettable. A thermal overload shall be provided in each phase. Thermal overloads shall be sized in accordance with the actual nameplate current of the motor served.
- D. Each magnetic starter shall be provided with "Start" and "Stop " push buttons, and under voltage protection for manual or automatic operation.
- E. Where required for automatic operation by a remote pilot device under the applicable sections of this Specification, magnetic starters shall be provided with a "Hand-Off-Automatic" selector switch.
- F. Hand-Off-Automatic device shall not be wired to override safety device interlocks on starter. If selector is mounted remotely, provide test start push button on starter.
- G. Each magnetic starter shall be provided with auxiliary contacts (N.O., N.C., or N.O.-N.C.) for interlocking and automatic operation required under the applicable sections of this Specification.
- H. Except where indicated on the drawings, all pilot lights, push buttons, and selector switches shall be mounted in the motor starter cover.
- I. Magnetic starters shall be Square D Class 8536, or approved equal by General Electric, Cutler Hammer, or Westinghouse.

2.06 MANUAL DISCONNECT SWITCHES:

- A. Division 15000 contractor shall provide manual disconnect switches where not indicated on Division 16000 drawings.
- B. Disconnect switches shall be line voltage type with overload protection. Disconnect switches shall be quick make and break, toggle operated, trip free, and shall be provided with a lockoff handle guard and oversized enclosure.
- C. Where required for automatic operation by a remote pilot device under the controls section of this specification, disconnect switches shall be provided with a "hand-off-automatic" selector switch in addition to the "on-reset-off" toggle switch.
- D. All disconnect switch enclosures shall be NEMA Type 1 unless specified otherwise. All disconnect enclosures directly exposed to weather shall be NEMA Type 3R.
- E. Disconnect switches shall be Square D Class 2510 Type F or approved equal by General Electric, Cutler Hammer, or Westinghouse.

PART 3 EXECUTION

3.01 INSTALLATION

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

- B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- C. Check line voltage and phase and ensure agreement with nameplate.

END OF SECTION

SECTION 15066 - VARIABLE FREQUENCY CONTROLLERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Variable frequency controllers.

1.02 REFERENCES

- A. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems; National Electrical Manufacturers Association; 1995.
- B. NEMA ICS 7 - Industrial Control and Systems: Adjustable Speed Drives; National Electrical Manufacturers Association; 1993.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association; 1997.
- D. NFPA 70 - National Electrical Code; National Fire Protection Association; 1999.

1.03 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
- C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.
- D. Test Reports: Indicate field test and inspection procedures and test results.
- E. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- F. Manufacturer's Field Reports: Indicate start-up inspection findings.
- G. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.
- H. Maintenance Data: NEMA ICS 7.1. Include routine preventive maintenance schedule.
- I. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Local representative
 - 2. Emergency instructions
 - 3. Recommended spare parts
 - 4. Spare parts lists
 - 5. Operating instructions
 - 6. Maintenance instructions, including preventative and corrective maintenance.
 - 7. Copies of warranties
 - 8. Wiring diagrams
 - 9. Shop drawings and product data

1.04 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Reliance Electric/Rockwell Automation: www.reliance.com.
- B. Robicon Corporation: www.robicon.com.
- C. Square D: www.squared.com.
- D. ABB
- E. Trane
- F. York

2.02 DESCRIPTION

- A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7. Select unspecified features and options in accordance with NEMA ICS 3.1.
- B. Enclosures: NEMA 250, Type 1, suitable for equipment application in places regularly open to the public.

2.03 OPERATING REQUIREMENTS

- A. Operating Ambient: 0 degrees C to 40 degrees C.
- B. Volts Per Hertz Adjustment: Plus or minus 10 percent.
- C. Current Limit Adjustment: 60 to 110 percent of rated.
- D. Acceleration Rate Adjustment: 0.5 to 30 seconds.
- E. Deceleration Rate Adjustment: 1 to 30 seconds.
- F. Input Signal: 4 to 20 mA DC.
- G. Harmonic current content less than 5%.

2.04 COMPONENTS

- A. Display: Provide integral digital display to indicate output voltage, output frequency, and output current.
- B. Status Indicators: Separate indicators for overcurrent, overvoltage, ground fault, overtemperature, and input power ON.
- C. Furnish HAND-OFF-AUTOMATIC selector switch and manual speed control.
- D. Include undervoltage release.

- E. Door Interlocks: Furnish mechanical means to prevent opening of equipment with power connected, or to disconnect power if door is opened; include means for defeating interlock by qualified persons.
- F. Safety Interlocks: Furnish terminals for remote contact to inhibit starting under both manual and automatic mode.
- G. Control Interlocks: Furnish terminals for remote contact to allow starting in automatic mode.
- H. Emergency Stop: Use dynamic brakes for emergency stop function.
- I. Disconnecting Means: Include integral fused disconnect switch on the line side of each controller.
- J. Wiring Terminations: Match conductor materials and sizes indicated.
- K. Manual Speed Control Potentiometer to set speed in the manual mode.
- L. Minimum and maximum speed adjustment potentiometers.
- M. Isolation transformer or live filters to guarantee compliance with FCC Rule 15, subpart J and IEEE STD 519-1981.
- N. Speed indicating meter, calibrated in per cent speed, to indicate speed of the converter-powered motor.
- O. Status lights for all normal and alarm functions.
- P. Voltmeter - 0-500 volt scale.
- Q. Over temperature trip and alarm light.
- R. Ammeter - corresponding to motor rating.
- S. Short circuit and ground fault protection.
- T. Frequency meter - 0-120 Hz scale.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.
- B. Tighten accessible connections and mechanical fasteners after placing controller.
- C. Provide fuses in fusible switches; refer to Section 16491 for product requirements.

END OF SECTION

SECTION 15073 - VIBRATION AND SEISMIC CONTROLS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Equipment support bases.
- B. Vibration isolators.
- C. Vibration isolators.
- D. Seismic restraints.

1.02 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. See Section 15010 - General Mechanical, for additional submittal procedures.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Isolation Technology, Inc: www.isolationtech.com.
- B. Kinetics Noise Control, Inc: www.kineticsnoise.com.
- C. Mason Industries: www.mason-ind.com.

2.02 VIBRATION ISOLATION AND SEISMIC RESTRAINTS

- A. General:
 - 1. Housekeeping Pads
 - a. Housekeeping pad reinforcement and monolithic pad attachment to the structure details and design shall be prepared by the restraint vendor if not already indicated on the drawings.
 - b. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.
 - 2. Supplementary Support Steel
 - a. Contractor shall supply supplementary support steel for all equipment, piping, ductwork, etc. including roof mounted equipment, as required or specified.
 - 3. Attachments:
 - a. 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.
- B. Specification Type "E"
 - 1. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" (6mm) neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring

- diameters, deflection, compressed spring height and solid spring height.
2. Mason Industries, Inc. type SLF
- C. Specification Type “J”
1. Hangers shall consist of rigid steel frames containing minimum 1 1/4" (32mm) thick neoprene elements at the top and a steel spring with general characteristics as in specification 5 seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 arc from side to side before contacting the rod bushing and short circuiting the spring. Submittals shall include a hanger drawing showing the 30 capability.
 2. Mason Industries, Inc. type 30N.
- D. Specification Type “JA”
1. Hangers shall be as described in J, but they shall be supplied with a combination rubber and steel rebound washer as the seismic upstop for suspended piping, ductwork, equipment and electrical cabletrays. Rubber thickness shall be a minimum of 1/4" (6mm). Submittals shall include a drawing of the hanger showing the installation of the rebound washer.
 2. Mason Industries, Inc. type RW30N.
- E. Specification Type “K”
1. Hangers shall be as described in J, but they shall be precompressed and locked at the rated deflection by means of a resilient seismic upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30 capability.
 2. Mason Industries, Inc. type PC30N.
- F. Specification Type “L”
1. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint. Cables must be prestretched to achieve a certified minimum modulus of elasticity. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Preapproval “OPA” Number from OSHPD in the State of California verifying the maximum certified load ratings.
 2. Mason Industries, Inc. type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam.
 3. Specifications L applies to trapeze as well as clevis hanger locations. At trapeze anchor locations piping must be shackled to the trapeze.
 4. Specification L applies to hanging equipment as well.
- G. Specification Type “M”
1. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall

- have anchorage preapproval "OPA" number from OSHPD in the state of California verifying the maximum certified load ratings.
2. Mason Industries, Inc. type SSB, SSBS or SSRF.
 3. Specifications M applies to trapeze as well as clevis hanger locations. At trapeze anchor locations piping must be shackled to the trapeze.
 4. Specification M applies to hanging equipment as well.
- H. Specification Type "N"
1. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Rod clamp assemblies shall have an Anchorage Preapproval "OPA" Number from OSHPD in the State of California.
 2. Mason Industries, Inc. type SRC or UC.
 3. Specifications N applies to trapeze as well as clevis hanger locations. At trapeze anchor locations piping must be shackled to the trapeze.
 4. Specification N applies to hanging equipment as well.
- I. Specification Type "O"
1. Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the cross bolt. Clevis cross braces shall have an Anchorage Preapproval "OPA" Number from OSHPD in the State of California.
 2. Mason Industries, Inc. type CCB.
- J. Specification Type "R"
1. Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying its allowable loads.
 2. Mason Industries, Inc. type SAS.
- K. Specification Type "S"
1. Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.O. Evaluation Service, Inc. verifying to its allowable loads.
 2. Mason Industries, Inc. type SAB.
- L. Specification Type "X"
1. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" (75mm) and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:
 - a. Flanged
 - 1) 3" x 14" (75 x 350mm)
 - 2) 6" x 20" (150 x 500mm)
 - 3) 12" x 28" (300 x 700mm)
 - 4) 4" x 15" (100 x 375mm)
 - 5) 8" x 22" (200 x 550mm)
 - 6) 14" x 30" (350 x 750mm)

- 7) 5" x 19" (125 x 475mm)
 - 8) 10" x 26" (250 x 650mm)
 - 9) 16" x 32" (400 x 800mm)
 - b. Male Nipples
 - 1) 1/2" x 9" (12 x 225mm)
 - 2) 1 1/4" x 12" (32 x 300mm)
 - 3) 2" x 14" (50 x 350mm)
 - 4) 3/4" x 10" (19 x 250mm)
 - 5) 1 1/2" x 13" (38 x 325mm)
 - 6) 2 1/2" x 18" (64 x 450mm)
 - 7) 1" x 11" (25 x 275mm)
 - c. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible.
 2. Mason Industries, Inc. type BSS.
- M. Specification Type "Y"
1. All-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum 1/2" (12mm) thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi (.35 kg/mm²) and the design shall be balanced for equal resistance in any direction.
 2. Mason Industries, Inc. type ADA.
- N. Specification Type "Z"
1. Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" (12mm) thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of $\pm 1\ 5/8"$ (41mm) motion, or to meet location requirements.
 2. Mason Industries, Inc. type VSG.
- O. Specification Type "AA"
1. Split Wall Seals consist of two bolted pipe halves with minimum 3/4" (19mm) thick neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of 1" (25mm) past either face of the wall. Where temperatures exceed 240F(115C), 10# (4.5kg) density fiberglass may be used in lieu of the sponge.
 2. Mason Industries, Inc. type SWS.

2.03 VIBRATION ISOLATION OF PIPING

- A. Horizontal pipe isolation:
1. The first four pipe hangers in the main lines near the mechanical equipment shall be as described in specification K. Brace hanger rods with SRC clamps specification N.
 2. Horizontal runs in all other locations throughout the building shall be isolated by hangers as described in specification J & JA.
 3. Floor supported piping shall rest on isolators as described in specification F.
 4. Piping connected to equipment located in basements and hangs from ceilings under

occupied spaces the first three hangers shall have:

- a. 0.75" (19mm) deflection for pipe sizes up to and including 3" (75mm).
 - b. 1 1/2" (38mm) deflection for pipe sizes up to and including 6" (150mm).
 - c. 2 1/2" (64mm) deflection thereafter.
 - d. Hangers shall be located as close to the overhead structure as practical. Hanger locations that also have seismic restraints attached must have type RW Rebound Washers to limit uplift.
5. Where piping connects to mechanical equipment install specification W expansion joints or specification X stainless hoses if W is not suitable for the service.

B. Riser isolation:

1. Risers shall be suspended from specification JA hangers or supported by specification E mountings, anchored with specification Y anchors, and guided with specification Z sliding guides.
2. Steel springs shall be a minimum of 0.75" (19mm) except in those expansion locations where additional deflection is required to limit load changes to $\pm 25\%$ of the initial load.
3. Submittals must include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.

2.04 SEISMIC DESIGN

A. General

1. Specifications and plans shall indicate minimum requirements and general intent. The actual requirements shall be determined by the seismic system designer but those requirements shall not be less than indicated on the plans and in these specifications.
2. Calculations shall be submitted and signed by a licensed professional engineer in the state where the project is located.
3. This project is subject to the seismic bracing requirements of the International Building Code, 2006 edition. The following criteria are applicable to this project.
 - a. Seismic Use Group (Table 1604.5): III
 - b. Site Class Category (Table 1615.1.1): D
 - c. Forces shall be calculated for the above requirements and Equation 16-67, 68, & 69 in section 1621.1.4, unless exempted by 1621.1.1.

B. Seismic restraint of piping:

1. Seismically restrain all piping listed below. Use specification M cables if isolated. Specification M or N restraints may be used on unisolated piping.
 - a. Piping located in boiler rooms, mechanical equipment rooms, and refrigeration equipment rooms that is 1 1/4" (32mm) I.D. and larger.
 - b. All other piping 2 1/2" (64mm) diameter and larger.
2. Transverse piping restraints shall be at 40' (12m) maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
3. Longitudinal restraints shall be at 80' (24m) maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
4. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.
5. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe

section of the same size connected perpendicular to it if the restraint is installed within 24" (600mm) of the elbow or TEE or combined stresses are within allowable limits at longer distances.

6. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.
 7. Branch lines may not be used to restrain main lines.
 8. Cast iron pipe of all types, glass pipe and any other pipes joined with a four band shield and clamp assembly in areas with Ss of 0.35 or greater shall be braced as in sections 3.02.C.2 and 3. For areas with Ss less than 0.35, 2 band clamps may be used with a reduced spacing of 1/2 of those listed in sections 3.02.C.2 and 3.
 9. Connection to the structure must be made with a non-friction connection (i.e. no "C" clamps)
 10. Hanger locations that also have seismic restraints attached must have Specification JA.
 11. Pipe Exclusions
 - a. Piping in boiler and mechanical rooms less than 1 1/4" (32mm) inside diameter.
 - b. All other piping less than 2 1/2" (64mm) inside diameter.
 - c. All piping suspended by clevis hangers where the distance from the top of the pipe to the suspension point is 12" or less.
 - d. All trapezed piping where the distance from the suspension point to the trapeze member is 12" or less.
 - e. If any suspension location in the run exceeds the above, the entire run must be braced.
- C. Seismic restraint of ductwork:
1. Seismic restraint of ductwork
 - a. Seismically restrain all ductwork with specification L or M restraints as listed below:
 - 1) Restrain rectangular ducts with cross sectional area of 6 sq.ft. (.5 m2) or larger.
 - 2) Restrain round ducts with diameters of 28" (700mm) or larger.
 - 3) Restrain flat oval ducts the same as rectangular ducts of the same nominal size.
 - b. Transverse restraints shall occur at 30' (9m) intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.
 - c. Longitudinal restraints shall occur at 60' (18m) intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4' (1.2m) of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints shall conform to SMACNA duct construction standards.
 - d. The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.
 - e. A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.
 - f. Walls, including gypsum board non bearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.
 - g. Connection to the structure must be made with a non-friction connection (i.e. no "C" clamps)
 - h. Hanger locations that also have seismic restraints attached must have Specification JA.
 - i. Ductwork Exclusions:
 - 1) Rectangular and square and ducts that are less than 6 square feet in cross

- sectional area.
- 2) Round duct less than 28" (.5m²) in diameter.
 - 3) All trapezed ductwork where the distance from the suspension point to the trapeze member is 12" or less.
 - 4) Ductwork hung with straps where the top of the duct is 12" or less from the suspension point and the strap has 2 #10 sheet metal screws within 2" of the top of the duct.
 - 5) If any suspension location in the run exceeds the above, the entire run must be braced.

2.05 PERFORMANCE REQUIREMENTS

A. General:

1. All vibration isolators, base frames and inertia bases to conform to all uniform deflection and stability requirements under all operating loads.
2. Steel springs to function without undue stress or overloading.

2.06 EQUIPMENT SUPPORT BASES

2.07 VIBRATION ISOLATORS

PART 3 EXECUTION

3.01 INSTALLATION - GENERAL

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

3.02 GENERAL

- A. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.
- B. Installation of vibration isolators and seismic restraints must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.
- C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.
- D. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.
- E. Coordinate work with other trades to avoid rigid contact with the building.
- F. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractors expense.
- G. Bring to the architects/engineers attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractors expense.
- H. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the contractors expense.

- I. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:
 - 1. Flanges of structural beams.
 - 2. Upper truss cords in bar joist construction.
 - 3. Cast in place inserts or wedge type drill-in concrete anchors.
- J. Specification L cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.
- K. Specification L cable assemblies are installed taut on non-isolated systems. Specification M seismic solid braces may be used in place of cables on rigidly attached systems only.
- L. At locations where specification L or M restraints are located, the support rods must be braced when necessary to accept compressive loads with specification N braces.
- M. At locations where specification L cable restraints are installed on support rods with spring isolators, the spring isolation hangers must be specification type JA.
- N. At all locations where specification L or M restraints are attached to pipe clevis, the clevis cross bolt must be reinforced with specification type O braces.
- O. Drill-in concrete anchors for ceiling and wall installation shall be specification type R, and specification type S female wedge type for floor mounted equipment.
- P. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide specification AA wall seals.
- Q. All fire protection piping shall be braced in accordance with NFPA 13 and 14.
- R. All mechanical equipment shall be vibration isolated and seismically restrained as specified.
- S. All fire protection equipment is considered life safety equipment and shall be seismically restrained.
- T. Terminal boxes and fan powered equipment weighing less than 50 lbs. (23kg) and rigidly connected to the supply side of the duct system and supported with a minimum of 4 hanger rods.

3.03 SEISMIC CERTIFICATION AND ANALYSIS:

- A. Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer licensed in the state of the job location.
- B. Calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered professional engineer licensed in the state of the job location. Testing and calculations must include both shear and tensile loads as well as one test or analysis at 45 to the weakest mode.
- C. Analysis must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure.

3.04 FIELD QUALITY CONTROL

- A. Inspect isolated equipment after installation and submit report. Include static deflections.

3.05 SCHEDULE

- A. Pipe Isolation Schedule.
 - 1. 1 Inch Pipe Size: Isolate 120 diameters from equipment.
 - 2. 2 Inch Pipe Size: Isolate 90 diameters from equipment.
 - 3. 3 Inch Pipe Size: Isolate 80 diameters from equipment.
 - 4. 4 Inch Pipe Size: Isolate 75 diameters from equipment.

END OF SECTION

SECTION 15075 - MECHANICAL IDENTIFICATION

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems; The American Society of Mechanical Engineers; 2007.
- B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2001 (Reapproved 2007).

1.03 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.
- E. Manufacturer's Installation Instructions: Indicate special procedures, and installation.
- F. Project Record Documents: Record actual locations of tagged valves.
- G. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Spare parts lists
 - 2. Shop drawings and product data

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

- A. Fans: Nameplates.
- B. Control Panels: Nameplates.
- C. Air handlers/Rooftop Units: Nameplates.
- D. Major Control Components: Nameplates.
- E. Piping: Pipe markers.
- F. Pumps: Nameplates.
- G. Valves: Tags and ceiling tacks where located above lay-in ceiling.
- H. Water Treatment Devices: Nameplates.

2.02 MANUFACTURERS

- A. Brady Corporation: www.bradycorp.com.
- B. Champion America, Inc: www.Champion-America.com.
- C. Seton Identification Products: www.seton.com/aec.

2.03 NAMEPLATES

- A. Description: Laminated three-layer plastic with engraved letters.
 - 1. Letter Color: White.
 - 2. Letter Height: 1/4 inch.
 - 3. Background Color: Black.
 - 4. Plastic: Conform to ASTM D709.

2.04 TAGS

- A. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- B. Chart: Typewritten letter size list in anodized aluminum frame.

2.05 PIPE MARKERS

- A. Manufacturers:
- B. Comply with ASME A13.1.
- C. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

PART 3 EXECUTION

3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.

3.02 INSTALLATION

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- D. Identify fans, air handlers, rooftop units, and heat transfer equipment with plastic nameplates.
- E. Identify control panels and major control components outside panels with plastic nameplates.
- F. Identify valves in main and branch piping with tags.
- G. Tag automatic controls, instruments, and relays. Key to control schematic.
- H. Identify piping, concealed or exposed, with plastic pipe markers. Use tags on piping 3/4 inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or

enclosure, and at each obstruction.

3.03 SCHEDULES

A. Piping

1. All pipe identification shall be color coded in accordance with the following:
 - a. Steam - Yellow
 - b. Chilled water supply and return - Blue
 - c. Domestic cold water - Green

END OF SECTION

SECTION 15080 - MECHANICAL INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Duct insulation.
- B. Piping insulation.

1.02 SCOPE OF WORK:

- A. Provide insulation as specified for make-up water and chilled water piping systems, including valves, fittings, flanges, strainers, and mechanical couplings.

1.03 RELATED SECTIONS

- A. Section 15075 - Mechanical Identification.

1.04 REFERENCES

- A. ASTM C 518 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 1991.
- B. ASTM C 553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 1992.
- C. ASTM C 612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 1993.
- D. ASTM E 96 - Standard Test Methods for Water Vapor Transmission of Materials; 1995.

1.05 SUBMITTALS

- A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- B. Manufacturer's Instructions: Indicate installation procedures which ensure acceptable workmanship and installation standards will be achieved.
- C. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Shop drawings and product data

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

1.07 REGULATORY REQUIREMENTS

- A. Materials: Conform to maximum flame spread/smoke developed rating of 25/50 in accordance with ASTM E 84.

1.08 DELIVERY, STORAGE, AND PROTECTION

- A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical

damage, by storing in original wrapping.

1.09 ENVIRONMENTAL REQUIREMENTS

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

PART 2 PRODUCTS

2.01 DUCT INSULATION

A. GLASS FIBER, FLEXIBLE

- 1. Manufacturers.
 - a. Provide products complying with the specifications by one of the following manufactures.
 - 1) Certain Teed Corporation.
 - 2) Johns Manville
 - 3) Knauf Fiberglass GmbH.
 - 4) Owens-Corning Fiberglass Corporation.
- 2. Insulation: ASTM C 553; flexible, noncombustible blanket.
 - a. 'K' value : ASTM C 518, 0.31 at 75 degrees F.
 - b. Maximum service temperature: 250 degrees F.
 - c. Maximum moisture absorption: 0.20 percent by volume.
- 3. Vapor Barrier Jacket:
 - a. Kraft paper with glass fiber yarn and bonded to aluminized film.
 - b. Moisture vapor transmission: ASTM E 96; 0.02 perm.
 - c. Secure with pressure sensitive tape.
- 4. Vapor Barrier Tape:
 - a. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

B. GLASS FIBER, RIGID

- 1. Manufacturers.
 - a. Provide products complying with the specifications by one of the following manufactures.
 - 1) Certain Teed Corporation.
 - 2) Johns Manville
 - 3) Knauf Fiberglass GmbH.
 - 4) Owens-Corning Fiberglass Corporation.
- 2. Insulation: ASTM C 612; rigid, noncombustible blanket.
 - a. 'K' value : ASTM C 518, 0.24 at 75 degrees F.
 - b. Maximum service temperature: 250 degrees F.
 - c. Maximum moisture absorption: 0.20 percent by volume.
 - d. Density: 3.0 lb/cu ft.
- 3. Vapor Barrier Jacket:
 - a. Kraft paper with glass fiber yarn and bonded to aluminized film.
 - b. Moisture vapor transmission: ASTM E 96; 0.04 perm.
 - c. Secure with pressure sensitive tape.
- 4. Vapor Barrier Tape:
 - a. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with

pressure sensitive rubber based adhesive.

2.02 PIPE INSULATION

- A. Insulation shall have composite (insulation jacket or facing, and adhesive used to adhere the facing or jacket to the insulation) fire and smoke hazard ratings as tested by procedure ASTM E84, NFPA 255 or UL 723 not exceeding:
 - 1. Flame Spread: 25.
 - 2. Smoke Developed: 50.
- B. Insulation shall be glass fiber with a maximum K factor of .24 at 75 degrees F mean temperature with factory applied fire resistant vapor barrier jacket, for cold piping and fire retardant jacket for hot water. Insulation for outdoor piping shall be rigid foam urethane, Armalok II or equal.
 - 1. For fittings and valve bodies 3" and smaller, insulation shall be one-pound density glass fiber blanket wrapped firmly under compression with No. 20 gauge galvanized annealed steel wire and given a smoothing coat of finishing cement.
- C. Accessories such as adhesives, mastics, cements, tapes and cloth for fittings shall have the same component rating as listed above. All products or their shipping cartons shall bear a label indicating that flame and smoke ratings do not exceed requirements. Treatment of jackets or facings to impart flame and smoke-safety shall be permanent. The use of water-soluble treatments are prohibited.
 - 1. Where Benjamin-Foster adhesives are specified equal products manufactured by 3M Company, or the manufacturer of the insulation are acceptable upon approval by the Engineer. Armstrong 520 adhesive shall be used for Armstrong insulation.
 - 2. In lieu of longitudinal lap seam specified, self-sealing lapped jacket shall be acceptable with requirement for aluminum bands on concealed piping.
- D. GLASS FIBER
 - 1. Manufacturers.
 - a. Provide products complying with the specifications by one of the following manufactures.
 - 1) Certain Teed Corporation.
 - 2) Johns Manville
 - 3) Knauf Fiberglass GmbH.
 - 4) Owens-Corning Fiberglass Corporation.
 - 2. Insulation: ASTM C 547 and ASTM C 795; rigid molded, noncombustible.
 - a. 'K' value: ASTM C 177, 0.24 at 75 degrees F.
 - b. Maximum service temperature: 850 degrees F.
 - c. Maximum moisture absorption: 0.2 percent by volume.
 - 3. Insulation: ASTM C 795; semi-rigid, noncombustible, end grain adhered to jacket.
 - a. 'K' value: ASTM C 177, 0.24 at 75 degrees F.
 - b. Maximum service temperature: 650 degrees F.
 - c. Maximum moisture absorption: 0.2 percent by volume.
 - 4. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E 96 of 0.02 perm-inches.
 - 5. Vapor Barrier Lap Adhesive:
 - a. Compatible with insulation.
 - 6. Insulating Cement/Mastic:
 - a. ASTM C 195; hydraulic setting on mineral wool.

7. Fibrous Glass Fabric:
 - a. Cloth: Untreated; 9 oz/sq yd weight.
 - b. Blanket: 1.0 lb/cu ft density.
 - c. Weave: 5x5.
- E. HYDROUS CALCIUM SILICATE
 1. Insulation: ASTM C 533 and ASTM C 795; rigid molded, asbestos free, gold color.
 - a. 'K' value: ASTM C 177 and C518; 0.40 at 300 degrees F.
 - b. Maximum service temperature: 1200 degrees F.
 - c. Density: 15 lb/cu ft.
 2. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
 3. Insulating Cement:
 - a. ASTM C 449/C 449M.
- F. FLEXIBLE ELASTOMERIC CELLULAR INSULATION
 1. Manufacturer:
 - a. Armacell International: www.armacell.com.
 - b. Substitutions: See Section 01600 - Product Requirements.
 2. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C 534; use molded tubular material wherever possible.
 - a. Minimum Service Temperature: -40 degrees F.
 - b. Maximum Service Temperature: 220 degrees F.
 - c. Connection: Waterproof vapor barrier adhesive.
 3. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.
- G. JACKETS
 1. Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire retardant lagging adhesive.
 - a. Lagging Adhesive:
 - 1) Compatible with insulation.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. DUCT INSULATION
 1. Insulated ducts conveying air below ambient temperature:
 - a. Provide insulation with vapor barrier jackets.
 - b. Finish with tape and vapor barrier jacket.
 - c. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - d. Insulate entire system including fittings, joints, flanges, fire dampers, flexible

connections, and expansion joints.

2. Insulated ducts conveying air above ambient temperature:
 - a. Provide with or without standard vapor barrier jacket.
 - b. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

D. PIPE INSULATION

1. Longitudinal lap and 4" wide vapor barrier joint seal strips shall be adhered neatly in place with BF 85-20 adhesive or approved equal and banded.
2. The ends of pipe insulation shall be sealed off with BF 30-35 coatings at all flanges, valves and fittings and at intervals of not more than 21 feet on continuous runs or pipes.
3. Fittings shall be vapor sealed by applying a layer of white open weave glass fabric (20 x 20 between two 1/16" thick coats of BF 30-35.
4. Insulation shall be fastened in place with 16 gauge annealed wire on 18" centers maximum for piping runs and as required for a secure installation at fittings, valves, and appurtenances. Provide 8 ounce canvas jacket pasted in place and sized for all exposed piping.
5. Exposed piping in mechanical rooms shall receive 8 ounce canvas jacket.
6. Insulated pipes conveying fluids below ambient temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.
7. Glass fiber insulated pipes conveying fluids below ambient temperature:
 - a. Provide vapor barrier jackets, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
 - b. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
8. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
9. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
10. Glass fiber insulated pipes conveying fluids above ambient temperature:
 - a. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
 - b. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
11. Inserts and Shields:
 - a. Application: Piping 1-1/2 inches diameter or larger.
 - b. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - c. Insert location: Between support shield and piping and under the finish jacket.
 - d. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - e. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
12. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Section 07840.

3.03 SCHEDULES

A. DUCTWORK INSULATION

1. Outside Air Intake Ducts:
 - a. Rigid Glass Fiber Duct Insulation: 2 inch thick.
2. Supply Ducts.
 - a. Flexible Glass Fiber Duct Insulation: 2 inch thick.

B. PIPING INSULATION

1. Chilled water supply and return piping:
 - a. All pipe sizes: 1-1/2 inch Glass fiber insulation.
2. Chilled water supply and return piping outdoors:
 - a. All pipe sizes: 1-1/2 inch Cellular Glass insulation.
3. Heating water supply and return piping:
 - a. All pipe sizes: 1-1/2 inch Glass fiber insulation.
4. Condensate piping:
 - a. All pipe sizes: 1-1/2 inch Glass fiber insulation.
5. Steam Piping:
 - a. All pipe sizes: 1-1/2 inch Glass fiber insulation.
6. Steam Condensate:
 - a. All pipe sizes: 1-1/2 inch Glass fiber insulation.
7. Condensate Drains from Cooling Coils:
 - a. All pipe sizes: 1-1/2 inch Glass fiber insulation.
 - b. All pipe sizes: 3/4" inch Flexible Elastomeric Cellular Insulation.

END OF SECTION

SECTION 15128 - GAGES AND METERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pressure gages and pressure gage taps.
- B. Thermometers and thermometer wells.

1.02 RELATED REQUIREMENTS

- A. Section 15182 - Hydronic Piping.
- B. Section 15184 - Steam and Steam Condensate Piping.

1.03 REFERENCE STANDARDS

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments; The American Society of Mechanical Engineers; 2005.
- B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers; 2007.
- C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers; 2007.
- D. UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide list that indicates use, operating range, total range and location for manufactured components.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01600 - Product Requirements. for additional provisions.
- D. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Local representative
 - 2. Recommended spare parts
 - 3. Spare parts lists
 - 4. Operating instructions
 - 5. Maintenance instructions, including preventative and corrective maintenance.
 - 6. Maintenance instructions for special finishes, including recommended cleaning methods and materials, and special precautions identifying detrimental agents.
 - 7. Copies of warranties

1.05 FIELD CONDITIONS

- A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 PRODUCTS

2.01 PRESSURE GAGES

- A. Manufacturers:

1. Dwyer Instruments, Inc: www.dwyer-inst.com.
 2. Moeller Instrument Co., Inc: www.moellerinstrument.com.
 3. Omega Engineering, Inc: www.omega.com.
 4. Weiss
 5. Substitutions: See Section 01600 - Product Requirements.
- B. Pressure Gages: ASME B40.100, UL 393 drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
1. Case: Steel with brass bourdon tube.
 2. Size: 4-1/2 inch diameter.
 3. Mid-Scale Accuracy: One percent.
 4. Scale: Psi.

2.02 PRESSURE GAGE TAPPINGS

- A. Gage Cock: Tee or lever handle, brass for maximum 150 psi.
- B. Pulsation Damper: Pressure snubber, brass with 1/4 inch connections.
- C. Syphon: Steel, Schedule 40, 1/4 inch angle or straight pattern.

2.03 STEM TYPE THERMOMETERS

- A. Manufacturers:
1. Dwyer Instruments, Inc: www.dwyer-inst.com.
 2. Omega Engineering, Inc: www.omega.com.
 3. Weiss
 4. Weksler Glass Thermometer Corp: www.wekslerglass.com.
 5. Substitutions: See Section 01600 - Product Requirements.
- B. Thermometers - Adjustable Angle: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
1. Size: 9 inch scale.
 2. Window: Clear Lexan.
 3. Accuracy: 2 percent, per ASTM E77.
 4. Calibration: Degrees F.

2.04 THERMOMETER SUPPORTS

- A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
- B. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install pressure gages with pulsation dampers. Provide gage cock to isolate each gage. Extend nipples to allow clearance from insulation.

- C. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- D. Coil and conceal excess capillary on remote element instruments.
- E. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- F. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- G. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- H. Locate test plugs adjacent thermometers and thermometer sockets.

3.02 SCHEDULES

- A. Pressure Gage Tappings, Location:
 - 1. Control valves 3/4 inch & larger - inlets and outlets.
 - 2. Major coils - inlets and outlets.
- B. Thermometer Sockets, Location:
 - 1. Control valves 1 inch & larger - inlets and outlets.

END OF SECTION

SECTION 15145 - PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe, pipe fittings, valves, and connections for piping systems.
 - 1. Sanitary sewer.
 - 2. Domestic water.
 - 3. Gas.
 - 4. Deionized water

1.02 RELATED REQUIREMENTS

- A. Section 15082 - Piping Insulation.

1.03 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems; The American Society of Mechanical Engineers; 1996 (Reaffirmed 2003).
- B. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings; The American Society of Mechanical Engineers; 2010.
- C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2012 (ANSI B16.18).
- D. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2010).
- E. ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV; The American Society of Mechanical Engineers; 2011.
- F. ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV; The American Society of Mechanical Engineers; 2007.
- G. ASME B31.2 - Fuel Gas Piping; The American Society of Mechanical Engineers; 1968.
- H. Pipe.ASTM B 32 - Standard Specification for Solder Metal; 2008.
- I. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2009.
- J. ASTM B302 - Standard Specification for Threadless Copper Pipe, Standard Sizes; 2007.
- K. ASTM C1053 - Standard Specification for Borosilicate Glass Pipe and Fittings for Drain, Waste, and Vent (DWV) Applications; 2000 (Reapproved 2010).
- L. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2006.
- M. ASTM F438 - Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40; 2009.
- N. ASTM F439 - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80; 2009.
- O. ASTM F441/F441M - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80; 2009.

- P. ASTM F442/F442M - Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR); 2009.
- Q. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe; 2010.
- R. ASTM F493 - Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings; 2010.
- S. NFPA 54 - National Fuel Gas Code; National Fire Protection Association; 2012.

1.04 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
- C. Project Record Documents: Record actual locations of valves.
- D. Shop drawings and product data

1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with State of South Carolina, standards.
 - 1. Maintain one copy on project site.
- B. Valves: Manufacturer's name and pressure rating marked on valve body.
- C. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations.
- D. Welder Qualifications: Certified in accordance with ASME (BPV IX).
- E. Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

1.06 REGULATORY REQUIREMENTS

- A. Perform Work in accordance with State of South Carolina plumbing code.

1.07 PIPE MARKERS

- A. Color: Conform to ASME A13.1.
- B. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

1.08

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

- C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 CHEMICAL RESISTANT SEWER PIPING

- A. CPVC TYPE IV GRADE I ASTM F2618, SCHD 40.
- B. CPVC Pipe:
 - 1. Schd. 40
 - 2. Fittings: CPVC.
 - 3. FJoints: Solvent welded, with ASTM F493 solvent cement.
 - 4. CPVC to Glass Joints: Charlotte Pipe transition coupling AW 95C
 - 5. CPVC to Duriron Joints: Charlotte Pipe transition coupling AW 96C
 - 6. Flame spread of less than 25 and smoke developed rating of less than 50 based on the ULC S102.2 test protocol

2.02 WATER PIPING, ABOVE GRADE

- A. Copper Tube: ASTM B 88, Type L (B), Drawn (H).
 - 1. Fittings: ASME B16.22, wrought copper and bronze, or ASME B16.18 bronze sand castings. Fittings manufactured to copper tubing sizes, with grooved ends designed to accept grooved end couplings of the same manufacturer. (Flaring of tube and fitting ends to IPS dimensions is not allowed.
 - 2. Joints: ASTM B 32, alloy Sn95 solder. Maximum lead content 0.10%

2.03 NATURAL GAS PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M Schedule 40 black.
 - 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
 - 2. Joints: NFPA 54, threaded or welded to ASME B31.1.

2.04 Fittings: ASME B16.22, wrought copper and bronze, or ASME B16.18 bronze sand castings. Fittings manufactured to copper tubing sizes, with grooved ends designed to accept grooved end couplings of the same manufacturer. (Flaring of tube and fitting ends to IPS dimensions is not allowed.

2.05 Joints: ASTM B 32, alloy Sn95 solder. Maximum lead content 0.10%

2.06 Deionized Water Piping

A.

2.07 FLANGES, UNIONS, AND COUPLINGS

- A. Unions for Pipe Sizes 3 Inches and Under:
 - 1. Copper tube and pipe: Class 150 bronze unions with soldered joints.

2.08 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
 - 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
 - 2. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.

3. Trapeze Hangers: Welded steel channel frames attached to structure.
 4. Vertical Pipe Support: Steel riser clamp.
- B. Plumbing Piping - Drain, Waste, and Vent:
1. Conform to ASME B31.9.
 2. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inches: Malleable iron, adjustable swivel, split ring.
 3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
 4. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
 5. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
 6. Vertical Support: Steel riser clamp.
 7. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 8. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- C. Plumbing Piping - Water:
1. Conform to ASME B31.9.
 2. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inches: Malleable iron, adjustable swivel, split ring.
 3. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.09 BALL VALVES

- A. Manufacturers:
1. Allied Healthcare Products: www.alliedhpi.com/index.html
 2. Apollo
 3. Conbraco Industries: www.conbraco.com.
 4. Substitutions: See Section 01600 - Product Requirements.
- B. Construction 2 Inches and Smaller: Meets the intent of MSS SP-110, 300 psi CWP, forged brass body, two piece, chrome plated brass ball and stem, standard port, Teflon seats, blow-out proof stem, lever handle, Vic Press 304™ ends.

PART 3 EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- C. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
- D. Install piping to maintain headroom, conserve space, and not interfere with use of space.
- E. Group piping whenever practical at common elevations.
- F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected

equipment. Refer to Section 15122.

- G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 15082.
- H. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08310.
- I. Install valves with stems upright or horizontal, not inverted.
- J. Install water piping to ASME B31.9.
- K. Sleeve pipes passing through partitions, walls and floors.
- L. Inserts:
 - 1. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 2. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- M. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.9.
 - 2. Support horizontal piping as scheduled.
 - 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches of each horizontal elbow.
 - 5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - 7. Provide copper plated hangers and supports for copper piping.
 - 8. Prime coat exposed steel hangers and supports. Refer to Section 09900. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- N.

3.03 APPLICATION

- A. Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
- B. Provide plug valves in natural gas systems for shut-off service.

3.04 TOLERANCES

- A. Drainage Piping: Establish invert elevations within 1/2 inch vertically of location indicated and slope to drain at minimum of 1/4 inch per foot slope.
- B. Water Piping: Slope at minimum of 1/32 inch per foot and arrange to drain at low points.

3.05 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Disinfect water distribution system in accordance with Section 02515.
- B. Prior to starting work, verify system is complete, flushed and clean.
- C. Ensure Ph of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda

ash) or acid (hydrochloric).

- D. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
- E. Maintain disinfectant in system for 24 hours.
- F. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
- G. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
- H. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

3.06 SCHEDULES

- A. Pipe Hanger Spacing:
 - 1. Metal Piping:
 - a. Pipe size: 1/2 inches to 1-1/4 inches:
 - 1) Maximum hanger spacing: 6.5 ft.
 - 2) Hanger rod diameter: 3/8 inches.
 - b. Pipe size: 1-1/2 inches to 2 inches:
 - 1) Maximum hanger spacing: 10 ft.
 - 2) Hanger rod diameter: 3/8 inch.
 - 2. Plastic Piping:
 - a. All Sizes:
 - 1) Maximum hanger spacing: 6 ft.
 - 2) Hanger rod diameter: 3/8 inch.

END OF SECTION

SECTION 15146 - PLUMBING SPECIALTIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Floor drains.
- B. Cleanouts.
- C. Thermostatic mixing valves.

1.02 RELATED REQUIREMENTS

- A. Section 15145 - Plumbing Piping.
- B. Section 15410 - Plumbing Fixtures.

1.03 REFERENCE STANDARDS

- A. ASSE 1012 - Backflow Preventer with Intermediate Atmospheric Vent; American Society of Sanitary Engineering; 2009 (ANSI/ASSE 1012).

1.04 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- C. Manufacturer's Instructions: Indicate Manufacturer's Installation Instructions: Indicate assembly and support requirements.
- D. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- E. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
- F. Operating instructions
- G. Maintenance instructions, including preventative and corrective maintenance.
- H. Copies of warranties
- I. Shop drawings and product data

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept specialties on site in original factory packaging. Inspect for damage.

PART 2 PRODUCTS

2.01 DRAINS

- A. Manufacturers:
 - 1. Charlotte Pipe Company. www.charlottepipe.com
 - 2. Jay R. Smith Manufacturing Company: www.jayrsmith.com.

3. Zurn Industries, Inc: www.zurn.com.
4. Substitutions: See Section 01600 - Product Requirements.

B. FD-1; Floor Drain

1. Stainless steel adjustable top with 6" round grate and membrane collar. Similar to Charlotte Pipe AW-160MS

2.02 CLEANOUTS

A. Manufacturers:

1. Charlotte Pipe and Foundry
2. Jay R. Smith Manufacturing Company: www.jayrsmith.com.
3. Josam Company: www.josam.com.
4. Wade
5. Zurn Industries, Inc: www.zurn.com.
6. Watts

B. CO ; Cleanout (Plug)

1. CPVC Type IV Grade I
2. Similar to Charlotte Pipe ChemDrain

2.03 DISHWASHER BOXES AND VALVES

A. Box Manufacturers:

1. Guy Grey
2. IPS Corporation/Water-Tite: www.ipscorp.com.
3. Oatey: www.oatey.com.

B. Valve Manufacturers:

1. Guy Grey
2. IPS Corporation/Water-Tite: www.ipscorp.com.

- C. Description: Plastic preformed rough-in box with brass long shank valves with wheel handles, socket for 2 inch waste, slip in finishing cover.

2.04 REFRIGERATOR VALVE AND RECESSED BOX

A. Box Manufacturers:

1. IPS Corporation/Water-Tite: www.ipscorp.com.
2. Oatey: www.oatey.com.
3. Substitutions: See Section 01600 - Product Requirements.

B. Valve Manufacturers:

1. IPS Corporation/Water-Tite: www.ipscorp.com.
2. Zurn Industries, Inc: www.zurn.com.
3. Substitutions: See Section 01600 - Product Requirements.

- C. Description: Plastic preformed rough-in box with brass valves with wheel handle, slip in finishing cover.

2.05 DOUBLE CHECK VALVE ASSEMBLIES

A. Manufacturers:

1. Ames
2. Conbraco Industries: www.conbraco.com.

3. Watts Regulator Company: www.wattsregulator.com.
4. Substitutions: See Section 01600 - Product Requirements.

B. Double Check Valve Assemblies:

1. ASSE 1012; Bronze body with corrosion resistant internal parts and stainless steel springs; two independently operating check valves with intermediate atmospheric vent.

2.06 VACUUM BREAKERS

A. Manufacturers:

1. T&S Brass
2. Charlotte Pipe and Foundry
3. WATERSAVER
4. Watts Regulator Company: www.wattsregulator.com.
5. Substitutions: See Section 01600 - Product Requirements.

2.07 MIXING VALVES

A. Thermostatic Mixing Valves:

1. Manufacturers:
 - a. Bradley Corporation. www.bradleycorp.com
 - b. Griswold Controls: www.griswoldcontrols.com
 - c. Lawler: www.lawlervalve.com
 - d. Leonard Valve Company: www.leonardvalve.com.
 - e. WATERSAVER
2. Accessories:
 - a. Check valve on inlets.
 - b. Volume control shut-off valve on outlet.
 - c. Stem thermometer on outlet.
 - d. Strainer stop checks on inlets.
3. Cabinet: 16 gage prime coated steel, for recessed mounting with keyed lock.

B. Pressure Balanced Mixing Valves:

1. Manufacturers:
 - a. Delta Faucet Company: www.deltafaucet.com.
 - b. Lawler: www.lawlervalve.com
 - c. Leonard Valve: www.leonardvalve.com
 - d. Powers/ Watts
2. Valve: Chrome plated cast brass body, stainless steel cylinder, integral temperature adjustment.
3. Accessories:
 - a. Volume control shut-off valve on outlet.
 - b. Stem thermometer on outlet.
 - c. Strainer stop checks on inlets.
 - d. Cabinet: 16 gage prime coated steel, for recessed mounting with keyed lock.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.

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COLUMBIA, SC

STATE PROJECT # H27-6101
A/E PROJECT # 12023.01

END OF SECTION

SECTION 15182 - HYDRONIC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hydronic system requirements.
- B. Heating water piping, above grade.
- C. Chilled water piping, above grade.
- D. Pipe and pipe fittings for:
 - 1. Heating water piping system.
 - 2. Chilled water piping system.
 - 3. Equipment drains and overflows.
- E. Pipe hangers and supports.
- F. Unions, flanges, mechanical couplings, and dielectric connections.
- G. Valves:
 - 1. Gate valves.
 - 2. Globe or angle valves.
 - 3. Ball valves.
 - 4. Butterfly valves.
 - 5. Check valves.

1.02 RELATED REQUIREMENTS

- A. Section 15075 - Mechanical Identification.
- B. Section 15123 - Expansion Fittings and Loops for HVAC Piping.
- C. Section 15073 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- D. Section 15183 - Hydronic Specialties.
- E. Section 15189 - Chemical Water Treatment: Pipe cleaning.

1.03 REFERENCE STANDARDS

- A. ASME (BPV IX) - Boiler and Pressure Vessel Code, Section IX - Welding and Brazing Qualifications; The American Society of Mechanical Engineers; 2010.
- B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2012 (ANSI B16.18).
- C. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; 2001 (R2010).
- D. ASME B31.9 - Building Services Piping; 2011 (ANSI/ASME B31.9).
- E. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2005).
- F. ASME B31.9 - Building Services Piping; The American Society of Mechanical Engineers; 2008 (ANSI/ASME B31.9).

- G. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2010.
- H. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2011.
- I. ASTM B32 - Standard Specification for Solder Metal; 2008.
- J. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2009.
- K. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2005.
- L. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications; 2007.
- M. AWS A5.8/A5.8M - Specification for Filler Metals for Brazing and Braze Welding; 2011 and errata.
- N. AWS A5.8/A5.8M - Specification for Filler Metals for Brazing and Braze Welding; American Welding Society; 2004 and errata.
- O. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2010.
- P. AWWA C606 - Grooved and Shouldered Joints.
- Q. AWWA C606 - Grooved and Shouldered Joints; 2011 (ANSI/AWWA C606).
- R. AWWA C606 - Standard Specification for Grooved and Shouldered Joints; American Water Works Association; 2006.
- S. MSS SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2009.

1.04 SYSTEM DESCRIPTION

- A. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- B. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- C. Use non-conducting dielectric connections whenever jointing dissimilar metals.
- D. Provide pipe hangers and supports in accordance with ASME B31.9 unless indicated otherwise.
- E. Use ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- F. Use globe valves for throttling, bypass, or manual flow control services.
- G. Use plug cocks for throttling service. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.
- H. Use only butterfly valves in chilled water systems for throttling and isolation service.
- I. Use lug end butterfly valves to isolate equipment.

- J. Use 3/4 inch gate valves with cap for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

1.05 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.
- C. Welders Certificate: Include welders certification of compliance with ASME (BPV IX).
- D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- E. Project Record Documents: Record actual locations of valves.
- F. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- G. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Recommended spare parts
 - 2. Spare parts lists
 - 3. Maintenance instructions, including preventative and corrective maintenance
 - 4. Shop drawings and product data

1.06 QUALITY ASSURANCE

- A. Welder Qualifications: Certify in accordance with ASME (BPV IX).

1.07 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 code for installation of piping system.
- B. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations.
- C. Provide certificate of compliance from authority having jurisdiction, indicating approval of welders.

1.08 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 HYDRONIC SYSTEM REQUIREMENTS

- A. Comply with ASME B31.9 and applicable federal, state, and local regulations.
- B. Piping: Provide piping, fittings, hangers and supports as required, as indicated, and as follows:

1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
 2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
 3. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.
 4. Provide pipe hangers and supports in accordance with ASME B31.9 unless indicated otherwise.
- C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges or unions to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
- D. Valves: Provide valves where indicated:
1. Provide drain valves where indicated, and if not indicated provide at least at main shut-off, low points of piping, bases of vertical risers, and at equipment. Use 3/4 inch gate valves with cap; pipe to nearest floor drain.
 2. Isolate equipment using butterfly valves with lug end flanges or grooved mechanical couplings.
 3. For throttling, bypass, or manual flow control services, use globe, ball, or butterfly valves.
 4. In chilled water systems, butterfly valves may be used interchangeably with gate and globe valves.
 5. For shut-off and to isolate parts of systems or vertical risers, use gate, ball, or butterfly valves.
 6. For throttling service, use plug cocks. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.
- E. Welding Materials and Procedures: Conform to ASME (BPV IX).

2.02 HEATING WATER PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A 53/A 53M, Schedule 40, black.
1. Fittings: ASTM B 16.3, malleable iron; ASTM A 234/A 234M, wrought steel; ASTM A 395 and A 536, ductile iron; or ASTM A 53, (fabricated from carbon steel pipe), grooved end or welding type fittings.
 2. Joints: Grooved, threaded, or AWS D1.1 welded.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn, using one of the following joint types:
1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings.
 - a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
 - b. Braze: AWS A5.8/A5.8M BCuP copper/silver alloy.
 2. Grooved Joints: AWWA C606 grooved tube, fittings of same material, and copper-tube-dimension mechanical couplings.

2.03 CHILLED WATER PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M, Schedule 40, black; using one of the following joint types:
1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1 welded.
 2. Fittings: ASTM A 234/A 234M, wrought steel; ASTM A 395 and A 536, ductile iron; or ASTM A 53, (fabricated from carbon steel pipe), grooved end or welding type

- B. Copper Tube: ASTM B 88 (ASTM B 88M), Type K (A), drawn.
 - 1. Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.
 - 2. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.
 - 3. Joints: Solder, lead free, ASTM B 32, HB alloy (95-5 tin-antimony), or tin and silver.

2.04 Fittings: ASTM A 234/A 234M, wrought steel; ASTM A 395 and A 536, ductile iron; or ASTM A 53, (fabricated from carbon steel pipe), grooved end or welding type

2.05 EQUIPMENT DRAINS

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 galvanized; using one of the following joint types:
 - 1. Joints: Threaded, or grooved mechanical couplings.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn; using one of the following joint types:
 - 1. Joints: Solder, lead free, ASTM B 32, HB alloy (95-5 tin-antimony), or tin and silver.

2.06 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
 - 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
- B. Conform to ASME B31.9.
- C. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.
- D. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
- E. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
- F. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- G. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
- H. Vertical Support: Steel riser clamp.
- I. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- J. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- K. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.

2.07 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

- A. Unions for Pipe 2 Inches and Under:
 - 1. Ferrous Piping: 150 psig malleable iron, threaded, or type 304/304L stainless steel, threaded type, with Vic Press 304™ ends.
- B. Flanges for Pipe Over 2 Inches:
- C. Ferrous Piping: 150 psig forged steel, slip-on.
 - 1. Gaskets: 1/16 inch thick preformed neoprene.
- D. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing

segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.

1. Dimensions and Testing: In accordance with AWWA C606.
 2. Mechanical Couplings: Comply with ASTM F1476.
 3. Housing Material: Malleable iron or ductile iron, galvanized.
 4. Housing Clamps: Ductile iron galvanized, in accordance with ASTM A 153, to engage and lock, designed to permit some angular deflection, contraction, and expansion.
 - a. Rigid Type: Housings cast with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1 and B31.9.
 - b. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Three (3) Flexible couplings may be used in lieu of flexible connectors at equipment connections. (Couplings shall be placed in close proximity to the vibration source.)
 5. Sealing Gasket: C-shape elastomer for operating temperature range from -30 degrees F to 230 degrees F.
 6. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
 7. When pipe is field grooved, provide coupling manufacturer's grooving tools.
- E. Dielectric Connections: Union or waterway fitting with water impervious isolation barrier and one galvanized or plated steel end and one copper tube end, end types to match pipe joint types used.

2.08 GATE VALVES

- A. Manufacturers:
1. Conbraco Industries: www.conbraco.com.
 2. Nibco, Inc: www.nibco.com.
 3. Milwaukee Valve Company: www.milwaukeevalve.com.
 4. Substitutions: See Section 01600 - Product Requirements.
- B. Up To and Including 2 Inches:
1. Bronze body, bronze trim, screwed bonnet, non-rising stem, lockshield stem, inside screw with backseating stem, solid wedge disc, alloy seat rings, solder ends.
- C. Over 2 Inches:
1. Iron body, bronze trim, bolted bonnet, rising stem, handwheel, outside screw and yoke, solid wedge disc with bronze seat rings, flanged ends.

2.09 GLOBE OR ANGLE VALVES

- A. Manufacturers:
1. Conbraco Industries: www.conbraco.com.
 2. Nibco, Inc: www.nibco.com.
 3. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Up To and Including 2 Inches:
1. Bronze body, bronze trim, screwed bonnet, rising stem and handwheel, inside screw with backseating stem, renewable composition disc and bronze seat, solder ends.
- C. Over 2 Inches:
1. Iron body, bronze trim, bolted bonnet, rising stem, handwheel, outside screw and yoke, rotating plug-type disc with renewable seat ring and disc, flanged ends.

2.10 BALL VALVES

- A. Manufacturers:
 - 1. Conbraco Industries: www.conbraco.com.
 - 2. Nibco, Inc: www.nibco.com.
 - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
 - 4. Substitutions: See Section 01600 - Product Requirements.
- B. Up To and Including 2 Inches:
 - 1. Bronze one piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder ends with union.
- C. Over 2 Inches:
 - 1. Ductile iron body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, grooved ends or flanged, rated to 800 psi.
 - 2. Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, flanged.

2.11 BUTTERFLY VALVES

- A. Manufacturers:
 - 1. Hammond Valve: www.hammondvalve.com.
 - 2. Crane Co.: www.cranevalve.com.
 - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
 - 4. Substitutions: See Section 01600 - Product Requirements.
- B. Body: Cast or ductile iron with resilient replaceable EPDM seat, wafer or lug ends, extended neck.
- C. Disc: Aluminum bronze.
- D. Operator: 10 position lever handle.

2.12 SPRING LOADED CHECK VALVES

- A. Manufacturers:
 - 1. Hammond Valve: www.hammondvalve.com.
 - 2. Crane Co.: www.cranevalve.com.
 - 3. Milwaukee Valve Company: www.milwaukeevalve.com.
 - 4. Substitutions: See Section 01600 - Product Requirements.
- B. Iron body, bronze trim, split plate, hinged with stainless steel spring, resilient seal bonded to body, wafer or threaded lug ends.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.
- C. Remove scale and dirt on inside and outside before assembly.
- D. Prepare piping connections to equipment with couplings, flanges or unions.
- E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or

caps.

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

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install chilled water piping to ASME B31.9 requirements.
- C. Install piping to conserve building space and to avoid interfere with use of space.
- D. Group piping whenever practical at common elevations.
- E. Sleeve pipe passing through partitions, walls and floors.
- F. Slope piping and arrange to drain at low points.
- G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- H. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- I. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.9.
 - 2. Support horizontal piping as scheduled.
 - 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches of each horizontal elbow.
 - 5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
- J. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 15080.
- K. Provide access where valves and fittings are not exposed.
- L. Use eccentric reducers to maintain top of pipe level.
- M. Install valves with stems upright or horizontal, not inverted.

3.03 SCHEDULES

- A. Hanger Spacing for Steel Piping.
 - 1. 1/2 inch, 3/4 inch, and 1 inch: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 - 2. 1-1/4 inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 3. 1-1/2 inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 - 4. 2 inches: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 5. 2-1/2 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 - 6. 3 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
 - 7. 4 inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.

END OF SECTION

SECTION 15183 - HYDRONIC SPECIALTIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air vents.
- B. Strainers.
- C. Combination flow controls.
- D. Flow indicators, controls, meters.
- E. Relief valves.

1.02 RELATED REQUIREMENTS

- A. Section 15182 - Hydronic Piping.
- B. Section 15189 - Chemical Water Treatment: Pipe Cleaning.

1.03 REFERENCE STANDARDS

1.04 ADMINISTRATIVE REQUIREMENTS

- A. ASME (BPV VIII, 1) - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; The American Society of Mechanical Engineers; 2007.

1.05 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.
- C. Certificates: Inspection certificates for pressure vessels from authority having jurisdiction.
- D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- E. Project Record Documents: Record actual locations of flow controls.
- F. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.
- G. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Recommended spare parts
 - 2. Spare parts lists
 - 3. Operating instructions
 - 4. Maintenance instructions, including preventative and corrective maintenance.
 - 5. Copies of warranties
 - 6. Wiring diagrams
 - 7. Inspection procedures
 - 8. Shop drawings and product data

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 AIR VENTS

- A. Manufacturers:
 - 1. Armstrong International, Inc: www.armstronginternational.com.
 - 2. ITT Bell & Gossett: www.bellgossett.com.
 - 3. Taco, Inc: www.taco-hvac.com.
 - 4. Substitutions: See Section 01600 - Product Requirements.
- B. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.
- C. Float Type:
 - 1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
 - 2. Cast iron body and cover, float, bronze pilot valve mechanism suitable for system operating temperature and pressure; with isolating valve.

2.02 STRAINERS

- A. Manufacturers:
 - 1. Armstrong International, Inc: www.armstronginternational.com.
 - 2. Green Country Filtration: greencountryfiltration.com.
 - 3. WEAMCO: www.weamco.com.
 - 4. Substitutions: See Section 01600 - Product Requirements.
- B. Size 2 inch and Under:
 - 1. Screwed brass or iron body for 175 psi working pressure, Y pattern with 1/32 inch stainless steel perforated screen.
- C. Size 2-1/2 inch to 4 inch:
 - 1. Flanged iron body for 175 psi working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

2.03 COMBINATION FLOW CONTROLS

- A. Manufacturers:
 - 1. Amtrol Inc: www.amtrol.com.
 - 2. Griswold
 - 3. ITT Bell & Gossett: www.bellgossett.com.
 - 4. Cla-Val Co: www.cla-val.com.
 - 5. Substitutions: See Section 01600 - Product Requirements.
- B. Construction: Brass or bronze body with union on inlet and outlet, temperature and pressure

test plug on inlet and outlet with blowdown/backflush drain.

- C. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 3.5 psi.
- D. Control Mechanism: Stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring.
- E. Accessories: In-line strainer on inlet and ball valve on outlet.

2.04 RELIEF VALVES

- A. Manufacturers:
 - 1. Tyco Flow Control: www.tycoflowcontrol.com.
 - 2. Armstrong International, Inc: www.armstronginternational.com.
 - 3. ITT Bell & Gossett: www.bellgossett.com.
 - 4. Conbraco Industries, Inc: www.conbraco.com.
 - 5. Substitutions: See Section 01600 - Product Requirements.
- B. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install specialties in accordance with manufacturer's instructions.
- B. Where large air quantities can accumulate, provide enlarged air collection standpipes.
- C. Provide manual air vents at system high points and as indicated.
- D. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
- E. Provide air separator on suction side of system circulation pump and connect to expansion tank.
- F. Provide valved drain and hose connection on strainer blow down connection.
- G. Provide pump suction fitting on suction side of base mounted centrifugal pumps where indicated. Remove temporary strainers after cleaning systems.
- H. Provide combination pump discharge valve on discharge side of base mounted centrifugal pumps where indicated.
- I. Support pump fittings with floor mounted pipe and flange supports.
- J. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.
- K. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
- L. Pipe relief valve outlet to nearest floor drain.

END OF SECTION

SECTION 15184 - STEAM AND STEAM CONDENSATE PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe and pipe fittings.
- B. Valves.
- C. Steam piping system.
- D. Steam condensate piping system.

1.02 RELATED REQUIREMENTS

- A. Section 15075 - Mechanical Identification.
- B. Section 15073 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- C. Section 15185 - Steam and Steam Condensate Specialties.
- D. Section 15189 - Chemical Water Treatment: Pipe cleaning.

1.03 REFERENCE STANDARDS

- A. ASME (BPV IX) - Boiler and Pressure Vessel Code, Section IX - Welding and Brazing Qualifications; The American Society of Mechanical Engineers; 2010.
- B. ASME B16.3 - Malleable Iron Threaded Fittings; The American Society of Mechanical Engineers; 2011.
- C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2012 (ANSI B16.18).
- D. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2010).
- E. ASME B31.1 - Power Piping; The American Society of Mechanical Engineers; 2010 (ANSI/ASME B31.1).
- F. ASME B31.9 - Building Services Piping; The American Society of Mechanical Engineers; 2011 (ANSI/ASME B31.9).
- G. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless; 2010.
- H. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2011.
- I. AWS D1.1/D1.1M - Structural Welding Code - Steel; American Welding Society; 2010.
- J. MSS SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation; Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.; 2009.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.05 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 and ASME B31.1 code for installation of piping system.
- B. Welding Materials and Procedures: Conform to ASME (BPV IX) and applicable state labor regulations.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 MEDIUM AND HIGH PRESSURE STEAM PIPING (150 PSIG MAXIMUM)

- A. Steel Pipe: ASTM A53/A53M, Schedule 80, black.
 - 1. Fittings: ASME B16.3 malleable iron Class 250, or ASTM A234/A234M wrought steel welding type.
 - 2. Joints: Threaded, or AWS D1.1 welded.

2.02 MEDIUM AND HIGH PRESSURE STEAM CONDENSATE PIPING

- A. Steel Pipe: ASTM A53/A53M, Schedule 80, black.
 - 1. Fittings: ASME B16.3 malleable iron Class 125, or ASTM A234/A234M wrought steel.
 - 2. Joints: Threaded, or AWS D1.1 welded.

2.03 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
 - 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
- B. Conform to ASME B31.9.
- C. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.
- D. Hangers for Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
- E. Hangers for Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
- F. Multiple or Trapeze Hangers for Pipe Sizes to 4 inches: Steel channels with welded spacers and hanger rods.
- G. Multiple or Trapeze Hangers for Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods; cast iron roll and stand.
- H. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
- I. Wall Support for Pipe Sizes 4 to 5 Inches: Welded steel bracket and wrought steel clamp.
- J. Wall Support for Pipe Sizes 6 Inches and Over: Welded steel bracket and wrought steel clamp;

adjustable steel yoke and cast iron roll.

- K. Vertical Support: Steel riser clamp.
- L. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- M. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
- N. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.04 UNIONS, FLANGES, AND COUPLINGS

- A. Unions for Pipe 2 Inches and Under:
 - 1. Ferrous Piping: 150 psig galvanized malleable iron, threaded.
- B. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.05 GATE VALVES

- A. Manufacturers:
 - 1. Tyco Flow Control; Model _____: www.tycoflowcontrol.com.
 - 2. Conbraco Industries: www.conbraco.com.
 - 3. Nibco, Inc: www.nibco.com.
 - 4. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Up To and Including 2 Inches:
 - 1. Bronze body, bronze trim, screwed bonnet, non-rising stem, lockshield stem, inside screw with backseating stem, solid wedge disc, alloy seat rings, solder ends.

2.06 BALL VALVES

- A. Manufacturers:
 - 1. Tyco Flow Control: www.tycoflowcontrol.com.
 - 2. Conbraco Industries: www.conbraco.com.
 - 3. Nibco, Inc: www.nibco.com.
 - 4. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Up To and Including 2 Inches:
 - 1. Bronze one piece body, chrome plated ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder ends with union.

2.07 SWING CHECK VALVES

- A. Manufacturers:
 - 1. Tyco Flow Control: www.tycoflowcontrol.com.
 - 2. Hammond Valve: www.hammondvalve.com.
 - 3. Nibco, Inc: www.nibco.com.
 - 4. Milwaukee Valve Company: www.milwaukeevalve.com.
- B. Up To and Including 2 Inches:
 - 1. Bronze or iron body, bronze trim, bronze rotating swing disc with composition seat, solder ends.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. Keep open ends of pipe free from scale and dirt. Whenever work is suspended during construction protect open ends with temporary plugs or caps.
- E. After completion, fill, clean, and treat systems. Refer to Section 15189.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Sleeve pipe passing through partitions, walls, and floors.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- G. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.9.
 - 2. Support horizontal piping as scheduled.
 - 3. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - 4. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
- H. Provide clearance for installation of insulation and access to valves and fittings.
- I. Slope steam piping one inch in 40 feet in direction of flow. Use eccentric reducers to maintain bottom of pipe level.
- J. Slope steam condensate piping one inch in 40 feet. Provide drip trap assembly at low points and before control valves. Run condensate lines from trap to nearest condensate receiver. Provide loop vents over trapped sections.
- K. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
- L. Install valves with stems upright or horizontal, not inverted.

3.03 SCHEDULES

- A. Hanger Spacing for Steel Steam Piping.
 - 1. 1/2 inch: Maximum span, 8 feet; minimum rod size, 1/4 inch.
 - 2. 3/4 inch and 1 inch: Maximum span, 9 feet; minimum rod size, 1/4 inch.
 - 3. 1-1/4 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 - 4. 1-1/2 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.

- B. Hanger Spacing for Steel Steam Condensate Piping.
 - 1. 1/2 inch, 3/4 inch, and 1 inch: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 - 2. 1-1/4 inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 3. 1-1/2 inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.

END OF SECTION

SECTION 15185 - STEAM AND STEAM CONDENSATE SPECIALTIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Steam traps.
- B. Steam air vents.
- C. Condensate return units.

1.02 RELATED REQUIREMENTS

- A. Section 15065 - Motors for Mechanical Equipment: Pump Motors.
- B. Section 15184 - Steam and Steam Condensate Piping.

1.03 REFERENCE STANDARDS

- A. ASME (BPV VIII, 1) - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; The American Society of Mechanical Engineers; 2010.
- B. ASME B31.9 - Building Services Piping; The American Society of Mechanical Engineers; 2011 (ANSI/ASME B31.9).
- C. ASTM A105/A105M - Standard Specification for Carbon Steel Forgings for Piping Applications; 2010a.
- D. ASTM A126 - Standard Specification for Grey Iron Castings for Valves, Flanges, and Pipe Fittings; 2004 (Reapproved 2009).
- E. ASTM A216/A216M - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service; 2008.
- F. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures; 1999 (Reapproved 2009).
- G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association; 2008.

1.04 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data:
 - 1. Provide for manufactured products and assemblies required for this project.
 - 2. Include product description, model, dimensions, component sizes, rough-in requirements, service sizes, and finishes.
 - 3. Submit schedule indicating manufacturer, model number, size, location, rated capacity, load served, and features for each specialty.
 - 4. Include electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate application, selection, and hookup configuration. Include pipe and accessory elevations.
- D. Operation and Maintenance Data: Include installation instructions, servicing requirements, and recommended spare parts lists.

- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01600 - Product Requirements, for additional provisions.
 - 2. Extra Pump Seals: One set for each type and size of pump.
 - 3. Steam Trap Service Kits: One for each type and size.
- F. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Recommended spare parts
 - 2. Spare parts lists
 - 3. Operating instructions
 - 4. Maintenance instructions, including preventative and corrective maintenance.
 - 5. Copies of warranties
 - 6. Wiring diagrams
 - 7. Inspection procedures
 - 8. Shop drawings and product data

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the types of products specified in this section, with minimum three years of documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose indicated.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 STEAM TRAPS

- A. Manufacturers:
 - 1. Armstrong International, Inc: www.armstronginternational.com.
 - 2. Marshall Engineered Products Company: www.mepcollc.com.
 - 3. Spence
 - 4. Spirax-Sarco: www.spiraxsarco.com/us.
 - 5. Tyco Flow Control: www.tycoflowcontrol.com.
 - 6. Weinman
- B. Steam Trap Applications:
 - 1. Use Float and Thermostatic Traps for:
 - a. Heating coils.
- C. Steam Trap Performance:
 - 1. Select to handle minimum of two times maximum condensate load of apparatus served.
 - 2. Pressure Differentials:

- a. Medium Pressure Steam (60 psi maximum): 15 psi.
- D. Float and Thermostatic Traps: ASTM A126 cast iron or semi-steel body and bolted cover, stainless steel or bronze bellows type air vent, stainless steel or copper float, stainless steel lever and valve assembly
 1. Rating: 15 psi WSP.
 2. Features: Access to internal parts without disturbing piping, bottom drain plug.
 3. Accessories: Gage glass with shut-off cocks.

2.02 STEAM AIR VENTS

- A. Manufacturers:
 1. Armstrong International, Inc: www.armstronginternational.com.
 2. ITT Hoffman Specialty: www.hoffmanspecialty.com.
 3. Spirax-Sarco: www.spiraxsarco.com/us.
- B. 125 psi WSP: Balanced pressure type; cast brass body and cover; access to internal parts without disturbing piping; stainless steel bellows, stainless steel valve and seat.

2.03 LOW PRESSURE CONDENSATE RETURN UNITS

- A. Manufacturers:
 1. Bryan Steam Corporation: www.bryanboilers.com.
 2. Marshall Engineered Products Company: www.mepcolc.com.
 3. PACO
 4. Spirax-Sarco: www.spiraxsarco.com/us.
 5. Weinman
- B. Condensate Return Units: Consist of receiver, inlet strainer, pumps, float switches, control panel and accessories.
- C. Condensate Receiver: Cast iron, equipped with externally adjustable float switches, water level gage, dial thermometer, pressure gages on pump discharge, bronze isolation valves between pumps and receiver, and lifting eye bolts.
- D. Inlet Strainer: Cast iron with vertical self-cleaning bronze screen and large dirt pocket, mounted on receiver. Screen shall be easily removable for cleaning.
- E. Pumps: One stage, vertical design, bronze fitted with stainless steel shaft, bronze impeller, renewable bronze case ring, mechanical shaft seal, close coupled to 1750 rpm motor.
- F. Control Cabinet:
 1. NEMA 250 enclosure, UL listed, with piano hinged door, grounding lug, terminal strip, and fusible control circuit transformer.
 2. Combination magnetic starters with overload relays, circuit breakers and cover interlock.
 3. Electric alternator.
 - a. Operate pumps on high level, alternating after each cycle.
 - b. Operate second pump upon failure of first pump and alarm.
 4. 'Auto-Off' switch
 5. Test button, high level alarm light, acknowledge button, alarm horn.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install steam and steam condensate piping and specialties in accordance with ASME B31.9.
- B. Install specialties in accordance with manufacturer's instructions.
- C. Steam Traps:
 - 1. Provide minimum 3/4 inch size on steam mains and branches.
 - 2. Install with union or flanged connections at both ends.
 - 3. Provide gate valve and strainer at inlet, and gate valve and check valve at discharge.
 - 4. Provide minimum 10 inch long, line size dirt pocket between apparatus and trap.
- D. Remove thermostatic elements from steam traps during temporary and trial usage, and until system has been operated and dirt pockets cleaned of sediment and scale.
- E. In high pressure and medium pressure mains, provide 3/4 inch nipple in bottom of main, extending 3/4 inch into and above bottom of pipe. Provide dirt pocket with 1/2 inch high pressure thermostatic trap.
- F. Rate relief valves for pressure upstream of pressure reducing station, for full operating capacity. Set relief at maximum 20 percent above reduced pressure.

END OF SECTION

SECTION 15189 - CHEMICAL WATER TREATMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Cleaning of piping systems.

1.02 RELATED REQUIREMENTS

- A. Section 15182 - Hydronic Piping.
- B. Section 15183 - Hydronic Specialties.

1.03 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate system schematic, equipment locations, and controls schematics, electrical characteristics and connection requirements.
- D. Manufacturer's Installation Instructions: Indicate placement of equipment in systems, piping configuration, and connection requirements.
- E. Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.
- F. Certificate: Submit certificate of compliance from authority having jurisdiction indicating approval of chemicals and their proposed disposal.
- G. Project Record Documents: Record actual locations of equipment and piping, including sampling points and location of chemical injectors.
- H. Operation and Maintenance Data: Include data on chemical feed pumps, agitators, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations.
- I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01600 - Product Requirements, for additional provisions.
 - 2. Sufficient chemicals for treatment and testing during required maintenance period.
- J. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Local representative
 - 2. Emergency instructions
 - 3. Safety instructions
 - 4. Recommended spare parts
 - 5. Spare parts lists
 - 6. Operating instructions
 - 7. Maintenance instructions, including preventative and corrective maintenance.
 - 8. Maintenance instructions for special finishes, including recommended cleaning methods and materials, and special precautions identifying detrimental agents.
 - 9. Copies of warranties
 - 10. Wiring diagrams

11. Shop drawings and product data

PART 2 PRODUCTS

2.01 MATERIALS

A. System Cleaner:

1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products; sodium tripoly phosphate and sodium molybdate.
2. Biocide chlorine release agents such as sodium hypochlorite or calcium hypochlorite.

PART 3 EXECUTION

3.01 CLEANING SEQUENCE

A. Concentration:

1. As recommended by manufacturer.

B. Hot Water Heating Systems:

1. Apply heat while circulating, slowly raising temperature to 160 degrees F and maintain for 12 hours minimum.
2. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water.
3. Circulate for 6 hours at design temperatures, then drain.
4. Refill with clean water and repeat until system cleaner is removed.

C. Chilled Water Systems:

1. Circulate for 48 hours, then drain systems as quickly as possible.
2. Refill with clean water, circulate for 24 hours, then drain.
3. Refill with clean water and repeat until system cleaner is removed.

D. Steam Systems:

1. Apply heat, slowly raising boiler temperature to 160 degrees F and maintain for 12 hours minimum.
2. Cool, then drain as quickly as possible.
3. Refill with clean water, drain, refill and check for sludge.
4. Repeat until system is free of sludge.
5. Apply heat to produce steam for piping system and maintain for 8 hours minimum. Bypass traps and waste condensate.

E. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect.

F. Flush open systems with clean water for one hour minimum. Drain completely and refill.

G. Remove, clean, and replace strainer screens.

H. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION

SECTION 15212 - COMPRESSED AIR SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe and Pipe Fittings.

1.02 REFERENCE STANDARDS

- A. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2012 (ANSI B16.18).
- B. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; The American Society of Mechanical Engineers; 2001 (R2010).
- C. ASTM B32 - Standard Specification for Solder Metal; 2008.
- D. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2009.
- E. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2005.

1.03 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
- C. Safety instructions
- D. Recommended spare parts
- E. Spare parts lists
- F. Operating instructions
- G. Maintenance instructions, including preventative and corrective maintenance.
- H. Copies of warranties
- I. Wiring diagrams
- J. Shop drawings and product data

PART 2 PRODUCTS

2.01 PIPE AND PIPE FITTINGS

- A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn.
 - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - 2. Joints: ASTM B32, solder, Grade Sn95.

END OF SECTION

SECTION 15410 - PLUMBING FIXTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Sinks.
- B. Laboratory Faucets.
- C. Eye and face wash fountains.
- D. Emergency showers.

1.02 RELATED REQUIREMENTS

- A. Section 07900 - Joint Sealers: Seal fixtures to walls and floors.
- B. Section 15145 - Plumbing Piping.
- C. Section 15146 - Plumbing Specialties.

1.03 REFERENCE STANDARDS

- A. ANSI Z124.2 - American National Standard for Plastic Shower Units; 1995.
- B. ANSI Z358.1 - American National Standard for Emergency Eyewash and Shower Equipment; 2009.
- C. ASME A112.6.1M - Supports for Off-the-Floor Plumbing Fixtures for Public Use; The American Society of Mechanical Engineers; 1997 (Reaffirmed 2002).
- D. ASME A112.18.1 - Plumbing Supply Fittings; The American Society of Mechanical Engineers; 2011.
- E. ASME A112.19.3 - Stainless Steel Plumbing Fixtures (Designed for Residential Use); The American Society of Mechanical Engineers; 2008.
- F. ISSFA-2 - Classification and Standards for Solid Surfacing Material; International Solid Surface Fabricators Association; 2001 (2007)

1.04 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.
- C. Manufacturer's Instructions: Indicate installation methods and procedures.
- D. Maintenance Data: Include fixture trim exploded view and replacement parts lists.
- E. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- F. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
- G. Recommended spare parts

- H. Spare parts lists
- I. Operating instructions
- J. Maintenance instructions, including preventative and corrective maintenance.
- K. Copies of warranties
- L. Shop drawings and product data

1.05 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience, and service facility within 100 miles of Project.
- C. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.07 REGULATORY REQUIREMENTS

- A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Accept fixtures on site in factory packaging. Inspect for damage.
- B. Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

1.09 WARRANTY

- A. See Section 01780 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for electric water cooler.

PRODUCTS

2.01 MANUFACTURERS

- A. Faucets:
 - 1. American Standard
 - 2. WaterSaver Faucet.
 - 3. T & S Brass
 - 4. Delta Faucet Co.
- B. Supplies and P-traps:
 - 1. American Standard
 - 2. Charlotte Pipe and Foundry
 - 3. Kohler Co.
 - 4. McGuire Manufacturing Co.

- C. Emergency Shower and/or Eyewash:
 - 1. Bradley
 - 2. WaterSaver
 - 3. Haws

2.02 WALL BOXES

- A. WB-1 ; DISHWASHER OUTLET BOX
 - 1. Recessed mounting outlet box with two angle valves and drain: Include enameled steel box and face plate with ½" IPS angle valve for cold water and ½" IPS angle valve for hot water. 1 1/2" sanitary drain. Outlets to be 3/4" hose connections. Comply with ASME A112.18M. Mount box 36" above finished floor. .
- B. WB-2 ; WATER BOX
 - 1. Recessed mounting outlet box with one angle valve: Include enameled steel box and face plate with ½" IPS angle valve for cold water. Outlet to be 3/4" hose connections. Comply with ASME A112.18M. Mount box 36" above finished floor.

2.03 EMERGENCY SHOWERS

- A. Emergency Shower Manufacturers:
 - 1. Haws Corporation: www.hawscor.com.
 - 2. Therm-Omega-Tech, Inc: www.thermomegatech.com.
 - 3. Bradley Corporation. www.Bradleycorp.com
 - 4. Substitutions: See Section 01600 - Product Requirements.
- B. Emergency Shower: ANSI Z358.1; wall-mounted, self- cleaning, non-clogging 8 inch diameter stainless steel deluge shower head with elbow, one inch full flow valve with pull chain and 8 inch diameter ring, one inch interconnecting fittings.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that walls and floor finishes are prepared and ready for installation of fixtures.

3.02 PREPARATION

- A. Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.03 INSTALLATION

- A. Install components level and plumb.

3.04 INTERFACE WITH WORK OF OTHER SECTIONS

- A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.05 ADJUSTING

- A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.06 CLEANING

- A. Clean plumbing fixtures and equipment.

3.07 SCHEDULES

- A. Fixture Rough-In
 - 1. Sink:
 - a. Hot Water: 1/2 Inch.
 - b. Cold Water: 1/2 Inch.
 - c. Waste: 1-1/2 Inch.
 - d. Vent: 1-1/4 Inch.
 - 2. Emergency shower and eyewash:
 - a. Cold Water: 1-1/4 Inch

END OF SECTION

SECTION 15720 - ROOFTOP UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Rooftop units.

1.02 RELATED REQUIREMENTS

- A. Section 15073 - Vibration and Seismic Controls for HVAC Piping and Equipment.

1.03 REFERENCE STANDARDS

- A. AHRI 430 - Standard for Central-Station Air-Handling Units; Air-Conditioning, Heating, and Refrigeration Institute; 2009.
- B. SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

1.04 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data:
 - 1. Published Literature: Indicate dimensions, weights, capacities, ratings, gages and finishes of materials, and electrical characteristics and connection requirements.
 - 2. Filters: Data for filter media, filter performance data, filter assembly, and filter frames.
 - 3. Fans: Performance and fan curves with specified operating point clearly plotted, power, RPM.
 - 4. Sound Power Level Data: Fan outlet and casing radiation at rated capacity.
 - 5. Electrical Requirements: Power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- C. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- D. Manufacturer's Instructions: Include installation instructions.
- E. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
- F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01600 - Product Requirements, for additional provisions.
 - 2. Extra Filters: One set for each unit.
- G. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Recommended spare parts
 - 2. Spare parts lists
 - 3. Operating instructions
 - 4. Maintenance instructions, including preventative and corrective maintenance.
 - 5. Maintenance instructions for special finishes, including recommended cleaning methods and materials, and special precautions identifying detrimental agents.
 - 6. Copies of warranties

7. Wiring diagrams
8. Shop drawings and product data

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- C. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

PART 2 PRODUCTS

2.01 Modular Air Handler Manufacturers

- A. The Carrier Corporation: www.carrier.com.
- B. The Trane Company: www.trane.com.
- C. York
- D. Substitutions: See Section 01600 - Product Requirement

2.02 GENERAL DESCRIPTION

- A. Configuration: Fabricate with fans plus accessories. See drawings for exact configuration.
- B. Fabrication: Conform to AMCA 99 and ARI 430.

2.03 CASING

- A. Construction: Fabricate on channel base and drain pan of welded steel. Assemble sections with gaskets and bolts.
 1. Outside Casing:
 - a. Finish: Manufacturers standard paint on exterior.
 2. Inside Casing:
 - a. Galvanized Steel: Solid, 0.0276 inch thick.
 3. Floor Plate:
 - a. Galvanized Steel: 1.382 inch thick.
- B. Insulation: Neoprene coated, glass fiber, applied to internal surfaces with adhesive and weld pins with exposed edges of insulation coated with adhesive.
 1. "K" value at 75 degrees F: Maximum 0.26 Btuh/inch/sq ft/degrees F.
 2. Density: 1-1/2 inch thick, 1-1/2 lbs/cu ft.
- C. Inspection Doors: Galvanized steel for flush mounting, with gasket, latch, and handle assemblies.
- D. Drain Pans: Construct from single thickness stainless steel with insulation between layers with welded corners. Cross break and pitch to drain connection. Provide drain pans under fan section.

2.04 FANS

- A. Type: Air foil, single width, single inlet, centrifugal or plug type fan.

- B. Performance Ratings: Determined in accordance with AMCA 210.
- C. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.
- D. Bearings: Self-aligning, grease lubricated, ball or roller bearings with lubrication fittings extended to exterior of casing with plastic tube and grease fitting rigidly attached to casing.
- E. Mounting: Locate fan and motor internally on welded steel base coated with corrosion resistant paint. Factory mount motor on slide rails. Provide access to motor, drive, and bearings through removable casing panels or hinged access doors. Mount base on vibration isolators.
- F. Flexible Duct Connections: For separating fan and coil, and adjacent sections; refer to Section 15820.

2.05 BEARINGS AND DRIVES

- A. Bearings: Heavy duty pillow block type, self-aligning, grease-lubricated ball bearings, with ABMA 9 L-10 life at 50,000 hours.
- B. Shafts: Solid, cold rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.
- C. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor.
- D. Belt Guard: Fabricate to SMACNA HVAC Duct Construction Standards - Metal and Flexible; 0.106 inch thick, 3/4 inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.06 COILS

- A. Casing: Provide access to both sides of coils. Enclose coils with headers and return bends fully contained within casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.
- B. Drain Pans: 24 inch downstream of coil and down spouts for cooling coil banks more than one coil high.
- C. Eliminators: Three break of galvanized steel, mounted over drain pan.
- D. Fabrication:
 - 1. Tubes: 5/8 inch OD seamless copper expanded into fins, brazed joints.
 - 2. Fins: Aluminum.
 - 3. Casing: Die formed channel frame of galvanized steel.
- E. Water Heating Coils:
 - 1. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
 - 2. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.
- F. Steam Heating Coils:

1. Headers: Cast iron with tubes expanded into header, seamless copper tube with silver brazed joints, or prime coated steel pipe with brazed joints.
2. Configuration: Drainable, with threaded plugs for drain and vent, threaded plugs in return bends and in headers opposite each tube, sloped within frame to condensate connection.

2.07 FILTERS

- A. Filter Box: Section with filter guides, access doors from both sides, for side loading with gaskets and blank-off plates.
- B. Filter Media: UL 900 listed, Class I or Class II, approved by local authorities.
- C. Refer to drawings and schedules for filter efficiency.
- D. Filter Gauges:
 1. 3-1/2 inch diameter diaphragm actuated dial in metal case with static pressure tips.

2.08 DAMPERS

- A. Damper Leakage: Maximum 2 percent at 4 inch wg differential pressure when sized for 2000 fpm face velocity.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Bolt sections together with gaskets.
- C. Install flexible duct connections between fan inlet and discharge ductwork and air handling unit sections. Ensure that metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.
- D. Provide fixed sheaves required for final air balance.
- E. Make connections to coils with unions or flanges.
- F. Hydronic Coils:
 1. Hydronic Coils: Connect water supply to leaving air side of coil (counterflow arrangement).
 2. Provide shut-off valve on supply line and lockshield balancing valve with memory stop on return line.
 3. Locate water supply at bottom of supply header and return water connection at top.
 4. Provide manual air vents at high points complete with stop valve.
 5. Ensure water coils are drainable and provide drain connection at low points.
- G. Steam Coils:
 1. Install vacuum breaker in steam line at or in header.
 2. Install steam traps with outlet minimum 12 inches below coil return connection.

END OF SECTION

SECTION 15755 - STEAM HUMIDIFIERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Dry Steam Humidifiers.

1.02 RELATED REQUIREMENTS

- A. Section 15184 - Steam and Steam Condensate Piping.
- B. Section 15185 - Steam and Steam Condensate Specialties.

1.03 REFERENCE STANDARDS

- A. AHRI 610 - Performance Rating of Central System Humidifiers for Residential Applications; Air-Conditioning, Heating, and Refrigeration Institute; 2004.

1.04 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog data indicating rated capacity, dimensions, duct and service connections, electric nameplate data and wiring diagrams.
- C. Shop Drawings: Indicate layout of system and components.
- D. Manufacturer's Instructions: Indicate installation instructions and recommendations.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- F. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- G. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
- H. Recommended spare parts
- I. Spare parts lists
- J. Operating instructions
- K. Maintenance instructions, including preventative and corrective maintenance.
- L. Copies of warranties
- M. Wiring diagrams
- N. Shop drawings and product data

1.05 WARRANTY

- A. See Section 01780 - Closeout Submittals, for additional warranty requirements.
- B. Provide two year manufacturer warranty for humidifier unit except the cylinder.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Armstrong International, Inc: www.armstronginternational.com.
- B. Dri-Steem Humidifier Company: www.dristeem.com.

2.02 DRY STEAM HUMIDIFIERS

- A. Humidifier: Steam separator type receiving steam at supply pressure and providing separation ahead of control valve, discharging through internal drying and silencing chambers, and distribution manifold at atmospheric pressure; complying with AHRI 610.
- B. Body: Cast iron with integral metering valve, separating and drying chambers, and silencing chamber with stainless steel silencing medium.
- C. Separating Chamber: To disengage and remove water droplets and particle matter when operated at maximum capacity.
- D. Control Valve: Steam jacketed parabolic plug, capable of modulating flow of steam over entire stroke of operator with modulating electric operator.
- E. Internal Drying and Silencing Chambers: To receive steam at atmospheric pressure and jacketed by steam at supply pressure.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Connect dry steam humidifiers to steam supply and to condensate piping. Provide gate valve, inlet strainer, and inverted bucket steam trap. Refer to Section 15184 and Section 15185.

END OF SECTION

SECTION 15810 - DUCTS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Metal ductwork.

1.02 RELATED REQUIREMENTS

- A. Section 15820 - Duct Accessories.
- B. Section 15950 - Testing, Adjusting, and Balancing.

1.03 REFERENCE STANDARDS

- A. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals; 2009.
- B. ASTM A240/A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications; 2011a.
- C. ASTM A480/A480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip; 2011a.
- D. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2010.
- E. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2010b.
- F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2012.
- G. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual; Sheet Metal and Air Conditioning Contractors' National Association; 1985, First Edition.
- H. SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

1.04 PERFORMANCE REQUIREMENTS

- A. No variation of duct configuration or sizes permitted except by written permission. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.05 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data for duct materials.
- C. Shop Drawings: Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work for 2 inch pressure class and higher systems.
- D. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual.
- E. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

- F. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Shop drawings and product data

1.06 REGULATORY REQUIREMENTS

- A. Construct ductwork to NFPA 90A standards.

1.07 FIELD CONDITIONS

- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B. Maintain temperatures within acceptable range during and after installation of duct sealants.

PART 2 PRODUCTS

2.01 DUCT ASSEMBLIES

2.02 MATERIALS

- A. Galvanized Steel for Ducts: Galvanized steel sheet, ASTM A 653/A 653M FS Type B, with G90/Z275 coating.
- B. Stainless Steel for Ducts: ASTM A 240/A 240M, Type 316.
- C. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
 - 1. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
 - 2. Surface Burning Characteristics: Flame spread of zero, smoke developed of zero, when tested in accordance with ASTM E84.
- D. Flexible Ducts:
 - 1. Two ply vinyl film supported by helically wound spring steel wire.
 - a. Pressure Rating: 10 inches WG positive and 1.0 inches WG negative.
 - b. Maximum Velocity: 4000 fpm.
 - c. Temperature Range: -10 degrees F to 160 degrees F.

2.03 DUCTWORK FABRICATION

- A. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. T's, bends, and elbows: Construct according to SMACNA (DCS).
- C. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- D. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- E. Clean shop fabricated ductwork of debris, oil and grease. Cover ends of ductwork with temporary closure material and tape. Protect ductwork from entry of dust and debris during shop storage, shipment and temporary storage at the job site.
- F. Wipe the inside of all ductwork to remove the debris, oil, grease, etc. Once ductwork is clean, cover with plastic or metal temporary closure material. Seal tight so that no water, moisture or debris can enter the ductwork. Protect ductwork from entry of dust and debris during shop

storage, shipment and temporary storage at the job site.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install, support, and seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- B. Install in accordance with manufacturer's instructions.
- C. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- D. Flexible Ducts: Connect to metal ducts with draw bands.
- E. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- F. Install and seal metal and flexible ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
- G. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- H. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- I. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with crimp in direction of air flow.
- J. Use double nuts and lock washers on threaded rod supports.
- K. Connect terminal units to supply ducts directly or with one foot maximum length of flexible duct. Do not use flexible duct to change direction.
- L. Leave temporary closures in place until ready for installation. At no time during the installation of the ductwork shall there be any openings that are not protected by temporary closures except for the section that is being installed at that time.
- M. Provide temporary closures on the face of all grilles, registers and diffusers.
- N. Seal all joints with sealant.
- O. Use welded stainless steel ductwork on all exhaust.

3.02 CLEANING

- A. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment that could be harmed by excessive dirt with temporary filters, or bypass during cleaning.

3.03 SCHEDULES

- A. Ductwork Material:
 - 1. Supply: Steel.
 - 2. Exhaust: Welded Stainless Steel.

- B. Ductwork Pressure Class:
 - 1. Supply: 3 inch
 - 2. Exhaust: 2 inch.

- C. Ductwork Seal Class:
 - 1. Supply: Class A.
 - 2. Exhaust: Class A.
 - 3. Fume Hood Exhaust: Class A.
 - 4. Outside Air Intake: Class A.

END OF SECTION

SECTION 15820 - DUCT ACCESSORIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Duct test holes.
- B. Flexible duct connections.

1.02 RELATED REQUIREMENTS

- A. Section 15073 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- B. Section 15810 - Ducts.

1.03 REFERENCE STANDARDS

- A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2012.
- B. SMACNA (DCS) - HVAC Duct Construction Standards - Metal and Flexible; Sheet Metal and Air Conditioning Contractors' National Association; 2005.
- C. UL 555 - Standard for Fire Dampers; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.
- D. UL 555S - Standard for Leakage Rated Dampers for Use in Smoke Control Systems; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide for shop fabricated assemblies including volume control dampers. Include electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers.
- D. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Spare parts lists
 - 2. Operating instructions
 - 3. Maintenance instructions, including preventative and corrective maintenance.
 - 4. Copies of warranties
 - 5. Wiring diagrams
 - 6. Shop drawings and product data

1.05 PROJECT RECORD DOCUMENTS

- A. Record actual locations of access doors and test holes.

1.06 QUALITY ASSURANCE

- A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

PART 2 PRODUCTS

2.01 DUCT TEST HOLES

- A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

2.02 FLEXIBLE DUCT CONNECTIONS

- A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- B. Flexible Duct Connections: Fabric crimped into metal edging strip.
 - 1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz per sq yd.
 - a. Net Fabric Width: Approximately 2 inches wide.

2.03 VOLUME CONTROL DAMPERS

- A. Manufacturers:
 - 1. Louvers & Dampers, Inc: www.louvers-dampers.com.
 - 2. Nailor Industries Inc: www.nailor.com.
 - 3. Ruskin Company: www.ruskin.com.
- B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
- C. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.
 - 1. Fabricate for duct sizes up to 6 x 30 inch.
 - 2. Blade: 24 gage, minimum.
- D. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
 - 1. Blade: 18 gage, minimum.
- E. Quadrants:
 - 1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
 - 2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 15810 for duct construction and pressure class.
- B. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide minimum 8 x 8 inch size for hand access, size for shoulder access, and as indicated. Provide 4 x 4 inch for balancing dampers only. Review locations prior to fabrication.
- C. Provide duct test holes where indicated and required for testing and balancing purposes.
- D. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.

- E. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.
- F. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

END OF SECTION

SECTION 15835 - POWER VENTILATORS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Roof exhausters.

1.02 RELATED REQUIREMENTS

- A. Section 15065 - Motors for Mechanical Equipment.
- B. Section 15073 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- C. Section 15820 - Duct Accessories: Backdraft dampers.

1.03 REFERENCE STANDARDS

- A. AMCA 99 - Standards Handbook; Air Movement and Control Association International, Inc.; 2010.
- B. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating; Air Movement and Control Association International, Inc.; 2007 (ANSI/AMCA 210, same as ANSI/ASHRAE 51).
- C. AMCA (DIR) - [Directory of] Products Licensed Under AMCA International Certified Ratings Program; Air Movement and Control Association International, Inc.; <http://www.amca.org/licenses/search.aspx>.
- D. AMCA 300 - Reverberant Room Method for Sound Testing of Fans; Air Movement and Control Association International, Inc.; 2008.
- E. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data; Air Movement and Control Association International, Inc.; 2006.

1.04 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.
- C. Manufacturer's Instructions: Indicate installation instructions.
- D. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.
- E. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Recommended spare parts
 - 2. Spare parts lists
 - 3. Operating instructions
 - 4. Maintenance instructions, including preventative and corrective maintenance.
 - 5. Copies of warranties
 - 6. Wiring diagrams
 - 7. Shop drawings and product data

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Greenheck: www.greenheck.com.
- B. Loren Cook Company: www.lorencook.com.
- C. PennBarry: www.pennbarry.com.

2.02 POWER VENTILATORS - GENERAL

- A. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.
- B. Sound Ratings: AMCA 301, tested to AMCA 300, and bearing AMCA Certified Sound Rating Seal.
- C. Fabrication: Conform to AMCA 99.
- D. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

2.03 ROOF EXHAUSTERS

- A. Fan Unit: V-belt or direct driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.
- B. Roof Curb: 8 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips.
- C. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.
- D. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.
- E. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof exhausters with cadmium plated steel lag screws to roof curb.
- C. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.

END OF SECTION

SECTION 15836 - INDUCED FLOW EXHAUST FANS

1.01 PART 1 GENERAL

A. SECTION INCLUDES

1. Induced Flow Exhaust Fans

B. RELATED REQUIREMENTS

1. Section 15065 - Motors for Mechanical Equipment.
2. Section 15073 - Vibration and Seismic Controls for HVAC Piping and Equipment.
3. Section 15820 - Duct Accessories: Backdraft dampers.

C. REFERENCE STANDARDS

1. AMCA 99 - Standards Handbook; Air Movement and Control Association International, Inc.; 2010.
2. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating; Air Movement and Control Association International, Inc.; 2007 (ANSI/AMCA 210, same as ANSI/ASHRAE 51).
3. AMCA (DIR) - [Directory of] Products Licensed Under AMCA International Certified Ratings Program; Air Movement and Control Association International, Inc.; <http://www.amca.org/licenses/search.aspx>.
4. AMCA 300 - Reverberant Room Method for Sound Testing of Fans; Air Movement and Control Association International, Inc.; 2008.

D. SUBMITTALS

1. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.
2. Manufacturer's Instructions: Indicate installation instructions.
3. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.
4. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - a. Recommended spare parts
 - b. Spare parts lists
 - c. Operating instructions
 - d. Maintenance instructions, including preventative and corrective maintenance.
 - e. Copies of warranties
 - f. Wiring diagrams
 - g. Shop drawings and product data

E. QUALITY ASSURANCE

1. Fan impeller shall be statically and dynamically balanced in accordance with AMCA Standard 204-96, "Balance Quality and Vibration Levels for Fans." Vibration tests shall be conducted and recorded on each assembled fan before shipment at the specified fan RPM. These readings shall conform to the AMCA 204-96 Standard.
2. Fan entrainment design shall have been verified by computational fluid dynamics (CFD). Computational fluid dynamics (CFD) evaluation of fan discharge and entrainment airflow may also be provided as requested by the owner and/or engineer.

3. Fans shall be manufactured at an ISO 9001 Certified facility.

1.02 PART 2 PRODUCTS

A. MANUFACTURERS

1. Greenheck: www.greenheck.com.
2. Loren Cook Company: www.lorencook.com.
3. MK Plastics
4. Twin City

B. INDUCED FLOW EXHAUST FANS

1. GENERAL

- a. Fan performance data shall follow AMCA Standard Conditions of 0 Ft elevation and 70 Deg F. (Air Density shall be 0.075 lb/ft)
- b. Fans selected shall allow for +/- 15% variation of scheduled static pressure and airflow.
- c. Fan systems shall incorporate integral lifting lugs for ease of installation.

2. FAN HOUSING AND CONSTRUCTION

- a. Fan housing shall be a minimum 14 gauge steel construction.
- b. Adjustable motor plate, where applicable shall utilize threaded studs for positive belt tensioning.
- c. Fan shall be constructed with an integral housing drain to alleviate rainwater.
- d. Fan shall include a bolted and gasketed access door.
- e. Belt driven fan shafts shall be AISI C-1045 hot rolled or stainless steel and accurately turned, ground, and polished.
- f. Unit fasteners exposed to corrosive airstream shall be of stainless steel construction.
- g. Coating shall be salt spray tested per ASTM B117 for in excess of 1000 hours without failure, humidity resistance tested per ASTM D2247 for in excess of 1000 hours without failure, and impact resistance tested per ASTM D2794 and shall pass a minimum of 100 in-lbs.
- h. Unit shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM, static pressure, and maximum fan RPM.

3. DILUTION NOZZLE

- a. Fans shall incorporate a double concentric accelerator fiberglass reinforced plastic (FRP) induction nozzle selected for optimal performance per the plans and specifications. Nozzle shall be constructed and designed to avoid extreme variations in velocity flows across the outlet, even against wind loading. Where required, CFD shall be provided demonstrating this on submitted nozzle. Bifurcated designs shall not be allowed.
- b. Induction nozzle shall be constructed and designed to efficiently handle up to 7000 feet per minute outlet velocity and shall have a optimally matched accelerator for the specified design conditions.

4. CENTRIFUGAL FAN IMPELLER

- a. Fan impeller shall be steel, non-overloading, centrifugal backward inclined, airfoil type. Blades shall be continuously welded to the backplate and inlet shroud.
- b. Fan impeller hub shall be keyed and securely attached to the fan shaft. Fan shaft shall be AISI C-1045 hot rolled or stainless steel and accurately turned, ground, and polished.
- c. Fan impeller shall be statically and dynamically balanced in accordance with AMCA Standard 204-96, "Balance Quality and Vibration Levels for Fans."
- d. Fan impeller shall be coated with finish to match the fan housing.

- e. Belt driven fan bearings shall be designed and tested specifically for use in air handling applications. Construction shall be heavy duty regreaseable ball or roller type in cast iron pillow block housing.
 - f. Belt driven fan bearings shall be selected for a minimum L50 life of not less than 200,000 hours.
 - g. Belt driven fan bearings shall have copper lubrication lines run to a centralized location for ease of maintenance.
5. BYPASS AIR PLENUM
- a. For constant volume systems the fan and nozzle assembly shall be directly connected to the roof curb and exhaust duct.
 - b. For variable volume systems a bypass air plenum shall be supplied as shown on the contract drawings.
 - c. Bypass air plenum shall introduce outside air above the roof level and shall have rain hood(s) and bird screen protection over the bypass air damper(s).
 - d. Bypass air plenum shall be constructed of welded steel, minimum 14 gauge, with a finish to match the fan housing.
 - e. Bypass dampers shall be opposed blade design, coated to match the fan housing and plenum.
 - f. A fan isolation damper gravity type coated to match fan housing and plenum shall be provided as show on the project documents.
6. FAN MOTORS AND DRIVES
- a. Fan motors shall be premium efficiency, NEMA frame, nominal 1800 or 3600 RPM Totally Enclosed Fan Cooled (TEFC) with a 1.15 service factor.
 - b. Belt driven fan drive belts shall be oil and heat resistant, static conducting. Fixed drives shall be sized for a minimum 1.5 service factor (150% of the motor horsepower) and shall be readily and easily accessible for service, if required.
 - c. Belt driven fans shall utilize precision machined cast iron type sheaves, keyed and securely attached to the wheel and motor shafts.

1.03 PART 3 EXECUTION

A. INSTALLATION

- 1. Install in accordance with manufacturer's instructions.
- 2. Provide sheaves required for final air balance.

END OF SECTION

SECTION 15840 - AIR TERMINAL UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Terminal units.

1.02 RELATED REQUIREMENTS

- A. Section 15065 - Motors for Mechanical Equipment.
- B. Section 15182 - Hydronic Piping: Connections to heating coils.
- C. Section 15183 - Hydronic Specialties: Connections to heating coils.
- D. Section 15810 - Ducts.
- E. Section 15820 - Duct Accessories.
- F. Section 15850 - Air Outlets and Inlets.
- G. Section 15928 - Instruments and Control Elements: Thermostats and Actuators.

1.03 SUBMITTALS

- A. See Section 01300 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
 - 1. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of 1 to 4 inch wg.
- D. Project Record Documents: Record actual locations of units.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.
- F. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- G. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Spare parts lists
 - 2. Operating instructions
 - 3. Maintenance instructions, including preventative and corrective maintenance.
 - 4. Copies of warranties
 - 5. Wiring diagrams
 - 6. Shop drawings and product data

1.04 WARRANTY

- A. See Section 01780 - Closeout Submittals, for additional warranty requirements.

- B. Provide five year manufacturer warranty for air terminal units.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Carrier
- B. Enviro-Tec
- C. Trane

2.02 AIR TERMINAL UNITS

- A. Refer to schedules for model and type terminal unit specified.
- B. Hot Water Heating Coil:
 - 1. Construction: 1/2 inch copper tube mechanically expanded into aluminum plate fins, leak tested under water to 200 psig pressure, factory installed.
- C. Automatic Damper Operator:
 - 1. Electric Actuator: 24 volt with high limit.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Support units individually from structure. Do not support from adjacent ductwork.
- C. Connect to ductwork in accordance with Section 15810.

END OF SECTION

SECTION 15850 - AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Diffusers.

1.02 SUBMITTALS

- A. See Section 01300 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.
- C. Project Record Documents: Record actual locations of air outlets and inlets.
- D. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
- E. Maintenance instructions for special finishes, including recommended cleaning methods and materials, and special precautions identifying detrimental agents.
- F. Shop drawings and product data

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Carnes Company HVAC: www.carnes.com.
- B. Krueger: www.krueger-hvac.com.
- C. Price Industries: www.price-hvac.com.
- D. Titus: www.titus-hvac.com.

2.02 RECTANGULAR CEILING DIFFUSERS

- A. Fabrication: Steel with baked enamel finish.
- B. Refer to Schedule for differ types.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- C. Install diffusers to ductwork with air tight connection.
- D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.

END OF SECTION

SECTION 15860 - AIR CLEANING DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Disposable panel filters.
- B. Extended surface high efficiency media filters.
- C. Filter gages.

1.02 REFERENCE STANDARDS

- A. ASHRAE Std 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 1992.
- B. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 2007.
- C. UL 900 - Standard for Air Filter Units; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on filter media, filter performance data, filter assembly and filter frames, dimensions, motor locations and electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate filter assembly and filter frames, dimensions, motor locations, and electrical characteristics and connection requirements.
- D. Manufacturer's Installation Instructions: Indicate assembly and change-out procedures.
- E. Operation and Maintenance Data: Include instructions for operation, changing, and periodic cleaning.
- F. Operation and Maintenance Manuals: Include in manuals the information listed below. For information on how to prepare and submit manuals see section 1780 (Closeout Submittals).
 - 1. Spare parts lists
 - 2. Shop drawings and product data

1.04 EXTRA MATERIALS

- A. See Section 01600 - Product Requirements, for additional provisions.
- B. Provide two sets of disposable panel filters.

PART 2 PRODUCTS

2.01 FILTER MANUFACTURERS

- A. American Filtration Inc: www.americanfiltration.com.
- B. AAF International/American Air Filter: www.aafintl.com.
- C. Camfil Farr Company: www.camfilfarr.com.

2.02 DISPOSABLE PANEL FILTERS

- A. Media: UL 900 Class 2, fiber blanket, factory sprayed with flameproof, non-drip, non-volatile adhesive.
- B. Minimum Efficiency Reporting Value (MERV): 8, when tested in accordance with ASHRAE 52.2.
- C. Casing: Cardboard frame.

2.03 EXTENDED SURFACE HIGH EFFICIENCY MEDIA FILTERS

- A. Media: Pleated, water-resistant glass fiber with aluminum separators; in 16 gage steel holding frame with corrosion resistant coating.
- B. Minimum Efficiency Reporting Value (MERV): 15, when tested in accordance with ASHRAE 52.2.

2.04 FILTER GAGES

- A. Manufacturers:
 - 1. Dwyer Instruments, Inc: www.dwyer-inst.com.
 - 2. H.O. Trerice Co: www.trerice.com.
 - 3. Weiss Instruments: www.weissinstruments.com.
 - 4. Substitutions: See Section 01600 - Product Requirements.
- B. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range 0-0.5 inch WG, 2 percent of full scale accuracy.
- C. Accessories: Static pressure tips with integral compression fittings, 1/4 inch aluminum tubing, 2-way or 3-way vent valves.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install air cleaning devices in accordance with manufacturer's instructions.
- B. Prevent passage of unfiltered air around filters with felt, rubber, or neoprene gaskets.
- C. Install filter gage static pressure tips upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum, in accessible position. Adjust and level.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with clean set.

END OF SECTION

SECTION 15926 - DIGITAL CONTROLS

PART 1 GENERAL

RELATED DOCUMENTS

2.01 All work of this Division shall be coordinated and provided by the single Central Control and Monitoring System (CCMS) Contractor.

- A. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Division 15 Sections for details.
- B. The work of this Division shall be as required by the Specifications, Point Schedules and Drawings.

2.02 Scope

- A. This section includes the controls, instrumentation and associated piping and wiring required to make the mechanical systems provided under Division 15 perform as described in these specifications and as shown. Provide a complete system of automatic temperature control of the direct digital type. The system shall be complete in all respects including all labor, materials, equipment, and service necessary, and shall be installed by personnel in the direct employ of the manufacturer. Provide a distributed process network control system complete with all necessary hardware and software including all programming. The DDC systems shall be an Andover Continuum Bacnet system installed by Emcor Inc.
- B. Provide a complete and operational Central Control and Monitoring System (CCMS) including all devices and software necessary to perform the functions herein described or indicated on the drawings.
- C. The CMMS shall be a Web based system communicating over the building owners Local Area Network (LAN). Contractor shall be responsible for coordination with the owner's IT staff to ensure that the CMMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN. TCP/IP connections and addresses shall be provided by the owner for connection of supervisory panels to the USCA network..
- D. The primary focus of the Central Control and Monitoring System (CCMS) will be to monitor and control the new HVAC system components, air handling units, fans, heat exchangers, coils, valves, pumps, variable speed drives, trending, graphic functions, etc. The system shall be expandable to serve future equipment, systems, and auxiliary field devices.
- E. CCMS contactor shall provide all DDC panels, power supplies, wiring, conduit, solenoid valves, relays, differential pressure transmitters, differential pressure switches, RTDS, pressure sensors, etc. necessary for a complete and operable automatic control system and DDC field panels and connecting LAN.
- F. The systems engineering phase shall include the selection and integration of components into a complete system which will meet the performance and prescriptive requirements of the Contract, together with drawings, specifications, descriptions of operation, diagrams including system architecture and other materials listed under "Submittals" paragraph of this Section. The successful contractor shall be responsible for all systems engineering.

2.03 Quality Assurance

- A. Quality assurance for automatic control systems includes a multi-step program consisting of a

pre-qualification procedure for manufacturer and installation specialist; a system engineering, products and shop drawing phase; installation; testing and adjusting; reporting; commissioning testing and verifications; operating instruction and training; and the submission of maintenance and operating manuals.

B. CMMS Contractor

1. The Central Control and Monitoring System (CMMS) herein specified shall be fully integrated and installed as a complete package by the Central Control and Monitoring System contractor. The System shall include all wiring, piping, installation supervision, calibration, adjustments, and checkout necessary for a complete and fully operational system.
2. The CMMS Contractor shall be a factory owned branch office that is regularly engaged in the engineering, programming, installation and service of CMMSs of similar size and complexity. Bids by wholesalers, mechanical contractors, franchised dealers, applied partners or any other firm whose principal business is not that of manufacturing and installing automatic temperature control systems shall not be acceptable.
3. The CMMS Contractor shall have a minimum of ten years experience with the complete, turnkey installation of CMMSs of similar size and technical complexity.
4. The CMMS shall be complete in all respects and shall be provided, installed and commissioned by the CMMS equipment manufacturer. Equipment manufacturer shall be responsible for and warrant the proper installation and operation of the CMMS and control system equipment.
5. The following CMMS contractors are approved to provide and install the CMMS for this project subject to their ability to meet all requirements of this specification:
6. Johnson Controls
7. Bid approval does not imply nor suggest compliance of specification requirements.

C. CMMS Products Manufacturer:

1. The CMMS architecture shall consist of the products of a manufacturer regularly engaged in the production of CMMSs, and shall be the manufacturer's latest standard of design. Controllers and DDC (Direct Digital Control) system components shall be current production products.
2. All other equipment shall be the products of the CMMS manufacturers or of an approved manufacturer regularly engaged in production of specialized CMMS materials or equipment.
3. Following is a list of acceptable CMMS products manufacturers:
4. Johnson Controls
5. Bid approval does not imply nor suggest compliance of specification requirements.

2.04 Work Included and Interface Requirements

A. Installation of Central Control and Monitoring System (CMMS)

1. The CMMS contractor shall provide all necessary hardware and software to integrate the new control system with the existing USC SOM campus CMMS. Integration means the ability to monitor, override, change setpoints, and provide real-time bi-directional dynamic data exchange between the new control system and the existing CMMS hardware and software.
2. The CMMS contractor shall upgrade existing Metasys software to latest version.
3. The existing USC SOM campus CMMS is a Johnson Controls Metasys system. The CMMS is comprised of multiple supervisory controllers, monitoring and communicating with various building control systems over the USC SOM campus Ethernet LAN system. The new building control system will be connected to, and communicate with, the existing

- campus CMMS over the USC SOM campus Ethernet LAN
4. All new control points, monitoring points and software points shall be added to the existing USC SOM CMMS database and shall be available for monitoring and adjustment at any computer, with current copy of Microsoft Internet Explorer software (Release 6.0 or later), that is connected to the USC SOM LAN.
 5. All new building software and databases shall be archived on the hard drive at the USC SOM CMMS server. In the event that any building controller should lose its program that controller's archived software program shall be downloaded across the CMMS network from the CMMS server to the respective building controller.
 6. Integrity of the existing CMMS shall be maintained during installation.
 7. The new building control system shall be compatible in every respect with existing Metasys CMMS hardware and software. All new controllers shall be compatible with Metasys database and Metasys software development tools.

2.05 Submittals

- A. Shop Drawings, Product Data, and Samples
 1. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance.
 2. Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.
 3. The CCMS Contractor shall correct any errors or omissions noted in the first review.
 4. At a minimum, submit the following:
 - a. CCMS network architecture diagrams including all nodes and interconnections.
 - b. Systems schematics, sequences and flow diagrams.
 - c. Points schedule for each point in the CCMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.
 - d. Samples of Graphic Display screen types and associated menus.
 - e. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
 - f. Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.
 - g. Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.
 - h. Details of all CCMS interfaces and connections to the work of other trades.
- B. Product data sheets or marked catalog pages including part number, photo and description for all products including software.

2.06 Record Documentation

- A. Operation and Maintenance Manuals
 1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following

for the CCMS provided:

- a. Table of contents.
 - b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
 - c. Manufacturers product data sheets or catalog pages for all products including software.
 - d. System Operator's manuals.
 - e. Archive copy of all site-specific databases and sequences.
 - f. CCMS network diagrams.
 - g. Interfaces to all third-party products and work by other trades.
2. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

2.07 Warranty

- A. Standard Material and Labor Warranty:
1. Provide a one-year labor and material warranty on the CCMS.
 2. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the CCMS Contractor at the cost of the CCMS Contractor.
 3. Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during CCMS Contractor's normal business hours.

PART 2 PRODUCTS

3.01 Large General Description

- A. The Building Management System (CCMS) shall use an open architecture. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.
- B. The Building Management System shall consist of the following:
1. Standalone Network Automation Engine(s)
 2. Field Equipment Controller(s)
 3. Input/Output Module(s)
 4. Local Display Device(s)
 5. Distributed User Interface(s)
 6. Network processing, data storage and communications equipment
 7. Other components required for a complete and working CCMS
- C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.
- D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

3.02 CCMS Architecture

- A. Automation Network
 - 1. The CCMS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.
 - 2. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
 - 3. Network Automation Engines (NAE) shall reside on the automation network.
 - 4. The automation network will be compatible with other campus-wide networks. Where indicated, the automation network shall be connected to the campus network and share resources with it by way of standard networking devices and practices.

- B. Control Network
 - 1. Network Automation Engines shall provide supervisory control over the control network.
 - 2. Control networks shall provide either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.
 - 3. DDC Controllers shall reside on the control network.

- C. Distributed Web Based User Interface
 - 1. All features and functions of the dedicated user interface previously defined in this document shall be available on any computer connected directly or via a wide area or virtual private network (WAN/VPN) to the automation network and conforming to the following specifications.
 - 2. Alarms
 - a. Alarms shall be routed directly from Network Automation Engines to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
 - 1) Log date and time of alarm occurrence.
 - 2) Generate a "Pop-Up" window, with audible alarm, informing a user that an alarm has been received.
 - 3) Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
 - 4) Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.
 - 5) Provide the capability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.
 - 6) Any attribute of any object in the system may be designated to report an alarm.
 - 7) The FMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions
 - 3. Reports and Summaries
 - a. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:
 - 1) All points in the CCMS
 - 2) All points in each CCMS application

- 3) All points in a specific controller
 - 4) All points in a user-defined group of points
 - 5) All points currently in alarm
 - 6) All points locked out
 - 7) All CCMS schedules
 - 8) All user defined and adjustable variables, schedules, interlocks and the like.
 - 9) Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.
 - 10) Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.
 - 11) The system shall allow for the creation of custom reports and queries via a standard web services XML interface and commercial off-the-shelf software such as Microsoft Access, Microsoft Excel, or Crystal Reports.
4. Schedules
 - a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:
 - 1) Weekly schedules
 - 2) Exception Schedules
 - 3) Monthly calendars.
 - 4) Weekly schedules shall be provided for each group of equipment with a specific time use schedule.
 - 5) It shall be possible to define one or more exception schedules for each schedule including references to calendars
5. Password
 - a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.
 - b. A minimum of five levels of access shall be supported individually or in any combination as follows:
 - 1) Level 1 = View Data
 - 2) Level 2 = Command
 - 3) Level 3 = Operator Overrides
 - 4) Level 4 = Database Modification
 - 5) Level 5 = Database Configuration
 - 6) Level 6 = All privileges, including Password Add/Modify
 - 7) Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
6. Dynamic Color Graphics
 - a. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.
 - b. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.
 - 1) The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.
7. Historical trending and data collection

- a. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:
 - 1) Any point, physical or calculated, may be designated for trending. Three methods of collection shall be allowed:
 - (a) Defined time interval
 - (b) Upon a change of value
 - (1) Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.
 - 2) The system shall provide a configurable data storage subsystem for the collection of historical data. Data can be stored in either Microsoft Access or SQL database format.
8. Trend data viewing and analysis
 - a. Provide a trend viewing utility that shall have access to all database points.
 - b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.
 - c. The trend viewing utility shall have the capability to define trend study displays to include multiple trends
 - d. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.
 - e. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.
 - f. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.
 - g. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

3.03 Network Automation Engines (NAE)

- A. Network Automation Engine (NAE)
 1. The Network Automation Engine (NAE) shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.
 2. Automation network - The NAE shall reside on the automation network and shall support a subnet of system controllers.
 3. Processor - The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.
 4. Memory - Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
 5. Diagnostics - The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
 6. Power Failure - In the event of the loss of normal power, The NAE shall continue to

operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

- a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
- b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

3.04 DDC System Controllers

A. Field Equipment Controller (FEC)

1. The Field Equipment Controller (FEC) shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol.
2. Controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.
3. The FEC shall be assembled in a plenum-rated housing with flammability rated to UL94-5VB.
4. The FEC shall include a removable base to allow pre-wiring without the controller.
5. The FEC shall accommodate the direct wiring of analog and binary I/O field points.
6. The FEC shall support the following types of inputs and outputs:
 - a. Universal Inputs - shall be configured to monitor any of the following:
 - 1) Analog Input, Voltage Mode
 - 2) Analog Input, Current Mode
 - 3) Analog Input, Resistive Mode
 - 4) Binary Input, Dry Contact Maintained Mode
 - 5) Binary Input, Pulse Counter Mode
 - 6) Binary Inputs - shall be configured to monitor either of the following:
 - (a) Dry Contact Maintained Mode
 - (b) Pulse Counter Mode
 - 7) Analog Outputs - shall be configured to output either of the following:
 - (a) Analog Output, Voltage Mode
 - (b) Analog Output, current Mode
 - 8) Binary Outputs - shall output the following:
 - (a) 24 VAC Triac
 - 9) Configurable Outputs - shall be capable of the following:
 - (a) Analog Output, Voltage Mode
 - (b) Binary Output Mode
7. The FEC shall have the ability to reside on a Field Controller Bus (FC Bus).
 - a. The FC Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.
 - b. The FC Bus shall support communications between the FECs and the NAE.
 - c. The FC Bus shall support a minimum of 100 IOMs and FEC in any combination.
 - d. The FC Bus shall operate at a maximum distance of 15,000 Ft. between the FEC and the furthest connected device.
 - e.
8. The FEC shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).

- a. The SA Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.
 - b. The SA Bus shall support a minimum of 10 devices per trunk.
 - c. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the FEC and the furthest connected device.
9. The FEC shall support, but not be limited to, the following:
- a. Hot water, chilled water/central plant applications
 - b. Built-up air handling units for special applications
 - c. Terminal units
 - d. Special programs as required for systems control

3.05 Field Devices

- A. Input/Output Module (IOM)
1. The Input/Output Module (IOM) provides additional inputs and outputs for use in the FEC.
 2. The IOM shall communicate with the FEC over either the FC Bus or the SA Bus using BACnet Standard protocol SSPC-135, Clause 9.
- B. VAV Modular Assembly (VMA)
1. The VAV Modular Assembly shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units. It shall address both single and dual duct applications.
 2. The VAV Modular Assembly shall communicate over the FC Bus using BACnet Standard protocol SSPC-135, Clause 9.
 3. The VAV Modular Assembly shall have internal electrical isolation for AC power, DC inputs, and MS/TP communications. An externally mounted isolation transformer shall not be acceptable.
 4. The VAV Modular Assembly shall be a configurable digital controller with integral differential pressure transducer and damper actuator. All components shall be connected and mounted as a single assembly that can be removed as one piece.
 5. The VAV Modular Assembly shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
 6. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 30 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.
 7. The controller shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.
 8. Each controller shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
 9. The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
 10. Each controller shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.
 11. The controller shall provide the ability to download and upload VMA configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.
 12. Control setpoint changes initiated over the network shall be written to VMA non-volatile

- memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.
13. The controller firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.
 14. The controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.
 15. The controller shall interface with balancer tools that allow automatic recalculation of box flow pickup gain (“K” factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.
 16. Controller performance shall be self-documenting via on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance. The VMA shall calculate exponentially weighted moving averages (EWMA) for each of the following. These metrics shall be available to the end user for efficient management of the VAV terminals.
 - a. Absolute temperature loop error.
 - b. Signed temperature loop error.
 - c. Absolute airflow loop error.
 - d. Signed airflow loop error.
 - e. Average damper actuator duty cycle.
 17. The controller shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:
 - a. Unreliable space temperature sensor.
 - b. Unreliable differential pressure sensor.
 - c. Starved box.
 - d. Actuator stall
 - e. Insufficient cooling.
 - f. Insufficient heating.
 - 1) The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The VMA would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.
 18. The controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality), and shall be capable of resetting the box minimum airflow Based on the percent of outdoor air in the primary air stream.
 19. The controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.
 20. Inputs:
 - a. Analog inputs with user defined ranges shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:
 - 1) 0-10 VDC Sensors
 - 2) 1000ohm RTDs
 - 3) NTC Thermistors
 - 4) Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input “bouncing.”
 - 5) For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.

- 6) Provide side loop application for humidity control.
21. Outputs
 - a. Analog outputs shall provide the following control outputs:
 - 1) 0-10 VDC
 - 2) Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.
 - 3) For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.
22. Application Configuration
 - a. The VAV Modular Assembly shall be configured with a software tool that provides a simple Question/Answer format for developing applications and downloading.
23. Sensor Support
 - a. The VAV Modular Assembly shall communicate over the Sensor-Actuator Bus (SA Bus) with a Network Sensor.
 - b. The VMA shall support an LCD display room sensor.
 - c. The VMA shall also support standard room sensors as defined by analog input requirements.
 - d. The VMA shall support humidity sensors defined by the AI side loop.
- C. Network Sensors (NS)
 1. The Network Sensors (NS) shall have the ability to monitor the following variables as required by the systems sequence of operations:
 - a. Zone Temperature
 - b. Zone humidity
 - c. Zone setpoint
 2. The NS shall transmit the zone information back to the controller on the Sensor-Actuator Bus (SA Bus) using BACnet Standard protocol SSPC-135, Clause 9.
 3. The Network Sensors shall include the following items:
 - a. A backlit Liquid Crystal Display (LCD) to indicate the Temperature, Humidity and Setpoint.
 - b. An LED to indicate the status of the Override feature.
 - c. A button to toggle the temperature display between Fahrenheit and Celsius.
 - d. A button to initiate a timed override command
 4. The NS shall be available with either screw terminals or phone jack.
 5. The NS shall be available in either surface mount or wall mount styles.

3.06 Input Devices

- A. General Requirements
 1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.
- B. Temperature Sensors
 1. General Requirements:
 - a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
 - b. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
 - c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:
 2. Room Temperature Sensors

- a. Room sensors shall be constructed for either surface or wall box mounting.
 - b. Room sensors shall have the following options when specified:
 - 1) Setpoint reset slide switch providing a +3 degree (adjustable) range.
 - 2) Individual heating/cooling setpoint slide switches.
 - 3) A momentary override request push button for activation of after-hours operation.
 3. Thermo wells
 - a. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
 - b. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
 - c. Thermo wells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
 - d. Thermo wells shall be constructed of 316 stainless steel.
 4. Outside Air Sensors
 - a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
 - b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
 - c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
 5. Duct Mount Sensors
 - a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
 - b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
 - c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
 6. Averaging Sensors
 - a. For ductwork greater in any dimension than 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.
 - b. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.
 - c. Capillary supports at the sides of the duct shall be provided to support the sensing string.
 7. Acceptable Manufacturers: Johnson Controls, Setra.
- C. Humidity Sensors
1. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.
 2. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.
 3. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.
 4. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealite fittings and stainless steel bushings.
 5. A single point humidity calibrator shall be provided, if required, for field calibration.

Transmitters shall be shipped factory pre-calibrated.

6. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.
7. Acceptable Manufacturers: Johnson Controls, Veris Industries, and Mamac.

D. Differential Pressure Transmitters

1. General Air Transmitter Requirements:

- a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
- b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
- c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
- d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

2. Low Differential Air Pressure Applications (0" to 5" w.c.)

- a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
- b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
 - 1) (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)
 - 2) 4-20 mA output.
 - 3) Maintain accuracy up to 20 to 1 ratio turndown.
 - 4) Reference Accuracy: +0.2% of full span.
 - 5) Acceptable Manufacturers: Johnson Controls and Setra.

3. Medium Differential Air Pressure Applications (5" to 21" w.c.)

- a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:
 - 1) Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
 - 2) Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.
 - 3) Thermal Effects: <+.033 F.S./Deg. F. over 40°F. to 100°F. (calibrated at 70°F.).
 - 4) Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
 - 5) Acceptable manufacturers: Johnson Controls and Setra.

E. Flow Monitoring

1. Air Flow Monitoring

- a. Duct Air Flow Measuring Stations
 - 1) Each device shall be designed and built to comply with, and provide results in

accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.

- 2) Airflow measuring stations shall be fabricated of 14-gauge galvanized steel welded casing with 90 Deg. connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air directionalizer and parallel cell profile suppressor (3/4" maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 6000 feet per minute. This air directionalizer and parallel cell honeycomb suppressor shall provide 98% free area, equalize the velocity profile, and eliminate turbulent and rotational flow from the air stream prior to the measuring point.
- 3) The total pressure measurement side (high side) will be designed and spaced to the Industrial Ventilation Manual 16th Edition, Page 9-5. The self-averaging manifolding will be manufactured of brass and copper components.
- 4) The static pressure sensing probes (low side) shall be bullet-nosed shaped, per detailed radius, as illustrated in Industrial Ventilation Manual 16th Edition, Page 9-5.
- 5) The main take-off point from both the total pressure and the static pressure manifolds must be symmetrical.
- 6) Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.
- 7) Acceptable manufacturers: Air Monitor Corp., Tek-Air, Ebtron, and Dietrich Standard.
- 8) Static Pressure Traverse Probe
 - (a) Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.
 - (b) Acceptable manufacturers: Cleveland Controls
- 9) Shielded Static Air Probe
 - (a) A shielded static pressure probe shall be provided at each end of the building. The probe shall have multiple sensing ports, an impulse suppression chamber, and airflow shielding. A suitable probe for indoor and outdoor locations shall be provided.

F. Power Monitoring Devices

1. Current Measurement (Amps)

- a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.
- b. Current Transformer - A split core current transformer shall be provided to monitor motor amps.
 - 1) Operating frequency - 50 - 400 Hz.
 - 2) Insulation - 0.6 Kv class 10Kv BIL.
 - 3) UL recognized.
 - 4) Five amp secondary.
 - 5) Select current ration as appropriate for application.
 - 6) Acceptable manufacturers: Veris Industries
 - 7) Current Transducer - A current to voltage or current to mA transducer shall be

provided. The current transducer shall include:

- (a) 6X input over amp rating for AC inrushes of up to 120 amps.
- (b) Manufactured to UL 1244.
- (c) Accuracy: +.5%, Ripple +1%.
- (d) Minimum load resistance 30kOhm.
- (e) Input 0-20 Amps.
- (f) Output 4-20 mA.
- (g) Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).
- (h) Acceptable manufacturers: Veris Industries

G. Smoke Detectors

1. Ionization type air duct detectors shall be furnished as specified elsewhere in Division 16 for installation under Division 15. All wiring for air duct detectors shall be provided under Division 16, Fire Alarm System.

H. Status and Safety Switches

1. General Requirements
 - a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the CCMS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.
2. Current Sensing Switches
 - a. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
 - b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
 - c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
 - d. Acceptable manufacturers: Veris Industries
3. Air Filter Status Switches
 - a. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.
 - b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
 - c. Provide appropriate scale range and differential adjustment for intended service.
 - d. Acceptable manufacturers: Johnson Controls, Cleveland Controls
4. Air Flow Switches
 - a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.
 - b. Acceptable manufacturers: Johnson Controls, Cleveland Controls
5. Air Pressure Safety Switches
 - a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.
 - b. Pressure range shall be adjustable with appropriate scale range and differential

- adjustment for intended service.
- c. Acceptable manufacturers: Johnson Controls, Cleveland Controls
- 6. Low Temperature Limit Switches
 - a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
 - b. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.
 - c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.
 - d. The low temperature limit switch shall be equal to Johnson Controls A70.

3.07 Output Devices

A. Actuators

1. General Requirements
 - a. Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.
2. Electronic Damper Actuators
 - a. Electronic damper actuators shall be direct shaft mount.
 - b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.
 - c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
 - d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.
 - e. Acceptable manufacturers: Johnson Controls, Mamac.
3. Electronic Valve Actuators
 - a. Electronic valve actuators shall be manufactured by the valve manufacturer.
 - b. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
 - c. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator

shall be sized Based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.

- d. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
- e. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.
- f. Acceptable manufacturers: Johnson Controls

B. Control Relays

1. Control Pilot Relays

- a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
- b. Mounting Bases shall be snap-mount.
- c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
- d. Contacts shall be rated for 10 amps at 120VAC.
- e. Relays shall have an integral indicator light and check button.
- f. Acceptable manufacturers: Johnson Controls, Lectro

C. Electronic Signal Isolation Transducers

1. A signal isolation transducer shall be provided whenever an analog output signal from the CCMS is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input signal from a remote system.
2. The signal isolation transducer shall provide ground plane isolation between systems.
3. Signals shall provide optical isolation between systems.
4. Acceptable manufacturers: Advanced Control Technologies

D. External Manual Override Stations

1. External manual override stations shall provide the following:
 - a. An integral HAND/OFF/AUTO switch shall override the controlled device pilot relay.
 - b. A status input to the Facility Management System shall indicate whenever the switch is not in the automatic position.
 - c. A Status LED shall illuminate whenever the output is ON.
 - d. An Override LED shall illuminate whenever the HOA switch is in either the HAND or OFF position.
 - e. Contacts shall be rated for a minimum of 1 amp at 24 VAC.

E. Control Valves (Chilled Water)

1. All modulating control valves shall be of the "pressure independent" type configured with one integrated valve body that incorporates one chamber with an adjustable Cv and a separate pressure regulating chamber used to maintain a constant differential pressure across the control surface.

2. Each control valve shall be individually flow tested at the factory and verified to deviate no more than $\pm 5\%$ through the selected operating pressure range. A calibrated performance tag shall be provided with each valve that verifies the flow rate in 10° rotation increments up to full rated flow (option with $1/2''$). All testing shall be performed with instruments calibrated to the requirements of ANSI/ISA-S75.11-1985, with traceability to NIST and/or ISO standards.
3. Control valve rangeability shall be 100:1 minimum.
4. Each control valve shall be subjected to 70 psid and tested to exceed ANSI/FCI 70-2-1998 leakage ratings. Class IV leakage or better is required for control valves 2" nominal size and less. Class III leakage or better is required for control valves larger than 2".
5. In all control valves 8" and smaller, it shall be possible to modify the valve flow characteristics without removing the valve from the piping system.
6. Balancing valves and associated balancing shall not be required where pressure independent modulating control valves are installed.
7. The control valve actuator shall modulate all valves up to 8" in nominal size from 0 to 100% design flow while rotating the valve stem a maximum of 90° .
8. There shall be three ports installed at the factory integral to each valve and capable of being used to measure pressure or temperature. The first port shall be installed at the inlet to the valve. The second shall be installed between the Cv chamber and the pressure regulating chamber. The third shall be installed at the outlet of the valve. Should the ports not be provided as part of the valve body than they shall be installed in a spool piece and attached to the body.
9. The differential pressure between the first and the third port shall be used in commissioning to verify that the minimum differential pressure (typically 5 psid) required for pressure independent operation is available.
10. The differential pressure between the first and second ports shall be used to verify proper valve operation and flow regulation. It shall be possible to verify the flow rate through the control valve using the valve stem position and the differential pressure measurement between the first and second port in the valve. If these valve features are not available, a flow meter shall be installed to verify actual flow rate in operation through the valve.
11. All valves shall be warranted by the manufacturer for no less than 5 years from the date of purchase.

F. Electronic/Pneumatic Transducers

1. Electronic to Pneumatic transducers shall provide:
 - a. Output: 3-15 PSIG.
 - b. Input: 4-20 mA or 0-10 VDC.
 - c. Manual output adjustment.
 - d. Pressure gauge.
 - e. External replaceable supply air filter.
 - f. Acceptable manufacturers: Johnson Controls, Mamac

3.08 Miscellaneous Devices

A. Local Control Panels

1. All control panels shall be factory constructed, incorporating the CCMS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch.
2. In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices-such as relays, transducers, and so

forth-that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.

3. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
4. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
5. All wiring shall be neatly installed in plastic trays or tie-wrapped.
6. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.

B. Power Supplies

1. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.
2. Input: 120 VAC +10%, 60Hz.
3. Output: 24 VDC.
4. Line Regulation: +0.05% for 10% line change.
5. Load Regulation: +0.05% for 50% load change.
6. Ripple and Noise: 1 mV rms, 5 mV peak to peak.
7. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.
8. A power disconnect switch shall be provided next to the power supply.

3.09 SYSTEM DESCRIPTION

- A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units with communications to Building Management System specified in Section ____ .
- B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
- C. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.
- D. Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and the like when directly connected to the control units. Individual terminal unit control is specified in Section 15928.
- E. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
- F. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

3.10 OPERATOR INTERFACE

- A. PC Based Work Station:
- B. Workstation, controllers, and control backbone to communicate using BACnet protocol and addressing.

C. Hardware:

3.11 CONTROLLERS

A. BUILDING CONTROLLERS

1. General:
 - a. Manage global strategies by one or more, independent, standalone, microprocessor based controllers.
 - b. Provide sufficient memory to support controller's operating system, database, and programming requirements.
 - c. Share data between networked controllers.
 - d. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
 - e. Utilize real-time clock for scheduling.
 - f. Continuously check processor status and memory circuits for abnormal operation.
 - g. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
 - h. Communication with other network devices to be based on assigned protocol.
2. Communication:
 - a. Controller to reside on a BACnet network using ISO 8802-3 (ETHERNET) Data Link/Physical layer protocol.
 - b. Perform routing when connected to a network of custom application and application specific controllers.
 - c. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.
3. Anticipated Environmental Ambient Conditions:
 - a. Outdoors and/or in Wet Ambient Conditions:
 - 1) Mount within waterproof enclosures.
 - 2) Rated for operation at 40 to 150 degrees F.
 - b. Conditioned Space:
 - 1) Mount within dustproof enclosures.
 - 2) Rated for operation at 32 to 120 degrees F.
4. Provisions for Serviceability:
 - a. Diagnostic LEDs for power, communication, and processor.
 - b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.
5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
6. Power and Noise Immunity:
 - a. Maintain operation at 90 to 110 percent of nominal voltage rating.
 - b. Perform orderly shutdown below 80 percent of nominal voltage.
 - c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

B. INPUT/OUTPUT INTERFACE

1. Hardwired inputs and outputs tie into the DDC system through building, custom application, or application specific controllers.
2. All Input/Output Points:
 - a. Protect controller from damage resulting from any point short-circuiting or grounding and from voltage up to 24 volts of any duration.

- b. Provide universal type for building and custom application controllers where input or output is software designated as either binary or analog type with appropriate properties.
3. Binary Inputs:
 - a. Allow monitoring of On/Off signals from remote devices.
 - b. Provide wetting current of 12 mA minimum, compatible with commonly available control devices and protected against the effects of contact bounce and noise.
 - c. Sense dry contact closure with power provided only by the controller.
4. Pulse Accumulation Input Objects: Conform to all requirements of binary input objects and accept up to 10 pulses per second.
5. Analog Inputs:
 - a. Allow for monitoring of low voltage 0 to 10 VDC, 4 to 20 mA current, or resistance signals (thermistor, RTD).
 - b. Compatible with and field configurable to commonly available sensing devices.
6. Binary Outputs:
 - a. Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
 - b. Outputs provided with three position (On/Off/Auto) override switches.
 - c. Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.
7. Analog Outputs:
 - a. Monitoring signal provides a 0 to 10 VDC or a 4 to 20 mA output signal for end device control.
 - b. Provide status lights and two position (AUTO/MANUAL) switch for building and custom application controllers with manually adjustable potentiometer for manual override on building and custom application controllers.
 - c. Drift to not exceed 0.4 percent of range per year.
8. Tri State Outputs:
 - a. Coordinate two binary outputs to control three point, floating type, electronic actuators without feedback.
 - b. Limit the use of three point, floating devices to the following zone and terminal unit control applications:
 - c. Control algorithms run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
9. System Object Capacity:
 - a. System size to be expandable to twice the number of input output objects required by providing additional controllers, including associated devices and wiring.
 - b. Hardware additions or software revisions for the installed operator interfaces are not to be required for future, system expansions.

3.12 POWER SUPPLIES AND LINE FILTERING

- A. Power Supplies:
 1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
 2. Limit connected loads to 80 percent of rated capacity.
 3. Match DC power supply to current output and voltage requirements.
 4. Unit to be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
 5. Regulation to be 1 percent combined line and load with 100 microsecond response time for

- 50 percent load changes.
 - 6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
 - 7. Operational Ambient Conditions: 32 to 120 degrees F.
 - 8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD 810 for shock and vibration.
 - 9. Line voltage units UL recognized and CSA approved.
- B. Power Line Filtering:
- 1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
 - 2. Minimum surge protection attributes:
 - a. Dielectric strength of 1000 volts minimum.
 - b. Response time of 10 nanoseconds or less.
 - c. Transverse mode noise attenuation of 65 dB or greater.
 - d. Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

3.13 SYSTEM SOFTWARE

- A. Operating System:
- 1. Concurrent, multi-tasking capability.
 - a. Common Software Applications Supported: Microsoft Excel.
 - b. Acceptable Operating Systems: _____.
 - 2. System Graphics:
 - a. Allow up to 10 graphic screens, simultaneously displayed for comparison and monitoring of system status.
 - b. Animation displayed by shifting image files based on object status.
 - c. Provide method for operator with password to perform the following:
 - 1) Move between, change size, and change location of graphic displays.
 - 2) Modify on-line.
 - 3) Add, delete, or change dynamic objects consisting of:
 - (a) Analog and binary values.
 - (b) Dynamic text.
 - (c) Static text.
 - (d) Animation files.
 - 3. Custom Graphics Generation Package:
 - a. Create, modify, and save graphic files and visio format graphics in PCX formats.
 - b. HTML graphics to support web browser compatible formats.
 - c. Capture or convert graphics from AutoCAD.
 - 4. Standard HVAC Graphics Library:
 - a. HVAC Equipment:
 - b. Ancillary Equipment:
- B. Workstation System Applications:
- 1. Automatic System Database Save and Restore Functions:
 - a. Current database copy of each Building Controller is automatically stored on hard disk.
 - b. Automatic update occurs upon change in any system panel.
 - c. In the event of database loss in any system panel, the first workstation to detect the loss automatically restores the database for that panel unless disabled by the operator.
 - 2. Manual System Database Save and Restore Functions by Operator with Password Clearance:

- a. Save database from any system panel.
- b. Clear a panel database.
- c. Initiate a download of a specified database to any system panel.
3. Software provided allows system configuration and future changes or additions by operators under proper password protection.
4. On-line Help:
 - a. Context-sensitive system assists operator in operation and editing.
 - b. Available for all applications.
 - c. Relevant screen data provided for particular screen display.
 - d. Additional help available via hypertext.
5. Security:
 - a. Operator log-on requires user name and password to view, edit, add, or delete data.
 - b. System security selectable for each operator.
 - c. System supervisor sets passwords and security levels for all other operators.
 - d. Operator passwords to restrict functions accessible to viewing and/or changing system applications, editor, and object.
 - e. Automatic, operator log-off results from keyboard or mouse inactivity during user-adjustable, time period.
 - f. All system security data stored in encrypted format.
6. System Diagnostics:
 - a. Operations Automatically Monitored:
 - 1) Workstations.
 - 2) Printers.
 - 3) Modems.
 - 4) Network connections.
 - 5) Building management panels.
 - 6) Controllers.
 - b. Device failure is annunciated to the operator.
7. Alarm Processing:
 - a. All system objects are configurable to "alarm in" and "alarm out" of normal state.
 - b. Configurable Objects:
 - 1) Alarm limits.
 - 2) Alarm limit differentials.
 - 3) States.
 - 4) Reactions for each object.
8. Alarm Messages:
 - a. Descriptor: English language.
 - b. Recognizable Features:
 - 1) Source.
 - 2) Location.
 - 3) Nature.
9. Configurable Alarm Reactions by Workstation and Time of Day:
 - a. Logging.
 - b. Printing.
 - c. Starting programs.
 - d. Displaying messages.
 - e. Dialing out to remote locations.
 - f. Paging.
 - g. Providing audible annunciation.

- h. Displaying specific system graphics.
- 10. Custom Trend Logs:
 - a. Definable for any data object in the system including interval, start time, and stop time.
 - b. Trend Data:
 - 1) Sampled and stored on the building controller panel.
 - 2) Archivable on hard disk.
 - 3) Retrievable for use in reports, spreadsheets and standard database programs.
 - 4) Archival on LAN accessible storage media including hard disk, tape, Raid array drive, and virtual cloud environment.
 - 5) Protected and encrypted format to prevent manipulation, or editing of historical data and event logs.
- 11. Alarm and Event Log:
 - a. View all system alarms and change of states from any system location.
 - b. Events listed chronologically.
 - c. Operator with proper security acknowledges and clears alarms.
 - d. Alarms not cleared by operator are archived to the workstation hard disk.
- 12. Object, Property Status and Control:
 - a. Provide a method to view, edit if applicable, the status of any object and property in the system.
 - b. Status Available by the Following Methods:
 - 1) Menu.
 - 2) Graphics.
 - 3) Custom Programs.
- 13. Reports and Logs:
 - a. Reporting Package:
 - 1) Allows operator to select, modify, or create reports.
 - 2) Definable as to data content, format, interval, and date.
 - 3) Archivable to hard disk.
 - b. Real-time logs available by type or status such as alarm, lockout, normal, etc.
 - c. Stored on hard disk and readily accessible by standard software applications, including spreadsheets and word processing.
 - d. Set to be printed on operator command or specific time(s).
- 14. Reports:
 - a. Standard:
 - 1) Objects with current values.
 - 2) Current alarms not locked out.
 - 3) Disabled and overridden objects, points and SNVTs.
 - 4) Objects in manual or automatic alarm lockout.
 - 5) Objects in alarm lockout currently in alarm.
 - 6) Logs:
 - (a) Alarm History.
 - (b) System messages.
 - (c) System events.
 - (d) Trends.
 - b. Custom:
 - 1) Daily.
 - 2) Weekly.
 - 3) Monthly.
 - 4) Annual.

- 5) Time and date stamped.
 - 6) Title.
 - 7) Facility name.
 - c. Tenant Override:
 - 1) Monthly report showing total, requested, after-hours HVAC and lighting services on a daily basis for each tenant.
 - 2) Annual report showing override usage on a monthly basis.
 - d. Electrical, Fuel, and Weather:
 - 1) Electrical Meter(s):
 - (a) Monthly showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
 - (b) Annual summary showing monthly electrical consumption and peak demand with time and date stamp for each meter.
 - 2) Fuel Meter(s):
 - (a) Monthly showing daily natural gas consumption for each meter.
 - (b) Annual summary showing monthly consumption for each meter.
 - 3) Weather:
 - (a) Monthly showing minimum, maximum, average outdoor air temperature and heating/cooling degree-days for the month.
- C. Workstation Applications Editors:
1. Provide editing software for all system applications at the PC workstation.
 2. Downloaded application is executed at controller panel.
 3. Full screen editor for each application allows operator to view and change:
 - a. Configuration.
 - b. Name.
 - c. Control parameters.
 - d. Set-points.
 4. Scheduling:
 - a. Monthly calendar indicates schedules, holidays, and exceptions.
 - b. Allows several related objects to be scheduled and copied to other objects or dates.
 - c. Start and stop times adjustable from master schedule.
 5. Custom Application Programming:
 - a. Create, modify, debug, edit, compile, and download custom application programming during operation and without disruption of all other system applications.
 - b. Programming Features:
 - 1) English oriented language, based on BASIC, FORTRAN, C, or PASCAL syntax allowing for free form programming.
 - 2) Alternative language graphically based using appropriate function blocks suitable for all required functions and amenable to customizing or compounding.
 - 3) Insert, add, modify, and delete custom programming code that incorporates word processing features such as cut/paste and find/replace.
 - 4) Allows the development of independently, executing, program modules designed to enable and disable other modules.
 - 5) Debugging/simulation capability that displays intermediate values and/or results including syntax/execution error messages.
 - 6) Support for conditional statements (IF/THEN/ELSE/ELSE-F) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
 - 7) Support for floating-point arithmetic utilizing plus, minus, divide, times, square

root operators; including absolute value; minimum/maximum value from a list of values for mathematical functions.

- 8) Language consisting of resettable, predefined, variables representing time of day, day of the week, month of the year, date; and elapsed time in seconds, minutes, hours, and days where the variable values can be used in IF/THEN comparisons, calculations, programming statement logic, etc.
- 9) Language having predefined variables representing status and results of the system software enables, disables, and changes the set points of the controller software.

3.14 CONTROLLER SOFTWARE

- A. All applications reside and operate in the system controllers and editing of all applications occurs at the operator workstation.
- B. System Security:
 1. User access secured via user passwords and user names.
 2. Passwords restrict user to the objects, applications, and system functions as assigned by the system manager.
 3. User Log On/Log Off attempts are recorded.
 4. Automatic Log Off occurs following the last keystroke after a user defined delay time.
- C. Object or Object Group Scheduling:
 1. Weekly Schedules Based on Separate, Daily Schedules:
 - a. Include start, stop, optimal stop, and night economizer.
 - b. 10 events maximum per schedule.
 - c. Start/stop times adjustable for each group object.
- D. Provide standard application for equipment coordination and grouping based on function and location to be used for scheduling and other applications.
- E. Alarms:
 1. Binary object is set to alarm based on the operator specified state.
 2. Analog object to have high/low alarm limits.
 3. All alarming is capable of being automatically and manually disabled.
 4. Alarm Reporting:
 - a. Operator determines action to be taken for alarm event.
 - b. Alarms to be routed to appropriate workstation.
 - c. Reporting Options:
- F. Maintenance Management: System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.
- G. Sequencing: Application software based upon specified sequences of operation in Section 15940.
- H. PID Control Characteristics:
 1. Direct or reverse action.
 2. Anti-windup.
 3. Calculated, time-varying, analog value, positions an output or stages a series of outputs.
 4. User selectable controlled variable, set-point, and PED gains.
- I. Staggered Start Application:
 1. Prevents all controlled equipment from simultaneously restarting after power outage.
 2. Order of equipment startup is user selectable.

- J. Energy Calculations:
 - 1. Accumulated instantaneous power or flow rates are converted to energy use data.
 - 2. Algorithm calculates a rolling average and allows window of time to be user specified in minute intervals.
 - 3. Algorithm calculates a fixed window average with a digital input signal from a utility meter defining the start of the window period that in turn synchronizes the fixed-window average with that used by the power company.
- K. Anti-Short Cycling:
 - 1. All binary output objects protected from short-cycling.
 - 2. Allows minimum on-time and off-time to be selected.
- L. On-Off Control with Differential:
 - 1. Algorithm allows binary output to be cycled based on a controlled variable and set-point.
 - 2. Algorithm to be direct-acting or reverse-acting incorporating an adjustable differential.
- M. Run-Time Totalization:
 - 1. Totalize run-times for all binary input objects.
 - 2. Provides operator with capability to assign high run-time alarm.

PART 3 EXECUTION

4.01 CCMS Specific Requirements

- A. Graphic Displays
 - 1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.
 - 2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection. .
- B. Actuation / Control Type
 - 1. Primary Equipment
 - a. Controls shall be provided by equipment manufacturer as specified herein.
 - b. All damper and valve actuation shall be electric.
 - 2. Air Handling Equipment
 - a. All air handlers shall be controlled with a HVAC-DDC Controller
 - b. All damper and valve actuation shall be electric.
 - 3. Terminal Equipment:
 - a. Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.

4.02 Installation Practices

- A. CCMS Wiring
 - 1. All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the CCMS Contractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.
 - 2. All CCMS wiring materials and installation methods shall comply with CCMS manufacturer recommendations.
 - 3. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the CCMS Contractor. If complications arise, however, due to the

incorrect selection of cable, cable trays, raceways and/or conduit by the CCMS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.

4. Class 2 Wiring
 - a. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
 - b. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
 5. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
 6. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.
- B. CCMS Raceway
1. All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2".
 2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.
 3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
 4. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.
- C. Penetrations
1. Provide fire stopping for all penetrations used by dedicated CCMS conduits and raceways.
 2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
 3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
 4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.
- D. CCMS Identification Standards
1. Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.
 - a. Cable types specified in Item A shall be color coded for easy identification and troubleshooting.
- E. CCMS Panel Installation
1. The CCMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
 2. The CCMS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.
- F. Input Devices

1. All Input devices shall be installed per the manufacturer recommendation
 2. Locate components of the CCMS in accessible local control panels wherever possible.
- G. HVAC Input Devices - General
1. All Input devices shall be installed per the manufacturer recommendation
 2. Locate components of the CCMS in accessible local control panels wherever possible.
 3. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.
 4. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.
 5. Outside Air Sensors
 - a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
 - b. Sensors shall be installed with a rain proof, perforated cover.
 6. Duct Temperature Sensors:
 - a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
 - b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
 - c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
 - d. The sensor shall be mounted to suitable supports using factory approved element holders.
 7. Space Sensors:
 - a. Shall be mounted per ADA requirements.
 - b. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.
 8. Low Temperature Limit Switches:
 - a. Install on the discharge side of the first water or steam coil in the air stream.
 - b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
 - c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
 9. Air Differential Pressure Status Switches:
 - a. Install with static pressure tips, tubing, fittings, and air filter.
- H. HVAC Output Devices
1. All output devices shall be installed per the manufacturers recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.
 2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.
 3. Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.
 4. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum

pressure drop for steam applications shall be 7 PSI.

5. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

4.03 Training

- A. The CCMS contractor shall provide the following training services:
 1. One day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the CCMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

4.04 SEQUENCE OF OPERATION

A. GENERAL

1. Power - Fail Restart:
 - a. In the event of a power failure the FMS computer will analyze the status of all controlled equipment and compare it with normal occupancy scheduling. The equipment will then be started or stopped as necessary to prevent all equipment from coming on at the same time.
2. FMS Monitoring:
 - a. Refer to the attached Input/Output schedule for a listing of all monitoring and override points and for additional software features.
3. Optimal Start:
 - a. All scheduled HVAC equipment will be started based on an optimal start feature that will calculate the approximate time the unit will have to be started prior to scheduled start time in order for the space temperature to be at setpoint at scheduled occupancy.
 - b. Once space temperatures reach occupied setpoint O.A. dampers will be modulated open. Whenever the unit goes in the unoccupied mode the O.A. damper will be closed.
4. Night High Limit and Night Low Limit:
 - a. During unoccupied periods scheduled HVAC equipment will be energized whenever space temperature drops below a night low limit setpoint of 65 degrees(adjustable) or a night high limit of 85 degrees(adj).
5. Controllers:
 - a. Each AHU, CH and RTU shall be provided with an individual standalone DDC controller for controlling temperature, humidity and pressure as indicated in sequence of operation.
6. Smoke dampers and smoke detectors:
 - a. Units 15,000 CFM or greater will be provided with both supply and return air smoke detectors (provided and wired by div 16 - installed by div 15) as well as both supply and return air smoke dampers. When the unit is to be started the supply and return air smoke dampers will be driven open. The supply fan will be started once the AHU supply and return air dampers reach 100% open as indicated by damper end switches. When the unit is stopped the smoke dampers will not be allowed to close until the supply fan has been allowed to coast down to a complete stop.

B. EQUIPMENT

1. RTU-1

- a. Start/Stop:
 - 1) The unit will be capable of being started and stopped based on a time of day schedule from the FMS.
 - 2) When the unit goes into the occupied mode and is to be started, the outdoor air damper will be driven to its minimum CFM position, as sensed by outdoor air CFM measuring device. The outdoor air damper will remain closed during night low limit and morning warmup. Outdoor air damper will not be allowed to be closed past minimum CFM position when the unit is in the occupied mode.
 - b. Safeties:
 - 1) Duct smoke detector will shut the supply fan off whenever products of combustion are sensed. The smoke detector will be provided and wired back to fire alarm system by division 16 and interlocked with the fan starter under division 15.
 - 2) A temperature low limit switch will shutdown the fan whenever mixed air temperatures drop below 38 degrees .
 - 3) A static pressure high limit switch will shut down the air handler whenever static pressure in the discharge of the air handler exceeds 5" W.G.
 - c. Temperature Control:
 - 1) Discharge air temperature shall be controlled at 53 degrees F. (adjustable) by modulating the CHW valve as necessary to maintain setpoint.
 - d. Pressure Control:
 - 1) The supply variable speed drive shall be modulated to maintain supply duct static pressure setpoint.
 - 2) When the supply fan starts the VSD shall be in the "unloaded" position. VSD will load fan over an adjustable time period.
2. VAV/CAV Boxes
- a. Each VAV box shall be controlled by a unit mounted DDC controller. On a call for cooling the air valve will be modulated as required to maintain room temperature setpoint. As space temperature drops below setpoint the air valve will be modulated to minimum position. On a continued drop in space temperature, the first stage of electric heat shall energize. Upon continued drop in space temperature, energize additional stage of electric heat..

END OF SECTION

SECTION 15950 - TESTING, ADJUSTING, AND BALANCING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Testing, adjustment, and balancing of air systems.
- B. Measurement of final operating condition of HVAC systems.

1.02 REFERENCE STANDARDS

- A. AABC MN-1 - AABC National Standards for Total System Balance; Associated Air Balance Council; 2002.
- B. ASHRAE Std 111 - Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 1988, with 1997 Errata.
- C. NEBB (TAB) - Procedural Standards for Testing Adjusting Balancing of Environmental Systems; National Environmental Balancing Bureau; 2005, Seventh Edition.

1.03 SUBMITTALS

- A. See Section 01300 - Administrative Requirements, for submittal procedures.
- B. Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.
- C. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
 - 1. Submit six weeks prior to starting the testing, adjusting, and balancing work.
 - 2. Include certification that the plan developer has reviewed the contract documents, the equipment and systems, and the control system with the Architect and other installers to sufficiently understand the design intent for each system.
 - 3. Include at least the following in the plan:
 - a. Preface: An explanation of the intended use of the control system.
 - b. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
 - c. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - d. Identification and types of measurement instruments to be used and their most recent calibration date.
 - e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - f. Final test report forms to be used.
 - g. Expected problems and solutions, etc.
 - h. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and methods to verify this.
 - i. Description of TAB work for areas to be built out later, if any.
 - j. Time schedule for deferred or seasonal TAB work, if specified.
 - k. False loading of systems to complete TAB work, if specified.
 - l. Procedures for field technician logs of discrepancies, deficient or uncompleted work

by others, contract interpretation requests and lists of completed tests (scope and frequency).

- m. Procedures for formal progress reports, including scope and frequency.
- n. Procedures for formal deficiency reports, including scope, frequency and distribution.

D. Progress Reports.

E. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

- 1. Submit under provisions of Section 01400.
- 2. Revise TAB plan to reflect actual procedures and submit as part of final report.
- 3. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.
- 4. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
- 5. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
- 6. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
- 7. Units of Measure: Report data in both I-P (inch-pound) and SI (metric) units.
- 8. Include the following on the title page of each report:
 - a. Name of Testing, Adjusting, and Balancing Agency.
 - b. Address of Testing, Adjusting, and Balancing Agency.
 - c. Telephone number of Testing, Adjusting, and Balancing Agency.
 - d. Project name.
 - e. Project location.
 - f. Project Architect.
 - g. Project Engineer.
 - h. Project Contractor.
 - i. Project altitude.
 - j. Report date.

F. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

1.04 QUALITY ASSURANCE (moved to PART 3)

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

- A. Perform total system balance in accordance with one of the following:
 - 1. AABC MN-1, AABC National Standards for Total System Balance.
 - 2. ASHRAE Std 111, Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
 - 3. NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems.
 - 4. SMACNA HVAC Systems Testing, Adjusting, and Balancing.
- B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work

prior to Substantial Completion of the project.

- C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D. TAB Agency Qualifications:
 - 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
 - 2. Certified by one of the following:
 - a. AABC, Associated Air Balance Council: www.aabchq.com; upon completion submit AABC National Performance Guaranty.
 - b. NEBB, National Environmental Balancing Bureau: www.nebb.org.
 - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org.
- E. TAB Supervisor Qualifications: Certified by same organization as TAB agency.

3.02 EXAMINATION

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 - 1. Systems are started and operating in a safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - 5. Duct systems are clean of debris.
 - 6. Fans are rotating correctly.
 - 7. Air outlets are installed and connected.
 - 8. Duct system leakage is minimized.
 - 9. Hydronic systems are flushed, filled, and vented.
 - 10. Pumps are rotating correctly.
 - 11. Proper strainer baskets are clean and in place.
 - 12. Service and balance valves are open.
- B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
- C. Beginning of work means acceptance of existing conditions.

3.03 ADJUSTMENT TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
- B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.

3.04 RECORDING AND ADJUSTING

- A. Field Logs: Maintain written logs including:
 - 1. Running log of events and issues.
 - 2. Discrepancies, deficient or uncompleted work by others.

3. Contract interpretation requests.
 4. Lists of completed tests.
- B. Ensure recorded data represents actual measured or observed conditions.
 - C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
 - D. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
 - E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
 - F. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

3.05 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- E. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- F. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- G. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- K. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

3.06 WATER SYSTEM PROCEDURE

- A. Adjust water systems to provide required or design quantities.
- B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance

on temperature difference across various heat transfer elements in the system.

- C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- D. Effect system balance with automatic control valves fully open to heat transfer elements.
- E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
- F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.07 SCOPE

- A. Test, adjust, and balance the following:
 - 1. Air Coils
 - 2. Air Handling Units
 - 3. Fans
 - 4. Air Filters
 - 5. Air Terminal Units
 - 6. Air Inlets and Outlets

3.08 MINIMUM DATA TO BE REPORTED

- A. Electric Motors:
 - 1. Manufacturer
 - 2. Model/Frame
 - 3. HP/BHP
 - 4. Phase, voltage, amperage; nameplate, actual, no load
 - 5. RPM
 - 6. Service factor
 - 7. Starter size, rating, heater elements
 - 8. Sheave Make/Size/Bore
- B. Cooling Coils:
 - 1. Identification/number
 - 2. Location
 - 3. Service
 - 4. Manufacturer
 - 5. Air flow, design and actual
 - 6. Entering air DB temperature, design and actual
 - 7. Entering air WB temperature, design and actual
 - 8. Leaving air DB temperature, design and actual
 - 9. Leaving air WB temperature, design and actual
 - 10. Water flow, design and actual
 - 11. Water pressure drop, design and actual
 - 12. Entering water temperature, design and actual
 - 13. Leaving water temperature, design and actual
- C. Heating Coils:
 - 1. Identification/number
 - 2. Location

3. Service
 4. Manufacturer
 5. Air flow, design and actual
 6. Water flow, design and actual
 7. Water pressure drop, design and actual
 8. Entering water temperature, design and actual
 9. Leaving water temperature, design and actual
 10. Entering air temperature, design and actual
 11. Leaving air temperature, design and actual
 12. Air pressure drop, design and actual
- D. Air Moving Equipment:
1. Location
 2. Manufacturer
 3. Model number
 4. Serial number
 5. Arrangement/Class/Discharge
 6. Air flow, specified and actual
 7. Return air flow, specified and actual
 8. Outside air flow, specified and actual
 9. Supply air temperature
 10. Total static pressure (total external), specified and actual
 11. Inlet pressure
 12. Discharge pressure
 13. Sheave Make/Size/Bore
 14. Number of Belts/Make/Size
 15. Fan RPM
- E. Return Air/Outside Air:
1. Identification/location
 2. Design air flow
 3. Actual air flow
 4. Design return air flow
 5. Actual return air flow
 6. Design outside air flow
 7. Actual outside air flow
 8. Return air temperature
 9. Outside air temperature
 10. Required mixed air temperature
 11. Actual mixed air temperature
 12. Design outside/return air ratio
 13. Actual outside/return air ratio
- F. Flow Measuring Stations:
1. Identification/number
 2. Location
 3. Size
 4. Manufacturer
 5. Model number
 6. Serial number
 7. Design Flow rate

8. Design pressure drop
 9. Actual/final pressure drop
 10. Actual/final flow rate
 11. Station calibrated setting
- G. Terminal Unit Data:
1. Manufacturer
 2. Type, constant, variable, single, dual duct
 3. Identification/number
 4. Location
 5. Model number
 6. Size
 7. Minimum static pressure
 8. Minimum design air flow
 9. Maximum design air flow
 10. Maximum actual air flow
 11. Inlet static pressure
- H. Air Distribution Tests:
1. Air terminal number
 2. Room number/location
 3. Terminal type
 4. Terminal size
 5. Area factor
 6. Design velocity
 7. Design air flow
 8. Test (final) velocity
 9. Test (final) air flow
 10. Percent of design air flow

END OF SECTION