SECTION 15010

MECHANICAL GENERAL REQUIREMENTS

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. General Mechanical Requirements.

B. Mechanical Submittals.

C. Motors.

D. Equipment and Piping Identification.

1.02 **GENERAL REQUIREMENTS**

A. Scope: Furnish all labor, materials, tools, equipment, and services for all mechanical work as specified in Division 15 and as shown on the drawings. This Section applies to all Division 15 Specifications and all project mechanical work. All mechanical equipment and devices furnished or installed under other Divisions of this specification (or by the Owner) which require connection to any mechanical systems (i.e., plumbing systems, duct systems or controls) shall be connected under this division of the Specifications.

B. General: All work shall conform with the General Conditions, Supplementary Conditions, and all other provisions of the Contract Documents.

C. Complete Systems: Furnish and install all materials, appurtenances, devices, and miscellaneous items not specifically mentioned herein or noted on the drawings, but which are necessary to make a complete working installation of all mechanical systems. Not all accessories or devices are shown or specified that are necessary to form complete and functional systems.

D. Review and Coordination: To eliminate all possible errors and interferences, thoroughly examine all the Drawings and Specifications before work is started, and consult and coordinate with each of the various trades regarding the Work. Such coordination shall begin prior to any work starting, and continue throughout the project.

E. Conflicts: Notify the Architect/Engineer of any discrepancies of conflicts within the Contract Documents or between the Contract Documents and field conditions. Do not proceed with any work or the purchasing of any materials for the area(s) of conflict until obtaining written instructions from the Architect/Engineer on how to proceed. Any work done after discovery of such discrepancies or conflicts and prior to obtaining the Architect/Engineer's instructions on how to proceed shall be done at the Contractor's expense. In case of a conflict between Division 15 requirements and other project requirements, the most stringent and expensive (as judged by the Architect/Engineer) shall prevail.

F. Field Conditions:

1. Check field conditions and verify all measurements and relationships indicated on the drawings before proceeding with any work.

2. In verifying existing conditions, the Contractor shall verify by direct physical inspection, complete tracing out of systems, by applying test pressures, by excavation and inspection, use of pipeline cameras and other suitable absolute certain methods to confirm the actual physical conditions that exist.

G. Drawings and Specifications: Drawings and specifications are complementary and what is called for in either is binding and is called for in both.

H. Offsets/Fittings: The drawings are diagrammatic and show the general arrangement of the construction and therefore do not show all offsets, fittings and accessories which are required to form a complete and operating installation.

1. Piping Systems: Include in bid all necessary fittings and offset to completely connect up all systems, maintain clear access paths to equipment, and comply with all project requirements. Contractor is responsible to determine the quantity of offsets and fittings required, and the labor involved. No added payment or "extras" will be granted for the Contractor's failure to correctly estimate the number of offsets and fittings and labor required. Contractor is advised that equipment connections may require more than ten (10) elbows per unit connection per pipe line; plumbing fixtures may require more than twenty (20) elbows per fixture per pipe line.

2. Duct Systems: Include in bid all necessary fittings, offsets, and transitions to completely connect all systems, maintain clear access paths, and comply with all project requirements. Contractor is responsible to

determine the quantity of offsets and fittings required, and the labor involved. No added payments or "extras" will be granted for the Contractor's failure to correctly estimate number of offsets, fittings, transitions and labor required, to all air inlets/outlets, crossing of bean lines, at crossing with piping, and similar locations.

I. Locations: Unless dimensioned locations for mechanical items are shown, select the precise location of the item in accordance with the Contract Documents and subject to the Architect/Engineer's review. No allowances will be granted for failure to obtain the Architect/Engineer's review.

J. Design: The level of design presented in the documents represents the extent of the design being furnished to the Contractor; any additional design needed shall be provided by the Contractor. All design by the Contractor shall be performed by individuals skilled and experienced in such work, and where required by local code (or elsewhere in the documents) shall be performed by engineers licensed in the State where the project is located. The Contractor shall include in his bid the costs of all such added design including engineering, drafting, coordination, and all related activities and Work. Such designs services are required for many building systems; including but not limited to fire sprinkler systems, control systems, hanger/support systems, temporary duct/piping systems, system offset/adjustments to suit structure, and for methods/means of accomplishing the Work.

K. Experience: All Work shall be performed by individuals experienced and knowledgeable in the work they are performing, and experienced with the same type of systems and building type as this project. By virtue of submitting a bid, the Contractor is acknowledging that workers to be utilized on this project have such experience and knowledge. Upon request of the Engineer, the Contractor shall submit resumes showing the work history, training, and types of projects worked on, for all individuals assigned to this project.

L. Sustainable Building Requirements: This project has special sustainable features and requires special sustainable construction practices. This project is attempting to obtain a USGBC LEED rating. Contractor shall review Contract Document requirements related to sustainability, LEED, USGBC requirements, and provide all necessary documentation to allow the highest achievable LEED certification level, and best sustainable practices.

1.03 **DEFINITIONS**

A. "Provide," except to the extent further defined, means to "furnish and install, complete and ready for the intended use."

B. “Governing codes” and “Code” means “the applicable provisions of all local codes and ordinances, including but not limited to:

Washington State Energy Code
Uniform Plumbing Code
International Mechanical Code
International Fire Code
International Building Code
NFPA Codes and Standards
Washington State Electrical Code
National Electric Code
State Public Health Department Regulations
ASME Code for Pressure Piping
ASME Pressure Vessel Code
ASME Unfired Pressure Vessel Code
Safety Code for Mechanical Refrigeration
Washington State General Safety and Health Standards
Washington State Boiler Code
"And all local amendments to these codes, plus any additional local codes or ordinances.”

The edition as adapted by the authority having jurisdiction shall prevail. In case of conflict between authorities, the most stringent edition and code shall prevail.

C. “Finished Areas” means “areas receiving a finish coat of paint on one or more wall surface.”

D. “As indicated” means “as shown on the drawings and described in the specifications.”

E. “Concealed” means “hidden from view” as determined when areas are in their final finished condition, from the point of view of a person located in the finished area. Items located in areas above suspended ceilings, in plumbing chases, and in similar areas are considered “concealed.” Items located in cabinet spaces (e.g. below sinks) are not considered concealed.

F. “As required” means “as necessary to form a safe, neat, and complete working installation (or product), fulfilling all the requirements of the specifications and drawings and in compliance with all governing codes.”

G. “Furnish,” except as otherwise defined in greater detail, means “supply and deliver to the project site, ready for unpacking assembly and installation.”

H. "Approved" and "or approved," as used in reference to a product or manufacturer, means "as judged satisfactory and acceptable by the Architect/Engineer within the limitations of the Architect/Engineer's responsibilities." Where used in conjunction with the Architect/Engineer's response to submittals, requests, applications, inquiries, reports, and claims by the Contractor, the meaning of the term will be held to the limitations of the Architect/Engineer's responsibilities and duties as specified in the General Conditions. In no case will "approval" by the Architect/Engineer be interpreted as an assurance to the Contractor that the requirements of the Contract Documents have been fulfilled.

I. "Approved equal" means "or approved."

J. "Equal" means "or approved."

K. The term "work included" (as used at the beginning of each specification section), and the items listed with it, is only an indication of some of the items specified in that section and is in no way limiting the work of that Section. See complete drawings and specifications for all required work.

L. The term "related work" (as used at the beginning of each specification section), and the sections listed with it, is only an indication of some of the specification sections which the work of that section may be strongly related to. Since all items of work relate to one another and require full coordination, all specification sections, as listed in the Table of Contents, shall be considered as being "related work," and shall be considered (by this reference) in the same manner as if they had all been listed under the term "related work" in each specification section.

M. "Verify" means "Contractor shall obtain, by a means independent of the project Architect/Engineer and Owner, the information noted and the information needed to properly perform the work". Where used as "verify existing" in reference to existing piping or duct system, the "verify" definition shall include "Confirm by positive means independent of any actual field labeling on the existing piping systems and independent of the Architect/Engineer and Owner what the existing piping (or duct) system contains, what the flow direction is, what normal pressures/temperatures are and what other systems and areas the piping (or duct) is interconnected to, all to insure that proper connections are made (and other work performed) on the system." Such independent means shall include methods such as: the use of exterior pressurized sources to pressurize piping system lines, use of flow test with dyes, physical tracing of piping and all connections to, electronic detection methods, electronic/electric line tracing, physical disassembling of system, excavation or uncovering of concealed systems, use of insertion cameras and similar efforts.

N. "Coordinate" means "to accomplish the work with all others that are involved in the work by: directly discussing the work with them, arranging and participating in special meetings with them to discuss and plan the work being done by each, obtaining and completing any necessary forms and documentation required, reaching agreement on how parts of the work performed by each trade will be installed relative to each other both in physical location and in time sequence, exchanging all necessary information so as to allow the work to be accomplished with a united effort in accordance with the project requirements".

O. Abbreviations (see Division 1 and the drawings for additional abbreviations):

AAV	Automatic Air Vent
AFF	Above Finished Floor
AHJ	Authority Having Jurisdiction
AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
APPROX	Approximately
APWA	American Public Works Association
ARCH	Architectural
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
AUTO	Automatic
AWWA	American Water Works Association
BHP	Brake Horsepower
BLDG	Building
B.O.D.	Bottom of Duct
BTU	British Thermal Unit
BTUH	British Thermal Unit/Hour
CAP	Capacity
CFM	Cubic Feet per Minute
CISPI	Cast Iron Soil Pipe Institute
CLG	Ceiling
CO	Cleanout
COMP	Compressor
COP	Coefficient of Performance
CONN	Connection
CONT	Continue, Continuation
CT	Closed Transition
CW	Cold Water

dB	Decibel
DB	Dry Bulb
DEG F, F	Degree Fahrenheit
DIAM	Diameter
DIL	Dynamic Insertion Loss
DL	Door Louver
DN	Down
DWG	Drawing
EA	Each
EAT	Entering Air Temperature
EDB	Entering Dry Bulb
EER	Energy Efficiency Ratio
EFF	Efficiency
ELEC	Electrical, Electric
EOL	End of Lining
ESP	External Static Pressure
EWB	Entering Wet Bulb
EXH	Exhaust
EXIST	Existing
F	Fire
FCO	Floor Clean Out
FL	Floor
FLA	Full Load Amps
FLEX	Flexible
fpm	feet per minute
FS or	
Fed. Spec.	Federal Specifications
FV	Face Velocity
GAL	Gallon
GALV	Galvanized
G.C.	General Contractor
GPH	Gallon Per Hour
GPM	Gallon Per Minute
HP	Horsepower
HW	Hot Water
HWC	Hot Water Circulation
IAPMO	International Association of Plumbing and Mechanical Officials
I.E.	Invert Elevation

IEEE	Institute of Electrical and Electronics Engineers
IN	Inch
INTEGR.	Integral
KW	Kilowatt
LAT	Leaving Air Temperature
LDB	Leaving Dry Bulb
LWT	Leaving Water Temperature
LWB	Leaving Web Bulb
MAX	Maximum
MBH	Thousandth BTUH
MCA	Minimum Circuit Amps
MECH	Mechanical
MFR	Manufacturer
MIN	Minimum
M.P.	Medium Pressure
MS or Mil. Spec.	Military Specifications
MSS	Manufacturers Standardization Society
MUA	Make-Up Air
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NO.	Number
NPSH	Net Positive Suction Head
NTS	Not to Scale
OA	Outside Air
OBD	Opposed Blade Damper
OS&Y	Outside Screw and Yoke
PH	Phase
PD	Pressure Drop
PDI	Plumbing and Drainage Institute
per	in accordance with
PSI	Pounds per Square Inch Gauge Pressure
PVC	Polyvinyl Chloride
R	Return
RA	Return Air
REF	Reference

REQ'D	Required
RLA	Rated Load Amps
RPM	Revolutions Per Minute
RM	Room
S	Supply
SA	Supply Air
SCO	Surface Cleanout
SHT	Sheet
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
S.O.	Screened Opening
SP	Static Pressure
S.S.	Stainless Steel
SWP	Steam Working Pressure
TD	Transfer Duct
TEMP	Temperature
TG	Transfer Grille
TSP	Total Static Pressure
TSTAT	Thermostat
TYP	Typical
U.C.	Undercut Door
UL	Underwriter's Laboratories
V	Volts, Voltage, Vent
VTR	Vent Through Roof
W	Waste
W/	With
WA	Watt
WB	Wet Bulb
w.g.	Water Gauge (inches of water)
W.P.	Working Pressure
WQA	Water Quality Association
WCO	Wall Clean Out

1.04 **QUALITY ASSUSRANCE REQUIREMENTS**

A. Code: All work shall be done in accordance with all applicable codes and ordinances. Throughout the Project Documents, items are shown or specified in excess of code requirements, in all such cases, the work shall be done so that code requirements are exceeded as indicated.

B. Code Knowledge: Contractor and workers assigned to this project shall be familiar and knowledgeable of all applicable codes and ordinances. By submitting a bid, the Contractor is acknowledging he and the workers to be utilized on this project have such knowledge.

C. Proof of Code Compliance: On completion of the Work, satisfactory evidence shall be furnished to show that all work has been installed in accordance with all codes and that all inspections required have been successfully passed. Satisfactory evidence includes signed inspections by the local code authority, test lab results, qualified and witnessed field tests, and related acceptance certificates by local code authorities, and field notes by the Contractor as to when all inspections and tests occurred.

D. Permits and Fees:

1. The Contractor shall obtain and pay for all permits, licenses, fees and inspections as required by the governing codes and as specified herein (unless noted otherwise in the Contract Documents).

2. Fees which this Contractor shall pay include all charges made by any utility company or municipality for material, labor or services incident to the connection of service (unless noted otherwise in the Contract Documents).

E. ASME: All pressure vessels, safety devices, and appurtenances shall comply with the standards of, and bear the stamp of ASME.

F. Electrical: All electrical devices and wiring and equipment shall comply with standards of NEC and Division 16 specifications. All electrical devices shall be UL (of other approved agency) listed and so identified.

G. Installation: All items shall be installed in accordance with the manufacturer's installation instructions and recommendations.

H. Quality Assurance Checks: Prior to ordering items or materials, confirm the following for each:

1. General: Item is suitable for the intended purpose and complies with the Contract Documents.

2. Manufacturer: Item's manufacturer is listed as an acceptable manufacturer, in the Contract Document's or a substitution request (where allowed) has been submitted and the manufacturer has been listed as acceptable.

3. Electrical (for items requiring electrical power):

   a. Item is for use with the voltage/phase as indicated on the electrical plans (or for the electrical circuit the item will be connected to).

   b. Item's ampacity requirements (MCA) do not exceed that indicated on the electrical plans (or for the electrical circuit the item will be connected to).

4. Weight: Item's weight is no greater than that indicated on the plans.

5. Adequate Space: Item will fit in the space available and along the path available to install the item.

6. Installation: A suitable method for installing the items has been selected which meets the project schedule and other requirements.

7. Lead Time: The item's fabrication, shipping, and delivery period meets the project schedule requirements.

I. Check-Out: The Contractor shall be responsible to verify that proper installation and proper connections have been provided for all mechanical work. Contractor shall provide installation checkout, start-up services, and perform and thorough check of all systems to prove proper operation. Contractor shall operate all items multiple times under varying conditions to confirm proper operation. Contractor shall submit a checklist listing all equipment, fixtures, and similar items furnished on this project, with a date and initials indicating when the item was checked, a list of what was checked, and by whom. Such check shall, as a minimum utilize documents provided by the equipment manufacturer. Such a check-out is in addition to any commissioning activities specified (unless noted otherwise).

1.05 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.06 **SUBMITTALS**

A. General:

1. Submittals shall comply with the Division 1 Specification Section entitled "Submittals."

2. Quantities: Submit the quantity indicated in the Division 1 submittal requirements; except where not indicated in Division 1 provide six (6) copies plus any copies the Contractor needs for his use (five copies will be retained by the Architect/Engineer team and one copy returned to the Contractor) and for inclusion in the O & M Manual. Provide one (1) additional submittal for Commissioning Authority.

3. Prior Approval-Product Information: All products to be used in this project must first have their product information submitted to the Architect/Engineer for review and approval before they may be ordered. The purpose of the submittal process is to allow the Owner and Engineer an opportunity to make revisions in products. Any item that the Contractor orders or installs prior to making a proper submittal and having it approved, violates the Contract requirements, and is done at the Contractor's own risk.

4. Prior Approval Shop Drawings: Those products or systems requiring approved shop drawings (as indicated in these specifications) must first have their shop drawings submitted to the Architect/Engineer for review and approval before they may be fabricated.

5. Contractor Responsibility: The Contractor is not relieved from the requirements of the Contract Documents by the Architect/Engineer's review or approval of the product or shop drawing submittals.

6. Review: The submittals will be reviewed by the Architect/Engineer with reasonable promptness, and will be stamped and initialed certifying review and marked indicating review. The reason for a rejection will be indicated. Allow twenty-one (21) days for Architect/Engineer review of Division 15 submittals. (unless noted otherwise).

7. Re-submittals: Within ten (10) working days after the date of the letter of transmittal returning the reviewed submittals to the Contractor, the Contractor shall submit new or revised items as indicated in place of those items rejected by the Architect/Engineer. (Re-submittals shall provide the same information and be of the same format as required of the initial submittals). If the Contractor fails to provide re-submittals

within the above specified time, or if any items on this second submittal are rejected as not being in accordance with the Contract Documents, the Architect/Engineer may select the item which the Contractor shall furnish and install without change in contract price or time of completion.

8. Review Costs: Any engineering submittal reviews required after the second submittal (due to Contractor omissions or submittal of unacceptable items) shall be paid for by the Contractor. Applicable rates are:

Engineer	prevailing rate/hour
Designer	prevailing rate/hour
Clerical	prevailing rate/hour

Payment shall reimburse the Consultant for time spent. By submitting a bid, the Contractor agrees to pay for such added reviews and understands that failure to pay will result in corresponding amounts being withdrawn from the Contractor's final payments.

9. Variations: Only variations that are specifically noted on submittals will be considered. Variations shall be noted by being submitted on 8 – ½" x 11" paper, with 1/4 " high lettering clearly describing what the proposed variation is, who is proposing it, why it is being proposed, any cost changes associated with the variation, the date, and related data to clearly identify the project and to which item(s) the variation pertains. Failure to submit information on the variation in this way will result in the review being conducted without considering the variation.

10. By submitting any item for review, the Contractor is claiming that all "Quality Assurance Checks" as specified in paragraph 1.04 of this specification section have been performed and satisfactorily passed.

B. Product Information Submittals:

1. "Product Information" submittals are manufacturers catalog data, technical data sheets manufacturers standard dimension sheets, and similar product data.

2. At least thirty (30) days (unless specified sooner elsewhere), submit multiple copies of the items' product submittals to the Architect/Engineer.

3. To the greatest extent possible all product submittals shall be delivered at the same time, and shall be for placement in three-ring binder as specified herein. The Contractor may make submittals in the following sequence (subject to Architect/Engineer acceptance and to a schedule that allows):

    a. Underground Material submittals (with full size and labeled notebook).

    b. Ground source heat pump site/bore hole shop drawings.

    c. Fire Sprinkler System shop drawings.

    d. Control System shop drawings.

    e. Other Materials (not listed above).

4. With each submittal all items submitted shall be listed in a typewritten index. A finished index shall be provided when all submittals have been made; listing all items, and shall be located at the front of the three-ring binder.

5. Product information sheets shall be neat, readable, clean, 8 – ½" x 11" in size; larger sizes shall be accordion folded to 8 – ½" x 11" size. Sheets shall be numbered corresponding to the product item number listed in the index.

6. With the first submittal the Contractor shall submit three-ring binder(s) of sufficient size to ultimately hold one (1) copy of all submittals. Notebook(s) shall have vinyl see thru covers, with an area to insert a typed sheet. The front cover shall be labeled with the name of the Job, Owner, Architect, Engineer, Contractor, and Date of Submittal. The spine shall be labeled with the name of the Job and Owner.

7. Notebook shall have divider sheets with typewritten identification tabs between categories.

8. The notebook shall be divided into categories corresponding to each section of the specifications or other logical sections corresponding to building trades.

9. Information Required: The following information is required for each item and is defined as making up the product submittal for that item. Failure to submit the required information will result in the rejection of the submittals and submitted item.

   a. Manufacturer's catalog information, containing product description, model number, and illustrations. Mark clearly to identify pertinent information and exact model and configuration being submitted.

   b. List of accessories and options provided with product.

   c. Product dimensions and clearances required.

   d. Product weight.

   e. Product name and symbol as shown on the drawings or written in the specifications.

   f. Performance Data: Provide performance capacity and characteristics showing compliance with the capacity listed in the equipment schedules and specified.

   g. Manufacturer's and nearest sales representatives names, addresses, and phone numbers.

   h. For equipment requiring piping or plumbing connections:

      1) Type of connections required.

      2) Size and locations of connections.

   i. For electrically operated equipment:

      1) Number and locations of electrical service connections required.

      2) Voltage required.

      3) Fuse or circuit breaker protection requirements.

      4) Motor starter requirements; if motor starter is furnished with the equipment, submit product information on motor starter.

j. Manufacturer's installation instructions and recommendations. Installation of the item will not be allowed to proceed until this information is received. Failure to furnish this information is cause for rejection of the material.

10. See each specification section for other submittal requirements.

11. Under separate tab provide manufacturers start-up procedures including checklists for each unique piece of equipment.

C. Shop Drawing Submittals:

1. "Shop Drawings" are defined as illustrative plans, to scale, showing installation details and dimensions for a given system. Shop drawings are custom design drawings, specifically prepared for and applicable to this project.

2. At least thirty (30) days (unless specified sooner elsewhere) after the notice-to-proceed, submit multiple copies of the shop drawings to the Architect/Engineer.

3. All shop drawings relating to the same system shall be submitted at the same time.

4. Drawings shall be opaque diazo prints (blueprints). Minimum drawing size shall be 24" x 36"; minimum scale shall be 1/8" = 1'0".

5. Drawings shall be neat, clean and legible; and shall clearly illustrate the fabrication, layout, operation, and installation (as applicable) of the product or system submitted.

6. Drawings shall have a title block containing the name of the job, name of the Contractor who made the drawing, date of drawing, and drawing title. A legend shall be included.

7. HVAC shop drawings shall show all duct that is 12" or larger with doublines (i.e., draw actual duct size). Drawings shall give bottom of duct height above finish floor, and top of duct height above finish floor.

8. Shop drawings shall be provided for the following systems:

a. HVAC Control System(s).

b. Fire Sprinkler System.

c. HVAC ductwork installed different than as shown on plans.

d. Ground coupled heat pump site piping and bore hole location and details.

e. Equipment support details.

f. Mechanical room layout.

g. For any parts of any system which are to be installed differently than as shown on the drawings.

h. Other areas/work as noted in documents.

9. For those systems requiring shop drawings, reference that system's specification section for any specific requirements of the shop drawings.

1.07 **SCHEDULE OF VALUES**

A. General: Provide schedule of values per Division 1 and related project requirements.

B. Division 15 Breakdown: Provide schedule of values for the following categories (as a minimum); provide a materials and labor breakdown for each category.

1. Mechanical Mobilization.

2. Mechanical General Project Management, General Design, General Coordination, Submittals.

3. Insulation.

4. Plumbing

   a. Underground

   b. Aboveground

5. Plumbing – Fixtures.

6. Hydronic Piping

a. Bore holes and Site Piping.

b. Aboveground, pumps, and accessories.

7. Heat Pumps.

8. Fire Protection

a. Engineering.

b. Fire Protection.

9. HVAC Dry Equipment (fans, DX AC units, etc.)

10. Ductwork and Accessories.

11. Controls

a. Engineering.

b. Controls Balancing.

12. Balancing.

13. Commissioning.

14. Mechanical O&M Manual.

15. Mechanical Record Data.

16. Mechanical Punchlist, Closeout, Owner Training.

C. The dollar value for “Mechanical Punchlist, Closeout, and Owner Training” shall in no case be less than 3% of the total dollar value of the Division 15 work.

D. The Contractor is advised that in addition to payments held out for retainage and project final completion as specified above and in Division 1, the Owner reserves the right to withhold a percentage of the funds for any of the above categories until the systems (of that category) have been proven to operate as specified and have been completely tested, adjusted, commissioned, and balanced.

1.08 **RECORD DATA**

A. Field Record Drawings: The Contractor shall maintain a set of full size contract plans at the project site upon which all changes from the as-bid plans are noted. These plans shall also include actual locations (with dimensions) of all underground and concealed mechanical systems. Connection points to outside utilities shall be located by field measurements and so noted on these record drawings. All addenda, change order, field orders, design clarifications, request for information, and all other clarifications and revisions to the plans shall also be made a part of these record drawings. Plans shall be available for weekly review by the Architect/Engineer. Label drawing "As-Builts" with date, name of Contractor, and name of individual overseeing the work.

B. ACAD Record Drawings: Upon completion of the project, the Contractor shall transfer all the data from the blueprint record drawings to computer drawing files using ACAD release 2005 (or newer) and provide plots of these as-built plans. The Contractor shall obtain from the Architect/Engineer's office the original ACAD drawing files and revise these originals. Prior to incorporating the site record drawing data ACAD, the Contractor shall submit and obtain the Architect/Engineer's approval of the blueprint record drawings. Label plots "AS-BUILT," along with date, name of Contractor and signature of an officer of the Contractor authorized to legally represent the Contractor.

C. Final Record Drawings Submittal: Deliver to the Architect/Engineer one set of the ACAD drawing files on CD, three (3) complete full size set of the plotted record drawings, and the original "Field Record" drawings.

D. Mylar Record Drawings: In addition to all other record drawings delivered, provide a full size set of the final record drawings plotted on Mylar.

E. Photographs: Photograph with minimum 6 mega pixel digital camera (or better) all concealed utilities located below ground, under floors, and in building. Photographs shall be taken prior to any insulation being installed, and with multiple views so as to allow clear understanding and locations of the systems from the photographs. Furnish two 3 x 5 prints on photographic quality paper of each photo. Number and describe each photograph, place in plastic sleeves, and arrange in two (2) sets of three-ring binders. Provide key plans identifying where each photo was taken. Provide divider tabs in binder, and organize photographs in logical groupings; provide table of contents listing all photographs. Provide two (2) labeled CD-ROMS of all photographs, with each photograph file name labeled in a manner to allow easy identification of the photographs.

1.09 **SPECIAL TOOLS**

A. At completion of project this Contractor shall furnish to the Engineer one (1) complete set of any and all special tools such as odd size wrenches, keys, etc. (allen wrenches are considered odd), which are necessary to gain access to, service, or adjust any piece of equipment installed under this contract. Each tool shall be marked or tagged to identify its use.

1.10 **PROJECT CLOSEOUT**

A. Closeout Submittals: The following items must be presented to the Architect/Engineer prior to final acceptance of the building. Final payment of the Contract will be contingent upon receiving these documents. See Division 1 requirements also.

1. Balancing Report.

2. As-Built Data.

3. Domestic Water Tests and Chlorination Certificate.

4. Operation & Maintenance Manuals.

5. Guarantees (including one-year).

6. Special Tools.

7. Spare Parts (see individual specification sections).

8. Proof of compliance with governing codes (copy of signed off permits or letter).

9. State of Washington certification of all pressure vessels.

10. Spare sprinkler heads & wrench (see 15500).

11. Extra sets of filters (see 15880).

12. Water Treatment Specialist Report (see 15745).

13. Equipment Start-up Reports (see equipment specification sections).

14. Control system report/statement (see 15900).

15. Air Quality Assurance Report (see 15960).

B. Completion Review and Punchlist: The Architect/Engineer responsible for review of the Division 15 work will provide one (1) substantial completion review to determine whether the work (or designated portion thereof) is substantially complete, and develop a list (punchlist) of those items that are not done. After completing these punchlist items, the Contractor shall submit to the Architect/Engineer a copy of the punchlist, with each item initialed by the General Contractor and by the Foreman (or Superintendent) of the trade responsible for the work. Every time shall be addressed as corrected, or as being otherwise resolved with the Architect/Engineer. After receipt and agreement with this initialed list, the Architect/Engineer will make one final completion review to determine if the work (or designated portion thereof) is fully complete.

C. Failure To Complete Punchlist: If, after making the final completion review as noted above, the Architect/Engineer determines that the work is not fully complete as the Contractor has indicated, an additional punchlist noting deficient items will be made. The Contractor shall reimburse the Architect/Engineer for all subsequent re-reviews of the work. Applicable rates are:

Engineer:	Prevailing rate/hour
Designer:	Prevailing rate/hour
Clerical:	Prevailing rate/hour

Payment shall reimburse the Architect/Engineer for time spent. By submitting a bid, the Contractor agrees to pay for such added reviews and agrees and under stands that failure to pay will result in corresponding amounts being withdrawn from the Contractor's final payments.

1.11 PRODUCT HANDLING AND PROTECTION

A. Protection:

1. Protect all material, equipment and apparatus provided under this section from damage, water, corrosion, freezing and dust, both in storage and when installed, until final project acceptance.

2. Protect premises and work of other divisions from damage arising out of installation of work of this division.

3. Completely cover motors, control panels, equipment, machinery and similar items to protect from dirt and water during construction.

B. Provide temporary heated and sheltered storage facilities for material and equipment.

C. Condensation: Provide adequate venting arrangements for all protected items to avoid condensation damage.

D. Openings: Cap all openings in pipe and ductwork to protect against entry of foreign matter until all work that has dust or fumes associated with it is complete. Caps shall be of sufficient strength and seal integrity to prevent entry of general fumes.

E. Equipment Storage Maintenance: Equipment requiring rotation, lubrication, or other maintenance or inspection during storage shall have records maintained and witnessed on a monthly basis and forwarded to the Architect/Engineer prior to acceptance.

F. Improper Storage/Protection: Material, equipment, or apparatus damaged because of improper storage or protection will be rejected.

G. Paint Finishes: Painting finishes that are damaged by handling, storage, etc. shall be corrected by the Contractor, at no additional cost to the Owner. Painting shall comply with Section 09900 and manufacturer's requirements.

1.12 **JOB CONDITIONS**

A. Special Requirements:

1. Maintain emergency and service entrance usable to pedestrian and vehicle traffic at all times. Where trenches are cut, provide adequate bridging for traffic.

2. Coordinate startup and shutdown of water, waste, heating systems, and other utilities with all other trades and the Owner's representative.

1.13 **PRE-INSTALLATION CONFERENCES**

A. General: Pre-installation conference shall be held prior to the Contractor installing any of the materials of selected sections. See each specification section for requirements. The conference shall occur after all submittals have been satisfactorily reviewed by the Architect/Engineer and returned to the Contractor, and approximately fourteen (14) days prior to the proposed system installation date. The purpose of these conferences is to review the Contractors installation methods, materials, schedule, coordination with all other trades, and related construction/design issues to allow for efficient and proper construction.

The Architect/Engineer and Owner will highlight various items of concern, typically problems encountered on similar projects, coordination issues, and related items.

B. Attendance: The pre-installation conferences shall be attended by the General Contractor, the Contractor doing the work of the Section involved, other Contractor trades (as appropriate to the proper coordination of the work being discussed), the Owner's Representatives (at their option), the Engineer (at his option), and the Architect (at his option).

C. Coordination: The Contractor shall notify the Architect of the Contractor's readiness to hold a pre-installation conference at least fourteen (14) days prior to the proposed meeting time, and mutually agreed upon meeting times arranged.

1.14 **COMMISSIONING**

A. The Products and systems specified in the Division 15 are to be commissioned per Section 01810-Commissioning. The Contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. At a minimum, the Contractor shall provide a documented and signed record to verify that all equipment and systems installed under this contract have been inspected and functionally tested to verify full compliance with the contract specifications. In many cases, this shall require the Contractor to create or otherwise provide procedures and checklists for approval by the Commissioning Consultant prior to the start of functional testing. Reference Section 01810 and coordinate all commissioning activities with the Commissioning Consultant.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Any reference in the Specifications or on the Drawings to any article, device, product, material, fixture, form or type of construction by manufacturer, name, make, model number, or catalog number shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition.

B. The manufacturers listed a Acceptable Manufacturers are approved to bid the project for the items indicated without obtaining prior approval.

C. Other manufacturers desiring to bid the project require prior approval. See Paragraph entitled "Substitutions" this specification section for requirements.

D. The listing of a manufacturer as an Acceptable Manufacturer does not necessarily mean that the products of that manufacturer are equal to those specified. The listing is only an indication of those manufacturers which may be capable of manufacturing, or have in the past manufactured, items equal to those specified. The Architect/Engineer shall be the final judge as to whether an item is equal to that specified.

E. Products provided by Acceptable Manufacturers shall be equal to or superior to the specified manufacturer's item in function, appearance, and quality, and has fulfilled all requirements of the plans and specifications. The Architect/Engineer shall be the final judge as to whether an item meets these requirements or not. If manufacturer is not certain that his product meets these requirements or not then the manufacturer shall submit data as required in Paragraph entitled "Substitutions" this specification section, to obtain the Architect/Engineer's approval prior to bid opening.

F. The approval of a manufacturer applies to the Manufacturer only and does not relieve the Contractor from the responsibility of meeting all applicable requirements of the plans and specifications.

G. Contractor shall be responsible for all costs to other trades and all revisions required to accommodate any products which are different than those specified or shown.

H. In reviewing a manufacturer for acceptance, factors considered include the following engineering data showing item's performance, proper local representation of manufacturer, likelihood of future manufacturer's local support of product, service availability, previous installation, previous use by Owner/Engineer/Architect and record, product quality, availability/quality of maintenance and operation data, capacity/performance compared to specified items, acoustics, items geometry/access utility needs, and similar concerns.

2.02 **PRODUCTS – GENERAL**

A. Standard Products: Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for two (2) years prior to bid opening. The two (2) year use shall include applications of equipment and materials under similar circumstances and of similar size. The two (20 year's experience must be satisfactorily completed by a product which has been sold or is offered for sale on the e commercial market through advertisements, manufactures'' catalogs, or brochures. Except that equipment changes made

solely to satisfy code requirements or to improve unit efficiency are not required to have two (2) year prior operation.

B. Service Support: Qualified permanent service organizations for support of the equipment shall be located reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

C. Manufacturer's Nameplate: For each item of equipment, provide a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place. The nameplate of the distributing agent will not be acceptable. Nameplates for fuel-burning appliances, electric heating appliances, heat pump appliances, and other items listed in IMC shall provide added information as required by the IMC.

D. Compatibility: All components and materials used shall be compatible to the conditions and materials the items will be exposed to. All items exposed to the weather shall be galvanized, or be of stainless steel or similar corrosion resistant material.

E. Lead Free: All solder, valve components, drinking fountain components, and other items in contact with potable water shall be lead free.

F. Nameplates/Labels/Legends: Where nameplates or labels are required, these shall have minimum of 1/8 inch high (unless indicated otherwise) lettering engraved on laminated plastic. Laminated plastic shall have black surface layer and white (unless other color indicated) sub-layer, with engraving through to expose white sub-layer. Prior to making a list and applying labels, the Contractor shall submit a list of all proposed labels.

G. Non-Specified Items: Materials shown on the drawings but not specified shall be provided as shown and as required to suit the application illustrated and intended and shall be of commercial quality, consistent with the quality of similar type items provided on the project. Not all items shown on the drawings necessarily have a corresponding specification; such items shall be provided per this paragraph and so as to provide complete, finished, fully functioning mechanical systems.

H. Warranty: Equipment shall be warranted by the manufacturer to be free from all manufacturing defects and capable of providing satisfactory operation for a period of one (1) year (or longer, where indicated so) after the date of the project acceptance. The Contractor shall include in his bid all costs associated with this warranty to insure that the warranty extends to one (1) year after the date of project acceptance. Possible project delays and failure by others to

complete their work may cause the date of project acceptance to be substantially delayed. The Contractor shall be responsible for increasing the warranty dates by corresponding amounts to still provide one (1) year warranties.

I. Weights: Unit weights shall not exceed the weights shown unless the Contractor provides added structural supports as required by the Engineer. The Contractor shall bear all costs for all redesign and added supports to accommodate heavier equipment. The Contractor shall reimburse the Engineer for all time associated with all review and analyses regarding the use of equipment heavier than that indicated.

J. Asbestos Free: All products used shall be asbestos free.

K. Temperature/Pressure Rating: All materials and components furnished shall be suitable for the temperature and pressures they will be exposed to. Contractor shall consider possible operating modes to insure proper material ratings. Consideration shall include such factors as high temperatures caused by heat transfer from piping, coils, etc when fans are shut down (e.g., motors, control devices, etc. installed within air handling units or mechanical rooms shall be rated for high temperatures due to such heat gain).

L. Standardization: All like products shall be by the same manufacturer and have the same characteristics and features to allow for Owner's standardization.

M. Model Numbers: Any reference to a manufacturers "model number" is a reference to a manufacturers series number or type of product, and if not a complete "model number", and does not indicate all features, accessories, and options that are required. These series numbers are only meant to convey a type of product that may meet the project requirements. Where conflicts of discrepancies occur regarding current manufacturer's series numbers versus series numbers specified in these documents, the features/accessories/options as shown in current catalogs in the Engineers office corresponding to the specified series number shall prevail. Such catalogs are available for review. Where conflicts or discrepancies occur regarding a listed manufacturer's series or "model" and a specified capacity or feature, the more stringent and expensive shall prevail.

N. Fault Current Rating: All equipment requiring the use of electrical power shall have a fault current rating of 25,000 AIC; except where a lower fault current value is indicated on the drawings, or Code allows uses of lower number. Where the Contractor wishes to utilize equipment having fault current limitations lower than 25,000 AIC (or as shown on plans, whichever is less), the contractor shall be responsible to provide suitable fusing, additional devices, and/or other changes

to the building electrical system as necessary to accommodate the proposed equipment.

O. Special Products: Numerous products specified for this project are custom products, or require special and unique construction, and special and unique features. Such special items may include: Finishes, controls, UL (or other independent testing lab) listing specialized for the custom one of a kind equipment specified, construction, configuration, capacities, accessories, spare parts, warranty, testing, flow rates, application, installation, delivery date, cleaning, etc. Include in bid all costs to provide items meeting all project requirements. Products may reference a manufacture's series number, but are still special and custom, with the series number identifying only a reference point for the unit manufacturer. The series number is not to be construed as limiting the features or capabilities of the item. Contractor shall review all requirements and all vendor quotes to ensure all requirements are being met and to include all costs in bid. No added cost will be paid for failure to include in bid all costs necessary to provide the special, unique, and custom items required.

2.03 **SUBSTITUTUIONS**

A. All substitutions shall have the approval of the Owner/Engineer prior to being used. Provide information required by the applicable Division 1 Specification Sections. Where not specified in Division 1, the following information on the proposed substitution shall be submitted no less than ten (10) calendar days before bid opening.

1. Differences between proposed substitution and specified item.

2. Estimated cost of changes in building design required to accommodate the proposed substitution.

3. Effect that the proposed substitution has on other trades.

4. Complete technical data on the proposed substitutions.

5. Previous projects proposed item have been used on.

B. If a substitution is approved it will be confirmed as an approved substitution by addendum to the bid package.

C. Where not disallowed in Division 1, the Contractor may choose to propose substitutions after contract award for which approval is not obtained prior to bid opening. Such proposals shall be done at his own risk and such substitutions

shall be submitted as specified in paragraph entitled “Submittals”, within thirty (30) days after award of contract including information required above.

D. Proposed substitutions shall be equal to or superior to the specified item in function, appearance, and quality, and shall fulfill all requirements of the plans and specifications. The Architect/Engineer shall be the final judge as whether an item meets these requirements or not.

E. The approval of a substitution applies to the manufacturer only, and does not relieve the Contractor from the responsibility of meeting all applicable requirements of the plans and specifications.

F. The Contractor shall be responsible for all costs to the other trades and all revisions required to accommodate any substitutions.

2.04 **ELECTRICAL**

A. All electrical work, conduit, boxes and devices in connection with control wiring as required to install the control equipment as specified herein or shown on the drawings shall be furnished and installed complete by the Division 15 Contractor.

B. All electrical work performed under this Section of the Specifications shall conform to all applicable portions of the Division 16 Specifications and shall conform to all governing codes.

C. Al starting switches and disconnect switches provided by this Contractor shall be labeled to identify the equipment served and usage. Such labeling shall match that specified in Division 16.

D. All equipment shall be factory wired to a junction box for connection of electrical service.

2.05 **MOTORS AND CONTROLS**

A. Where a piece of equipment specified includes an electric motor, the motor shall be furnished and mounted by this Contractor. Motor starter, disconnect switches and wiring from the electrical panel to the motor control devices and to the motor shall be provided by the Division 15 Contractor unless specifically shown to be provided by Division 16. Division 15 furnished electrical devices shall comply with the applicable Division 16 Specifications.

B. Motors:

1. Acceptable Manufacturers: General Electric, Westinghouse, Reliance, Allis-Chalmers, Gould, Century, Wagner, Baldor, U.S. Motors, Marathon.

2. Motors located indoors shall be open frame, drip-proof type, unless indicated otherwise. Motors located outdoors exposed to weather shall have corrosion resistant finish and shall be totally enclosed fan cooled (TEFC) or totally enclosed non-ventilated (TENV) type, unless indicated otherwise.

3. All motors shall be UL listed.

4. All motors 1 HP and larger shall be energy efficient type. Efficiency shall comply with the Washington State Energy Code (WSEC).

5. Motors shall not be smaller than indicated on drawings; however, motors shall be of adequate size to drive the respective equipment when handling the quantities specified without exceeding the nameplate full load current at any conditions encountered in actual operation. If it becomes evident that a motor furnished is too small to meet these requirements as a result of the Contractor using substituted equipment or having revised the system arrangement, the Contractor shall replace it with a motor of adequate size at no additional cost to the Owner. This Contractor shall also arrange with the Electrical Contractor to increase the size of the wiring, motor starter and other accessories as required to serve the larger motor at no additional cost to the Owner.

6. Motors used with Variable Frequency Drivers (VFD's) shall be rated for such use.

2.06 **PRODUCT LISTINGS**

A. General: Any piece of equipment used in this project and hereinafter specified which requires electrical hook-up, such as fans, pumps, hot water tanks, boosters, air handling equipment, etc. shall be provided with an approved label from an agency acceptable to the authority having jurisdiction does not require it.

B. Complete Assembly: Approval of agency shall be for the complete assembly (approval of individual components not acceptable) and all labels must be located outside of equipment and shall be visible to inspector.

C. Responsibility: It shall be the responsibility of the mechanical contractor or the equipment supplier to meet the requirements of this Section. All agency costs to provide appropriate label for a piece of equipment shall be included in the bid.

2.07 EQUIPMENT AND PIPING IDENTIFICATION

A. General: All piping, valves, and mechanical equipment shall be marked. All markings in concealed accessible spaces shall be reviewed and verified by Architect/Engineer prior to being concealed.

B. Piping: Piping shall be marked as follows:

1. Type: Self-sticking colored markers, lettered to identify the pipe contents, and banded at each end with arrow tape indicating the direction of flow. Markers shall similar and equal to Brady "System 1" and Set on "Opti-Code" markers. Spray painted stencil labeling is not acceptable. Some markers may be special order.

2. Marker Colors and Wording:

Piping System & Wording	Background	Letters
Domestic Cold Water	Green	White
Domestic Hot Water	Yellow	Black
Domestic Circ	Yellow	Black
Sprinkler-Fire	Red	White
Refrigeration Gas	Green	White
Refrigeration Liquid	Green	White
Non-Potable Water	Yellow	Black
Hydronic Heat Pump Water	Yellow	Black

3. Marker Lettering: Lettering shall identify the material conveyed in each pipe. Systems which have supply and return piping shall have piping labeled as such (i.e. chilled water return, chilled water supply etc.). Size of letters and color field shall comply with ANSI A13.1; repeated here for convenience:

Outside Diameter of Pipe or Covering	Length of Color Field	Size of Letters
¾ to 1-1/4 inches	8 inches	½ inches
1-1/2 to 2 inches	8 inches	¾ inches
2-1/2 to 6 inches	12 inches	1-1/4 inches
8 to 10 inches	24 inches	2-1/2 inches
Over 10 inches	32 inches	3-1/2 inches

4. Locations: Markers shall be installed on all exposed piping adjacent to each shut-off valve, at branches to indicate changes of direction, where pipes pass through walls and floors, on 20 foot centers or at least one in each room on each pipe. Markers shall be installed on all concealed accessible piping (i.e., piping above suspended ceilings, behind access doors, in accessible chases, etc.) near the point of access. For piping above suspended ceilings, markers shall be installed the same as if the piping was exposed (i.e., same as if the suspended ceiling was not in place). Markers shall be installed so as to easily read by a person standing on the floor. Provide additional direction of flow arrows at each pipe connections at all control valves.

C. Valves shall be marked as follows:

1. Identification tags made of aluminum, engraved with valve size, name of system served (cold water, hot water, etc.) and purpose of valve. Tags shall be installed on all valves except stops at plumbing fixtures. Tags shall not be less then 3" x 1" in size, lettering shall be minimum ¼ inch high. Tags on domestic hot water systems shall be red with white lettering; on hydronic systems white with black lettering; on fuel piping yellow with black lettering; and green with white lettering for other systems. Tags shall be wired to each valve with No. 6 polished nickel-steel jack chain.

2. Valve charts shall be provided for each mechanical room providing valve data for emergency, main building, and main area shut-off valves. Valve charts shall be neatly typed on 8-1/2" x 11" paper and framed under plastic with an aluminum or wood frame and posted in the appropriate room at a visible location acceptable to the Architect/Engineer. Sample chart organization:

"PROJECT NAME"
MAIN VALVE CHART

Valve Size	Service	Location	Purpose
3 inch	CW Main	Mechanical Rm 101 NW Corner	Main Water Shut-Off
2 inch	CW North Wing	Above Ceiling NE Corner, Rm 151	North Wing CW Shut-Off

D. All mechanical equipment which was scheduled on the Contract Drawings shall be marked with the name of the item; i.e., Heating Ventilation Unit No. 1, Exhaust Fan No. 2, Boiler No. 1, etc., and an additional label that indicates the area served by the equipment. The identification shall be the same as shown on

the Contract Drawings, and shall include the room names and numbers that the equipment serves. The marking shall be located on a side of the equipment so as to be easily read, with the marking visible to a person standing at floor level near the unit (assuming any necessary access to a concealed unit has been made). Lettering shall be a minimum 2" high (except that lettering indicating the room or area served shall be ½" high), with color contrasting sharply with the color of unit. Marking shall be with phenolic engraved labels, white lettering on a black background, drilled for fastening with two (2) screws. Equipment marking is not required for; air outlets and inlets, plumbing fixtures. Obtain room names and numbers from Owner. Submit list of labels prior to fabricating.

E. Concealed Items: Concealed above accessible ceiling shall have the ceiling marked to indicate such items' location and what the item is. Utilize black lettering on clear self-sticking tape, with 3/16" high lettering shall be applied to visible ceiling T-bar (or ceiling tile itself for concealed T-bar type ceilings) below the concealed item. Actual description to be used shall be verified with Owner. Submit sample of proposed label.

PART 3 – EXECUTION

3.01 **GENERAL**

A. Workmanship: This Contractor shall furnish and install all equipment included in the Contract to provide complete and functioning systems with a neat and finished appearance. If, in the judgment of the Architect/Engineer, any portion of the work has not been installed in accordance with the specifications and in a neat workmanlike manner, or has been left in a rough, unfinished manner, the Contractor shall be required to revise the work so that it complies with the specifications and is acceptable to the Architect/Engineer, at no increase in cost to the Owner.

B. Openings and Cutting and Patching in New Construction:

1. Openings – General: The General Contractor shall provide all required spaces and provisions in structures of new construction for the installation of work of all other contractors or subcontractors.

2. Coordination: The Division 15 Contractor shall furnish to the General Contractor (in a timely manner) all needed dimensions and a location of openings to allow for these openings to be provided as the construction adjacent to the opening is being done.

3. Cutting and Patching: Cutting and patching of structures in place made necessary to admit work, repair defective work, or by neglect of contractors and subcontractors to properly anticipate their requirements, shall be done by the General Contractor at the expense of the contractors or subcontractors responsible. Such cutting and patching shall comply with Subparagraphs 2, 3 and 4 of Paragraph C, "Openings and Cutting and Patching in Existing Construction."

4. Patching Materials: Patching shall be with materials of like kind and quality of the adjoining surface by skilled labor experienced in that particular trade.

C. Site Work: All trenching, backfilling, compacting, and similar groundwork for utilities shall comply with Division 2 and with Section 15050 and best professional practices.

3.02 **INSTALLATION**

A. Replacement and Maintenance: Install mechanical equipment to permit easy access for normal maintenance, and so that parts requiring periodic replacement or maintenance (e.g., coils, sheaves, filters, meters, bearings, etc.) can be removed. Relocate items which interfere with access.

B. Access Doors: Provide access doors in building, equipment, and ducts as required to allow for inspection, service, and proper maintenance.

C. Manually Operated Components: Valves, damper operators, and other devices which are manually adjusted or operated shall be located so as to be easily accessible by a person standing on the floor. Any such items which are not in the open shall be made accessible through access doors in the building construction.

D. Monitoring Components: Gauges, thermometers, instrumentation and other components which are installed to monitor equipment performance, operating conditions, etc., shall be oriented so as to be easily read by a person standing on the floor. Provide necessary brackets and hangers as needed.

E. Difficult Installation: If circumstances at a particular location make the accessible installation of an item difficult or inconvenient, the situation shall be discussed with the Architect/Engineer before installing the item in a poor access location.

F. Rotating Parts: Belts, pulleys, couplings, projecting setscrews, keys and other rotating parts which may pose a danger to personnel shall be fully enclosed or

guarded in accordance with applicable codes, and so as not to present safety hazard.

G. Equipment Pads: All ground and slab mounted mechanical equipment shall be installed on a minimum 4 inch thick concrete pad, unless indicated otherwise. Where the largest dimension for any pad exceeds 6 feet provide a 6 x 6 – 10 Ga. X 10 Ga. Welded wire fabric reinforcement in the pad (unless noted otherwise).

H. Dissimilar Metals: Provide separations between all dissimilar metals. Where not specified in any other way, use 10 mil plastic tape wrapped at point of contact or plastic centering inserts.

I. Electrical Offsets: Provide offsets around all electrical panels (and similar electrical equipment) to maintain space clear above and below electrical panels to structure and clearance of 3 feet directly in front of panel, except where indicated otherwise or required by NEC to be more.

J. Piping Through Framing: Piping through framing shall be installed in the approximate center of the member. Where located such that nails or screws are likely to damage the pipe, a steel plate at least 1/16 inch thick shall be installed to provide protection. At metal framing, wrap piping to prevent contact of dissimilar metals. At metal and wood framing, provide plastic pipe insulators at piping penetrations through framing nearest each fixture and on at least 32 inch centers.

K. Safety Protection: All ductwork, piping and related items installed by this Contractor that present a safety hazard (i.e., items installed at/near head height, items projecting into maintenance access paths, etc.) shall be covered (at hazardous area) with ¾" thick elastomeric insulation and reflective red/white self-sticking safety tape. All sharp corners on supports and other installed items shall be ground smooth.

L. Manufacturers' Instructions: Installation shall comply with manufacturers installation instructions. Submit such instruction for Engineers review prior to beginning installation.

3.03 **PAINTING**

A. All painting shall comply with Division 9 Specifications regarding painting. Colors, in all cases, shall be as selected by the Architect/Engineer. Color samples shall be submitted to the Architect/Engineer for approval prior to painting.

B. The following painting shall be provided under this Division 15:

1. All exposed metallic surfaces (includes piping, ducts, hangers, conduits, etc.) provided by this Contractor (except with factory finish or items mentioned in paragraph B below) shall receive one (1) coat of rust inhibiting primer and two (2) coats of selected finish paint.

2. All exposed insulated surfaces provided by this Contractor (except insulation on items mentioned in Paragraph B below) shall receive one (1) coat of primer and two (2) coats of selected finish paint.

3. The exposed under side of all plumbing fixtures (trough sinks, service sinks, etc.) shall be primed and finish coated white.

4. The inside of all ductwork (including visible dampers, roof vents, insulation pins, and any visible metal) behind grilles, registers, diffusers, and louvers shall be painted flat black.

C. Items to be painted under Division 9:

1. Exposed ductwork in finished areas.

2. Exterior mechanical equipment.

3. Exposed piping in finished areas.

3.04 **WATERPROOFING**

A. General: Where any work pierces construction intended to be watertight or weatherproof, including waterproof concrete, the method of installation shall be as approved by the Architect/Engineer before work is done. Contractor shall furnish all necessary caulking and flashing required to make such penetrations absolutely watertight. Where not detailed or indicated how to install, the Contractor shall submit shop drawings of his proposed methods.

B. Equipment: All equipment or material located outdoors shall be watertight and shall be designed and intended by the manufacturer to be used outdoors in the conditions of the climate of the installation.

3.05 **FINAL INSPECTION AND INSTRUCTION**

A. Instruction:

1. The O&M Manuals shall be submitted and approved by the Engineer and Owner prior to conducting the instruction periods.

2. Instruction shall include a minimum of 32 hours classroom time, discussion on the system's operation and presentation of information from maintenance manuals with appropriate references to drawings, followed by tours of equipment spaces explaining maintenance requirements, access methods, servicing, and maintenance schedules, procedures, temperature settings and available system and equipment adjustments.

3. Field instructions and demonstrations of maintenance procedures for all items covered in the O&M manual (reference Section 15015) shall be provided. Such field instruction and demonstration shall be for a minimum of 16 hours.

4. The Contractor's Representatives who conduct these instructions and demonstrations shall be qualified foremen or superintendents acquainted with this project and the trades involved. Manufacturer's authorized service representative or direct employee shall provide instruction for all major equipment and systems and where specified.

5. Notice of the contractor's readiness to conduct the instruction and demonstrations shall be given to Owner and Architect/Engineer at least two (2) weeks prior to proposed instruction periods and mutually agreed upon times arranged.

B. Final Inspection and Field Instruction:

1. Prior to acceptance of the Mechanical work, the Contractor shall put all Mechanical systems into operation for a period of not less than five (5) working days so that they may be inspected by the Architect/Engineer and the Owner's representatives.

2. The time of the final inspection shall be mutually agreed to by the Owner, Engineer and Contractor.

3. The Contractor shall furnish adequate staff to operate the mechanical systems during inspection.

4. During the final inspection period, the Contractor shall demonstrate to the Owner's representatives the operation of all equipment, showing that it operates and is controlled properly. Such demonstration period shall include a sixteen (16) hour field instruction period. Contractor shall have representatives present of the equipment manufacturers, to explain maintenance procedures.

END OF SECTION

SECTION 15015

MECHANICAL OPERATION AND MAINTENANCE MANUALS

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Preliminary O&M Manual

B. Final O&M Manual

1.02 **RELATED WORK**

A. Division 1 – General Requirements

B. Division 15 – Mechanical

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

PART 2 – PRODUCTS

2.01 **GENERAL**

A. General Contents: A maintenance manual shall be complied containing maintenance and operating information and maintenance schedules for all mechanical equipment installed in this project.

B. Preliminary Copy: Two (2) preliminaries review copy of the maintenance manual shall be submitted to the Architect/Engineer prior to completion of the Work. The Architect/Engineer and Commissioning Authority will review this preliminary copy and will inform the Contractor of any additional items or revisions required before final copies are delivered. Before submitting this preliminary review copy, the Contractor shall submit to the Architect/Engineer for approval an outline and description of the proposed manual organization.

C. Final Copies: Shall be delivered to the Architect/Engineer after all revisions and additions have been made.

D. Final Copy Quantities: Shall be as specified in Division 1. Where not specified in Division 1, provide five (5) copies.

2.02 MANUAL ORGANIZATION

A. Identification: Covers shall be labeled "OPERATION AND MAINTENANCE MANUAL," with name of the Project, Owner, Engineer, General and Mechanical Contractors and year of completion. Coordinate labeling with Division 1 requirements to label Division 15 information in same style, and as appropriate volume numbers of the entire O&M set.

B. Format: 8-1/2" x 11" size pages; neat, clean copies; larger pages and drawings accordion folded. All writing in the manuals shall be typewritten and divider sheets with typed identification tabs between sections.

C. Notebooks: Copies shall be punched and placed in a three-ring notebook, with clear plastic pocketed covers and spine. Notebook shall have inside pockets at front and rear. Where multiple notebooks are required, notebooks shall be of same size and type. Provide sufficiently sized notebooks to allow easy removal of material and future addition of Owner's notebook style as provided for other specification Divisions.

D. Organization: Manual shall be organized into the following sections:

1. Table of Contents
2. Directory
3. System Description
4. Maintenance Schedules
5. Submittal Data and Technical O&M Data (Provide sections corresponding to each Division 15 Specification Section or other logical organization).
6. Balancing Report
7. Reduced Size Record Drawings

2.03 MANUAL CONTENTS – GENERAL

A. Table of Contents: Provide detailed list of contents of entire manual.

B. Directory:

1. Provide directory listing names, addresses, and telephone numbers of Architect, Engineer, Contractor, all Subcontractors and all Equipment/Material Suppliers and their local representative or service agent.

2. Provide names, addresses and phone number for at least one (1) service agency for each equipment requiring maintenance.

2.04 MANUAL CONTENTS – SYSTEM DESCRIPTIONS

A. General: Provide brief description of each building mechanical system, type of equipment used, areas it serves, how system is sub-divided into zones, describe system major characteristics, describe how system is intended to operate and suggested system setpoints. This description is to give a general overview of the building's mechanical systems.

B. Such descriptions shall include, but not be limited to the following:

1. Plumbing Drainage Systems: Describe where main waste lines leave building, type of roof drainage and main lines.

2. Domestic Hot and Cold Water Systems: Describe how system is divided, how is hot water generated/locations, water main locations, pressure reducing valves, back-flow preventers types and locations, irrigation, etc.

3. Fire Protection System: Describe system types, riser locations, extent of coverage, etc.

4. Heating/Cooling System: Describe equipment types, general arrangement, etc.

5. Air Handling System: Describe unit types, locations, areas served.

6. Exhaust System: Describe general type of exhaust systems, locations, areas served.

7. Control System: Description of system type, layout, components, and sequence of operation.

2.05 **MANUAL CONTENTS – MAINTENANCE SCHEDULES**

A. General: Maintenance Schedules shall include an itemized list of maintenance activities and their scheduled frequency (i.e., weekly, monthly, semi-annually, etc.) for each type of equipment. This is to be a contractor-prepared listing derived from the manufacturer's O&M data and practical considerations.

B. Special Maintenance: List any critical maintenance items or areas requiring special attention.

C. Start-Up/Shut-Down: Provide normal start-up, operating, and shut-down procedures; emergency shut-down procedures; and (where applicable) seasonal shut-down procedures.

2.06 **MANUAL CONTENTS – SUBMITTAL DATA AND TECHNICAL O&M DATA**

A. General: This portion consists of the bulk of the O&M Manual and consists of multiple sections providing submittal data and technical O&M data for all equipment and materials.

B. Organization: Shall be broken into sections following the project specification sections of (where approved by Architect/Engineer) into building systems or similar logical groupings. Each of these sections shall be further broken down into subsections which cover each piece of equipment making up the specification section (or system).

C. Submittal Data: Provide manufacture's technical product data, labeled as to item number (same as used on contract drawings), manufacturer's model number, with description of the equipment noting equipment capacities, options, special features and accessories. (This information usually consists of the same information as the submittal data, (clearly identified and marked to suit each item). This information shall be provided for all items requiring maintenance and for items that may require replacement over a thirty (30) year period or be revised due to an owner building improvement (includes valves, plumbing fixtures, air outlets/inlets, etc.).

D. Technical O&M Data: Provide for each equipment or item requiring maintenance. Information to include:

1. Manufacturer's operating and maintenance manuals and instructions. Including:

    a. Itemized list of maintenance activities and their scheduled frequency.

b. maintenance instruction for each maintenance activity.

c. Manufacturers' parts list.

d. Manufacturers recommended lubricants.

2. Local representative and service companies names, addresses, and phone numbers.

3. Filters: Size, quantity and type unit requires (where applicable).

4. Belts: Size, quantity and type each unit requires (where applicable).

E. Controls: Provide control system maintenance and calibration information, wiring diagrams, schematics, control sequence descriptions, programming logic (for DDC type systems), and desired or field determined system setpoints.

F. Balancing Report: Include a full copy of the balancing report under a dividing tab for the specification section (or building system) where this work is specified. Where balancing is provided by others, obtain from the balancer a copy of the report to install in the O&M's.

2.07 **MANUAL CONTENTS – REDUCED RECORD DRAWINGS**

A. Reduced As-Built Drawings: Provide reduced as-built construction drawings and control drawings. Drawings' size shall be 11" x 17", except, where such size precludes the reading of portions of the drawing; a larger size may be used.

PART 3 – EXECUTION

NOT USED

END OF SECTION

SECTION 15050

EXCAVATION AND FILL FOR MECHANICAL UNDERGROUND UTILITIES

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Excavation

B. Trenching

C. Shoring and Trench Protection

D. Bedding

E. Backfilling

F. Compaction

G. Verification of Existing Utilities

H. Protection of Utilities

I. Dewatering

J. Identification Warning Tape

1.02 **RELATED WORK**

A. Section 15410 – Domestic Water Piping System

B. Section 15420 – Soil, Waste and Vent Piping System

C. Section 15500 – Fire Protection Sprinkler System

D. Section 15755 – Hydronic Heat Pump Ground Coupled Piping System

1.03 **DEFINITIONS**

A. "Utility Bedding" is defined to mean "material placed beneath the utility for utility support, and material placed adjacent to the pipe up to the centerline of the utility."

B. "Utility Zone Backfill" is defined to mean "backfill material that is place in the area from the centerline of the utility up to the specified height above the top of the utility, and is located above the pipe bedding and below the final backfill material."

C. "Haunching" is defined to mean "that portion of the pipe bedding extending from the bottom of the pipe up to the centerline of the pipe, and packed under the pipe haunches."

D. "Trench Backfill" is defined to mean "backfill material that is place above the utility zone backfill, and up to rough or finished grade.

E. "Underground Mechanical Structures" are defined to mean "vaults, tanks, interceptors, separators, manholes, and similar structures buried partially or completely underground."

F. "Unstable Material" is defined to mean "material that depresses more than ¼ inch under a load of 2000 pound/square foot, is not firm and stable, or in any way appears incapable of supporting the loads to be imposed."

1.04 **QUALITY ASSURANCE**

A. Inspection of Job Conditions:

1. Prior to starting work and during work, the installer shall examine the work by others, site and job conditions under which excavation, trenching, and backfilling for underground mechanical utilities work will be performed, and not proceed with work until unsatisfactory conditions have been corrected.

B. Codes and Standards:

1. Comply with all applicable codes and standards.

C. Experience:

1. Only contractors fully experienced and entirely knowledgeable in the type of work required shall work on this project. By providing bids for

this project the Contractor is acknowledging that he has such expertise, and will staff the project with personnel experienced and knowledgeable in the work to be performed.

1.05 **GENERAL REQUIREMENTS**

A. Safety:

1. Contractor is solely responsible for worker safety and for selecting and designing all trench shoring methods, trench protection methods, site utility protection means and other aspects of the work.

2. All such means, methods, and safety measures shall comply with applicable codes and standards, and the requirements of the Contract Documents.

B. Coordination:

1. Coordinate all work with other trades. Coordinate with other Divisions the location and termination of all work of other trades and interconnections with Division 15 work.

C. Scheduling:

1. Schedule work to avoid impacts to other trades due to open trenches, dewatering, and other activities.

D. Existing Utilities:

1. Verity location of all existing utilities that lay in the route of intended work. Verify the location of all existing utilities that will be connected to prior to beginning work for any new utilities.

E. Discrepancies:

1. Notify the Architect/Engineer of any discrepancies or conflicts within the Contract Documents or between the Contract Documents and field conditions.

2. Do not proceed with any work or purchasing of any materials for the area(s) of conflict until obtaining written instruction from the Architect/Engineer on how to proceed.

3. Any work done after discovery of such discrepancies or conflicts and prior to obtaining the Architect/Engineer's instruction on how to proceed, shall be done at the Contractor's expense.

4. In case of a conflict between Division 15 requirements and other project requirements, the most stringent and expensive (as judged by the Architect/Engineer) shall prevail.

1.06 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.07 **REFERENCES**

A. ASTM D 1557, Laboratory Compaction Characteristics of Soil Using Modified Effort.

B. ASTM D 2487, Soils for Engineering Purposes (Unified Soil Classification System).

C. WSDOT Standard Specifications for Road, Bridge, and Municipal Construction, 2004 Edition.

PART 2 – MATERIALS

1.08 **GENERAL MATERIALS**

A. General:

1. All materials used for bedding, backfill, and drainage purposes shall be free of debris, roots, wood, vegetation, refuse, soft unsound material, frozen material, deleterious or other objectional material.

B. Sand:

1. Clean, free flowing, coarse grade sand, as defined by ASTM D2487.

1.09 **BEDDING MATERIALS**

A. Standard:

1. Gravel backfill material, with characteristics of size and shape to allow for compaction, no dimension exceeding 1-1/2 inches, and meeting the following for grading and quality:

Sieve Size	Percent Passing (By Weight)
1-1/2” Square	100
1” Square	75-100
5/8” Square	50-100
U.S. No. 4	20-80
U.S. No. 40	3-24
U.S. No. 200	10.0 max.
Sand Equivalent	35 min.

(Based on WSDOT 2004, 9-03.12(3))

B. Special:

1. Minus 3/8 inch washed pea gravel, or sand (except where a specific one is indicated - - use type specified).

C. Bedding Material Application:

Utility	Bedding Material	Minimum Thickness*
Cast Iron Piping	Standard (or Special)	4”
Steel Piping/Conduit	Standard (or Special)	4”
Ductile Iron Piping	Standard (or Special)	4”
Plastic Piping/Conduit	Special	4”
Copper Piping	Special	4”
Conductors/Cable	Special	4”
U/G Mech Structures	Special	4”
U/G Heat Pump Piping	Sand	6”

*Below bottom of utility.

1.10 UTILITY ZONE BACKFILL MATERIALS

A. Standard:

1. Same as specified for standard bedding materials.

B. Special:

1. Minus 3/8" inch washed gravel, or sand (except where a specific one is indicated, use type indicated).

C. Utility Zone Backfill Material Application:

Utility	Bedding Material	Minimum Thickness*
Cast Iron Piping	Standard (or Special)	4"
Steel Piping/Conduit	Standard (or Special)	4"
Ductile Iron Piping	Standard (or Special)	4"
Plastic Piping/Conduit	Special	4"
Copper Piping	Special	4"
Conductors/Cable	Special	4"
U/G Mech Structures	Special	4"
U/G Heat Pump Piping	Sand	6"

*Above top of utility.

1.11 PIPE TRENCH BACKFILL

A. Standard:

1. Gravel backfill material, with size and shape to allow for compaction, no dimension exceeding 3" inches, and meeting the following:

Sieve Size	Percent Passing (By Weight)
2-1/2" Square	75-100
U.S. No. 4	22-100
U.S. No. 200	0-10
Dust Ratio	2/3 max.
Sand Equivalent	30 min.

(Based on WSDOT 2004, 9-30.19, modified for 2-1/2" Sieve size).

B. Satisfactory Native Material:

1. Excavated material from trenching (or other excavation on site), complying with 2.01 A., having no clods or rocks greater than 3" inches in any dimension.

C. Material Application: Either standard or satisfactory native materials may be used (unless noted otherwise).

1.12 **DUCT TRENCH BACKFILL**

A. Standard:

1. Gravel backfill material, with size and shape to allow for compaction, no dimension exceeding 3" inches, and meeting the following:

Sieve Size	Percent Passing (By Weight)
2-1/2" Square	75-100
U.S. No. 4	22-100
U.S. No. 200	0-10
Dust Ratio	2/3 max.
Sand Equivalent	30 min.

(Based on WSDOT 2004, 9-30.19, modified for 2-1/2" Sieve size).

B. Satisfactory Native Material:

1. Excavated material from trenching (or other excavation on site), complying with 2.01 A., having no clods or rocks greater than 3" inches in any dimension.

C. Material Application:

1. Either standard or satisfactory native materials may be used (unless noted otherwise).

1.13 **GENERAL BACKFILL MATERIALS**

A. Utility Foundation Backfill:

1. Class A per WSDOT 2004, 9-03.12 (1) A.

B. Drain Backfills:

1. Gravel backfill for drains shall conform to the following:

Sieve Size	Percent Passing (By Weight)
1” Square	100
¾” Square	80-100
3/8” Square	10-40
U.S. No. 4	0-4
U.S. No. 200	0-2

C. Drywell Backfills:

1. Gravel backfill for drywells shall conform to the following:

Sieve Size	Percent Passing (By Weight)
1-1/2” Square	100
1” Square	80-100
¾” Square	0-20
3/8” Square	0-1.5

D. Underground Mechanical Structure Backfill:

1. Minus 3/8” inch washed pea gravel, from bedding rough or finished grade.

E. Conductors/Cables/Raceway:

F. Excavated material from trenching (or other excavation on site), complying with 2.01 A. (From top of initial backfill up).

1.14 **BURIED UTILITY AND IDENTIFICATION TAPE**

A. General:

1. Polyethylene plastic tape manufactured specifically for warning and identification of buried utility lines.

2. Tape shall be a minimum 6” wide, acid and alkali resistant.

B. Detectable Type:

1. Minimum 0.004 inch thick, with integral wire, foil backing, or other means to allow detection of tape location.

2. Encase metallic element in protection jacket or other means to provide corrosion protection.

C. Non-Detectable Type:

1. Minimum 0.003 inch thick.

D. Labeling:

1. Tape shall be imprinted with bold black capital letters continuously and repeatedly over the entire tape length.

2. Warning shall read “CAUTION BURIED (utility type) BELOW” or similar wording.

3. Lettering identifying the utility type shall match as closely as possible the designation noted on the plans.

4. Tape lettering shall be permanent and be unaffected by moisture or other materials contained in trench backfill.

E. Tape Colors:

Utility	Color
Electric	Red
Sewer	Green
Storm	Green
Gas	Yellow
Oil	Yellow
Water	Blue
Heating Water	Yellow
Chilled Water	Yellow

1.15 **DETECTION WIRE**

A. Detection Wire:

1. Detection wire shall be insulated single strand, solid copper with a minimum of 12 AWG.

PART 3 – EXECUTION

1.16 **GENERAL**

A. Shoring and Trench Protection:

1. Contractor is responsible to design and provide all necessary trench shoring and trench protection to:

B. Provide safe conditions.

C. Provide conditions that comply with applicable codes and AHJ requirements.

D. Prevent undermining of pavement, foundation, slabs, and other structures.

E. Prevent movements in adjacent slopes of banks.

F. Workmanship:

1. Work shall abide by best professional practices as described in referenced standards.

G. Compaction:

1. Provide compaction to percent indicated per ASTM D 1557, of laboratory maximum density.

2. Compact to 95 percent (unless noted otherwise).

3. Compaction shall be accomplished by approved tamping rollers, pneumatic-tired rollers, three-wheel power rollers, or other approved compaction equipment.

H. Grading:

1. Provide grading to prevent surface water from flowing into areas of work to maintain the stability of the work area, and suitable working conditions.

I. Dewatering:

1. Provide dewatering system for the collection and disposal of surface and subsurface water encountered during construction in order to maintain

conditions suitable for the work. Provide all pits, drainage conveyances, pumps, dikes, etc. as required to accomplish the work.

J. Underground Utilities:

1. Location of utilities indicated in approximate.

2. Verify the location of all existing utilities prior to beginning work; utilize field electronic detection equipment, pipe cameras, visual site surveys, and careful exploratory digging at key locations.

3. Coordinate with other trades routing and locations of all new utilities to avoid conflicts and ensure proper connections.

K. Machinery and Equipment:

1. Movement of construction machinery and equipment over buried and backfilled pipes during construction shall be at the Contractor's risk.

2. Repair, or remove and provide new pipe for existing or newly installed pipe that has been displaced or damaged.

3. Pressure testing of piping before final Owner acceptance is required to verify no damage has occurred.

L. Protection:

1. Protect all areas of work from traffic, erosion, weather, settlement or other damaging effects. Protect all existing utilities from damage.

M. Jacking, Boring and Tunneling:

1. Unless otherwise indicated, excavation shall be by open cut, except that sections of a trench may be jacked, bored or tunneled if the utility can be safely and properly installed and backfill can be properly tamped in such sections.

N. Buried Warning and Identification Tape:

1. Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade.

2. Provide detectable type over non-metallic piping systems.

3. Piping system installed within the building footprint does not require identification tape.

O. Detection Wire:

1. Provide where indicated on plans.

2. Bury 12 inches above top of utility served.

3. Extend wire continuously and unbroken, from accessible appurtenance to accessible appurtenance (or as indicated).

4. Coil an extra 3 feet of wire at each end.

P. Vertical Bore Holes:

1. Work for vertical bore holes is specified in Section 15755.

1.17 EXCAVATION – GENERAL

A. General:

1. Provide all excavation as necessary to allow for the work indicated.

2. Excavations for underground mechanical structures shall be sufficient to provide a minimum of 12 inches clearance between their surfaces and the sides of the excavation.

B. Excavated Material:

1. Stockpiles:

a. Stockpile materials satisfactory for backfilling in an orderly manner at a safe distance from the excavation to avoid overloading the sides of the excavated area and to prevent slides or cave-ins.

2. Protection:

a. Protect stockpiles from contamination with unsuitable backfill materials.

b. Provide adequate drainage at stockpiled areas to prevent water retention in material.

c. If the Contractor fails to protect the stockpiles and any material becomes unsatisfactory as a result, such material shall be removed and replaced with satisfactory on-site or imported material from approved sources at no additional cost to the Owner.

3. Disposal:

a. Excavated material not required or not satisfactory for backfill or other uses on site shall be removed and disposed off site.

1.18 TRENCH EXCAVATION

A. General:

1. Excavate trenches to accommodate utility, required utility slopes, depths of connecting utility, existing and new utilities, required cover depth, and site conditions.

B. Removal of Unsuitable Material:

1. Unstable Material:

a. Where unstable material is encountered in the bottom of the trench, such material shall be removed by over excavation of the trench bottom 4 inches below the depth otherwise required.

b. Contractor is responsible for reviewing the soils report and overall site conditions and, for all costs associated with removal and replacement of unstable materials.

c. For bidding purposes, assume that a minimum of 10% of all excavated bottom areas will have unstable material.

2. Rocks and Stones:

a. Stones of 6 inches or greater in any dimension, and any rock or stone of any size/orientation that may disrupt the pipe bedding thickness or pipe supports shall be removed.

b. Rock shall be removed to 4 inches below the bottom of the pipe bearing elevation.

c. Review soils report and civil drawings notes for special rock conditions that exist.

3. Other:

a. Any wood, refuse, waste, organic material, or other material which would adversely affect pipe support shall be removed.

b. For bidding purposes, assume that 5% of all trench bottom area will have objectional material as described in this paragraph.

C. Replacement Material:

1. Replace removed unsuitable material with “Utility Foundation Material” as specified under paragraph titled “General Backfill Materials”, or with bedding material specified for the piping to be place in the trench.

D. Bottom Preparation:

1. Bottoms of trenches shall be accurately graded to provide uniform bearing and support for each section of pipe (or other utility) after bedding placement, and proper slope of piping.

E. Depth:

1. Trench shall be adequate to provide a minimum depth of cover as follows:

a. Fire Lines:

1) 3.5 feet (or deeper if required by the AHJ).

b. Water Lines:

1) 3.5 feet (or deeper if required by the AHJ); except that branch piping to fixtures within the building footprint shall have a minimum of 1 foot of cover (unless indicated otherwise).

1.19 **BEDDING**

A. Pipe Bedding:

1. Provide even bedding placement along the entire length of pipe to support pipe on a uniformly dense unyielding foundation, without load concentration at joint collars or bells.

2. Bedding shall be installed and compacted prior to installing pipe.

3. Bedding located beneath piping shall be minimum 4 inches thick (unless noted otherwise), and compacted to 90% maximum density.

4. All adjustment to line and grade shall be made by scraping away for filling in with bedding material under the body of the pipe and not by blocking or wedging.

5. Bedding disturbed by pipe movement, or by removal of shoring movement of a trench shield or box, shall be reconsolidated prior to backfill.

B. Non-Metallic Duct Bedding:

1. Provide even bedding placement along the entire length of the duct to support duct on a uniformly dense unyielding foundation, without load concentration at joint collars or bells.

2. Bedding shall be installed and compacted prior to installing duct.

3. Bedding located beneath ductwork shall be minimum 4 inches thick (unless noted otherwise), and compacted to 90% maximum density.

4. Recesses shall be excavated as necessary at each joint or coupling to eliminate point bearing and to allow uniform duct support by the bedding material the entire duct length.

5. Haunching shall be installed in maximum 4 inch lifts, hand placed and carefully worked under the duct haunches and then compacted to 90% maximum density.

6. All adjustment to line and grade shall be made by scraping away or filling in with bedding material under the body of the duct and not by blocking or wedging.

7. Bedding disturbed by duct movement, or by removal of shoring movement of a trench shield or box, shall be reconsolidated prior to backfill.

C. Other Utility Bedding:

1. Provide even bedding to allow for full support of the installed item on a uniform dense unyielding foundation.

2. Bedding shall be installed and compacted before installing ducts or underground mechanical structures.

3. Bedding shall be a minimum of 4 inches thick for ductwork and minimum of 6 inches thick for other items (unless noted otherwise). Compact to 95% maximum density.

1.20 **BACKFILLING**

A. General:

1. Provide backfill of all trenches and appurtenances to finish grade.

2. Provide adequate initial backfill to allow proper pressure tests.

3. Leave joints and couplings uncovered as necessary to discover pipe leaks.

B. Utility Zone Backfilling:

1. Backfill shall be placed in loose layers and compacted to 90% maximum density.

2. Backfill shall be placed in horizontal layers no more than 6 inches thick.

3. Backfill shall be brought up simultaneously on each side of the utility to the top of the pipe, and onto the top of the utility zone.

4. Backfill and compact in a manner to avoid damaging or disturbing the completed utility.

C. Pipe Trench Backfilling:

1. Backfill above the pipe zone backfill shall be accomplished in such a manner that the pipe will not be shifted out of position nor damaged by impact or overloading.

2. Where pipe is outside the building footprint, backfill shall be placed in horizontal layers no more than 6 inches thick and compacted to 95% maximum density.

3. Where pipe is inside the building footprint, backfill shall be placed in horizontal layers no more than 6 inches thick and shall be compacted to 85% maximum density.

D. Duct Trench Backfilling:

1. Backfill shall be accomplished in such a manner that the duct will not be shifted out of position nor damaged by impact or overloading.

2. Backfill shall be placed in horizontal layers n o more than 6 inches thick and compacted to 95% maximum density.

E. Underground Mechanical Structures:

1. After structure has been installed (or the concrete has been allowed to cure for the field constructed items), backfill shall be placed in such a manner that the structure will not be damaged by the shock of falling backfill.

2. The backfill shall be placed in such a manner as to prevent eccentric loading and excessive stress on the structure.

3. Backfill shall be standard or satisfactory native materials, except that backfill for fuel tanks shall use special backfill material.

F. Other Utility Backfill:

1. Backfill shall be accomplished in such a manner that the utility will not be shifted out of position nor damaged by impact or overloading.

2. Backfill shall be placed in horizontal layers no more than 6 inches thick and compacted to 95% maximum density.

END OF SECTION

SECTION 15060

PIPE AND PIPE FITTINGS

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Pipe.

B. Pipe Fittings.

C. Pipe Joining and Connections.

1.02 **RELATED WORK**

A. Section 15080 – Piping Specialties.

B. Section 15090 – Hangers and Supports

C. Section 15410 – Domestic Water Piping System.

D. Section 15420 – Soil, Waste and Vent Piping System.

E. Section 15500 – Fire Protection.

F. Section 15745 – Hydronic Heat Pump Water Piping System.

G. Section 15830 – Air Conditioning and Refrigeration System.

1.03 **SUBMITTALS**

A. Shall comply with Section 15010.

B. Product submittals are required for all pipe and pipe fittings to be used on this project.

1.04 **GENERAL REQUIREMENTS**

A. Application: See each individual system specification sections for call-out piping materials to be used for that system.

B. Fire Mains: Pipe and fittings where used on fire mains, serving fire hydrants, serving building fire risers, and fire standpipes shall comply with NFPA 24 and be Fire Marshal and UL approved for fire main use.

1.05 SUSTAINABLE BUILDING REQUIREMENTS

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.06 REFERENCES

A. ANSI/ASTM A53: Pipe, Steel, Black and Hot Dipped Zinc Coated, Welded and Seamless.

B. ANSI B16.4: Cast Iron Threaded Fittings.

C. ANSI B16.3: Malleable Iron Threaded Fittings.

D. ANSI B16.9: Steel Butt-Welding Fittings.

E. ANSI B16.11: Steel Socket – Welding Fittings.

F. ANSI B16.5: American 150, 300, 400, 600, 900, 1,500, and 2,500 Pound Steel Flange Standards.

G. ANSI/ASTM B88: Seamless Copper Water Tube.

H. ANSI/ASTM B32: Solder Metal.

I. ANSI B16.22: Wrought Copper and Bronze Solder Joint Pressure Fittings.

J. ANSI B16.18: Cast Bronze Solder Joint Pressure Fittings.

K. ANSI B16.24: Cast Copper and Bronze Flange Fittings.

L. CISPI 301: Cast Iron Soil Pipe and Fittings for Hubless Cast Iron Sanitary System.

M. ASTM C564: Rubber Gaskets for Cast Iron Soil Pipe and Fittings.

N. CISPI 310: Cast Iron Soil Pipe Couplings for Hubless Cast.

O. ANSI/ASTM 1784: Rigid Poly (Vinyl Chloride) Compounds and Chlorinated Poly (Vinyl Chloride) Compounds.

P. ANSI/ASTM 1785: Poly (Vinyl Chloride) (PVC) and Chlorinated Poly (vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40, 80, and 120.

Q. ANSI/ASTM D2466: Socket Type Poly (Vinyl Chloride) (PVC) and Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.

R. ANSI/ASTM D2564: Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Steel Pipe and Fittings: U.S. Steel, Bethlehem, Walworth, Flagg, Grinnell, Felker.

C. Copper Pipe and Fittings: Mueller, Nibco, Flagg, Elkhart.

D. Cast Iron Pipe: U.S. Steel, Tyler, U.S. Pipe & Foundry, American Brass and Iron Foundry.

E. No-Hub Couplings: M.G. Coupling Co., Anaheim Foundry Co., Mage-USA, Clamp-All.

F. Ductile Iron Pipe and Fittings: Pacific States, Union Foundry.

G. Miscellaneous Fittings/Materials: As called out in individual specifications.

2.02 **BLACK STEEL PIPE AND FITTINGS**

A. Pipe: Seamless or welded steel pipe per ANSI/ASTM A53. Schedule 40 unless indicated otherwise. Fire sprinkler piping may be lighter schedules as allowed by NFPA 13.

B. Fittings: Shall be as follows, except that for fire protection systems see Section 15500.

1. Pipe 2 Inches and Smaller: Threaded cast iron fittings per ANSI B16.4 or malleable iron fittings per ANSI B16.3, suitable for 125 psi working pressure (unless indicated otherwise).

2. Pipe 2-1/2 Inches and Lager: Weld fittings, seamless butt-welding per ANSI B16.9 or socket-welding per ANSI B16.11. Flanges: Weldneck or slip-on pattern, forged steel, 150 lb. per ANSI B16.5.

2.03 GALVANIZED STEEL PIPE AND FITTINGS

A. Galvanized Steel Pipe: Seamless or welded, hot-dipped galvanized steel pipe, per ANSI/ASTM A53. Schedule 40 unless indicated otherwise.

B. Fittings: Galvanized malleable iron fittings, 150 lb. per ANSI B16.3.

2.04 COPPER PIPE AND FITTINGS

A. Pipe: Seamless copper tubing, type K or L, as indicated, per ANSI/ASTM B88.

B. Fittings: Soldered joints with 95-5 tin-antimony solder per ANSI/ASTM B32 or "Silvabrite 100" (95.5 tin/4 copper/0.5 silver) solder. Solder shall be lead-free. Wrought copper fittings per ANSI B16.22, cast bronze fittings per ANSI B16.18, cast flange fittings 150 lb per ANSI B16.24. Underground joints shall be brazed, with BCuP-4, BCuP-5, or Bag-1 filler metals (per American Welding Society Standards).

C. Refrigerant Pipe and Fittings: Piping shall be ACR Type L copper tubing, with silver brazed joints using filler metals per American Welding Society Standards, and wrought copper fittings.

2.05 NO-HUB CAST IRON PIPE AND FITTINGS

A. Pipe: Service weight no-hub cast iron pipe per CISPI-301.

B. Fittings: Cast iron fittings complying with CISPI-301 with mechanically coupled joints. Mechanical couplings shall consist of cast iron or stainless steel couplings, complying with CISPI-301, having neoprene gaskets per ASTM C564. Underground pipe couplings shall be Husky Model SD 4000.

2.06 CAST IRON SOIL PIPE AND FITTINGS

A. Pipe: Service weight cast iron per ANSI/ASTM A74.

B. Fittings: Bell and spigot joints, with neoprene gaskets per ASTM C564, and CISP-HSN.

2.07 **DUCTILE IRON PIPE AND FITTINGS**

A. Pipe: Ductile iron pipe shall conform to AWWA C151 and shall be Thickness Class 52 minimum. Pipe shall have cement mortar lining conforming to AWWA C104/ANSI A21.4; standard thickness.

B. Fittings: Fittings shall conform to AWWA C110; fittings with push-on joint ends shall conform to the same requirements as fittings with mechanical-joint ends, except that the bell design shall be modified, as approved, for push-on joint. Fittings shall have pressure rating at least equivalent to that of the pipe. Fittings shall have cement-mortar lining conforming to AWWA c104/A21.4, standard thickness.

2.08 **COPPER DWV PIPE AND FITTINGS**

A. Pipe: Copper drainage tube (DWV), per ASTM B306.

B. Fittings: Wrought copper and wrought copper alloy solder-joint drainage fittings, per ANSI B16.29; or cast copper alloy solder joint drainage fittings, DWV, per ANSI B16.23.

2.09 **PVC PRESSURE PIPE**

A. Pipe: Polyvinyl chloride plastic type 1, grade 1, conforming to ANSI/ASTM D1784, bell end conforming to ANSI/ASTM D2672, and as follows:

Pipe Sizes	Pipe Type	ANSI/ASTM Standard
½" to 1-1/2"	Schedule 40	D1785
½" to 4"	Schedule 80	D1785
1-1/2" and Up	SDR 1.35, 315 psi Rated	D2241

B. Fittings: socket type fittings for Schedule 40 pipe per ANSI/ASTM D2466, for Schedule 80 pipe per ANSI/ASTM D2467. Threaded fittings for Schedule 80 pipe per ANSI/ASTM D2464. solvent cement per ANSI/ASTM D2564.

2.10 **PVC PIPE**

A. Pipe: Polyvinyl chloride plastic, conforming to ANSI/ASTM D1784; Schedule 40, per ANSI/ASTM D1785.

B. Fittings: Socket type fittings for Schedule 40 pipe per ANSI/ASTM D2466.

PART 3 – EXECUTION

3.01 **PIPE INSTALLATION – GENERAL**

A. All piping in finished areas shall be installed concealed unless specifically noted otherwise.

B. Install piping at such heights and in such a manner so as not to obstruct any portion of windows, doorways, or passageways.

C. Coordinate installation of piping with all trades which are affected by installation to avoid conflicts.

D. Offset or reroute piping as required to clear any interferences which may occur.

E. Consult all drawings for location of pipe spaces, ducts, electrical equipment, ceiling heights, door openings, window openings, and other details and report discrepancies or possible conflicts to Architect/Engineer before installing pipe.

F. Allow sufficient clearances for installation of pipe insulation in thickness specified. If interferences occur, reroute piping to accommodate insulation.

G. Pitch all piping and provide drain valves so that all piping and equipment can be drained.

H. Provide escutcheons where pipe passes through walls, floors, or ceilings.

I. Install all exposed piping parallel to the closest wall and in a neat, workmanlike manner.

3.02 **PIPE JOINING**

A. General: Prior to the joining of any section of pipe to a pipe run, the section shall be thoroughly cleaned inside and out, and the ends shall e reamed to remove any cutting burrs.

B. Threaded Connections: Cut piping carefully, ream, thread and work into place without springing. Use Teflon tape of lead and graphite lubricant-on male threads only.

C. Caulked Connections: Cat iron pipe shall be made with picked oakum and at least 1-1/2 inches of molten lead or joined with neoprene gaskets in accordance with manufacturer’s assembly instructions.

D. Hubless Connections: Made with hubless type coupling assemblies in accordance with manufacturer's recommendations.

E. Soldered Connections: Polish contact surfaces of fittings and pipes with emery cloth before fluxing male and female surfaces of joints. Steel wool and sandpaper not permitted for polishing.

F. Unions: Install unions in pipe connections to valves, coils, and any other equipment where it may be necessary to disconnect the equipment or piping for repairs or maintenance; and as indicated. Where flanged connections occur at equipment additional unions are not required unless indicated otherwise.

G. Insulating Unions: Install dielectric insulating unions or insulating type flexible connectors between all connections of copper piping and steel piping or steel equipment. Where flanged connections occur use insulating type flanges.

H. Welding: Quality welding procedures, welders, and operators in accordance with ANSI B31.1. Make welded joints on the piping system with continuous welds, without backing rings and with pipe ends beveled before welding. Gas cuts shall be true and free from burned metal. Before welding, surfaces shall be thoroughly cleaned. The piping shall be carefully aligned and no weld metal shall project inside the pipe.

END OF SECTION

SECTION 15080

PIPING SPECIALTIES

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Thermometers.

B. Pressure Gauges.

C. Strainers.

D. Unions.

E. Flexible Connectors.

F. Test Ports.

G. Access Doors.

1.02 **RELATED WORK**

A. Section 15410 – Domestic Water Piping System.

B. Section 15500 – Fire Protection Sprinkler Section.

1.03 **SUBMITTALS**

A. Submittals shall comply with Section 15010.

B. Submit product information data for all products.

1.04 **REFERENCES**

A. ASME B40.3 – Bimetallic Activated Thermometers.

B. ASME B40.100 – Pressure Gauges and Gauge Attachments.

1.05 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Thermometers: Trerice, Weiss.

C. Pressure Gauges: Trerice, Weiss.

D. Strainers: Watts, Keckley.

E. Unions: Watts, Epco, Victaulic.

F. Dielectric Connecters: Vitaulic.

G. Expansion Joints: Unisource, Metraflex, Mason.

H. Flexible Connectors: Universal, Mason.

I. Test Ports: Autoflow, Flowset, Peterson Equipment.

J. Access Doors: J.R. Smith, Zurn, Josam, Acudor, Elmdoor, Kees, J.C. Industries.

2.02 **THERMOMETHERS – INDUSTRIAL**

A. Type: 7 inch scale, adjustable angle, red reading mercury, industrial thermometer.

B. Construction: Aluminum or polyester case, acrylic plastic or heavy glass window, aluminum face, stem of brass or aluminum construction, with separate brass socket (i.e. thermowell). Bulb chambers tapered to match taper in thermowell to give metal to metal contact. Scale case adjustable over a minimum 180° range, with locking fastener.

C. Stem Length: Stem insertion length approximately one-half of pipe diameter. Where installed on tanks, minimum insertion length is 5”. Where installed on

insulated piping systems, provide a longer stem thermometer and extended neck socket (thermowell) to extend thermometer base past the insulation.

D. Display: White background with bold black numerals and Fahrenheit degree markings, red reading mercury.

E. Accuracy: Plus or minus 1% of full scale.

F. Ranges:

Measuring	Range Degrees F	Figure Intervals	Increments Degrees F
Domestic Cold Water	0-100	5	1
Domestic Hot Water	30-180	10	2

2.03 **PRESSURE GAUGES**

A. General: Gauges shall be 4-1/2" round dial, stem mounting, black impact resistant phenolic (or fiberglass reinforced polypropylene), flangeless case, white face with black numerals, phosphor bronze bourdon tube rated to minimum 1000 psi, brass socket, acrylic window, and ¼" npt (or ½" npt) bottom connection. Provide with shut off cock. Gauges shall be rated for use with the system pressures and temperatures to be exposed to, but be rated for no less than 250° F. Accuracy shall be 0.5% per ASME B40, 100 Grade 2A.

B. Pressure Gauge Ranges:

Measuring	Range PSIG	Numeral Intervals PSIG	Inter-Graduations
Fire	0 – 400	50	5
Domestic Hot Water	0 – 160	20	2
Domestic Cold Water	0 – 160	20	2

2.04 **STRAINERS**

A. Domestic Water System Strainers:

1. 2-1/2" and Smaller: Bronze body, "Y" type, screwed or solder type end connections, 250 lb class (rated 250 psi steam working pressure at 400° F minimum), stainless steel 20 mesh wire screen, and gasketed retainer cap. Reinforce wire mesh with perforated stainless steel sheet for sizes 2" and 2-1/2". Ratio of net free area of screen to pipe free area greater

than 3.5. Provide with blowdown valve, ball type, with ¾" NPT male end connection. Valve manufacturer shall be listed as an "Acceptable Manufacturer" in the domestic water piping section.

2. 3" and Larger: Bronze body, "Y" type, flanged end connections, 150 lb class (rated 150 psi steam working pressure at 400° F minimum), brass or stainless steel screen with 3/64" perforations for 3", and 3/32" perforations for larger sizes, with gasketed threaded retainer cap. Ratio of net free area of screen to pipe free area greater than 3. Provide with blowdown valve, ball type, with ¾" NPT male end connection. Valve manufacturer shall be listed as an "Acceptable Manufacturer" in the domestic water piping specification section.

2.05 **UNIONS**

A. Dielectric Unions: Shall not be used. Provide "dielectric connector" with standard union where union is required at connection point of dissimilar materials.

B. Unions on Copper Pipe:

1. In 2-inch Pipe and Smaller: Wrought copper solder joint copper to copper union.

2. In 2-1/2-inch Pipe and Larger: Brass flange unions.

C. Unions of Steel Pipe:

1. In 3-1/2-Inch Pipe and Smaller: Screwed malleable iron with ground joints, brass to iron insert, 150 psi minimum working pressure.

2. In 4-Inch Pipe and Larger: Flange unions, cast or malleable iron.

D. Dielectric Connector: Victaulic "Clearflow" dielectric waterway.

2.06 **FLEXIBLE CONNECTORS**

A. Water Piping Flexible Connectors: Corrugated hose type with outer braided wire sheath covering. Corrugations shall be close pitch annular type. Connector shall have a minimum working pressure of 250 psig, minimum length of 12 inches (or 12 times the connector's nominal diameter, whichever is more), and screwed or flanged end connections. Metal for hose shall be bronze or stainless steel; braided sheath shall be stainless steel, any type of ASTM 300 series.

2.07 **TEST PORTS**

A. Temperature/Pressure Type: Test port for installation in tee in piping allowing insertion of probe for measurement of pressure and/or temperature. Valve shall be of brass construction, have ¼ or ½ inch NPT male connection, with dual valves to prevent leakage and gasketed cap with attachment to test port. Rated for minimum 500 psi and 275° F. Provide extended length on insulated piping systems so that insulation does not cover the test port.

2.08 **ACCESS DOORS**

A. Hinged lockable steel access door, for mounting on face of wall, with minimum 16 gauge frame and 16 gauge door, concealed hinge, cam and cylinder lock, and anchor straps or anchor frame with mounting holes. Provide Type 304 stainless steel construction with No. 4 finish where used in restrooms, locker rooms, kitchens, and similar "wet" areas. Provide steel construction with prime coated finish in other areas. Door shall have rounded corners, and concealed pivoting rod hinge. Size shall be 12" x 12" (unless indicated otherwise) but shall be large enough to allow necessary access to item being served and sized to allow removal of the item (where access door is the only means of removal without disturbing fixed construction).

B. Fire Rating: Door shall maintain fire rating of element installed in; reference drawings for required rating.

C. Access doors shall all be keyed alike. Provide two (2) keys for each door.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Thermometers: Install thermometers and thermal wells in piping at locations indicated, and so as to be easily read.

B. Pressure Gauges: Install pressure gauges at inlet and outlets of all pumps; at each side of pressure reducing valves; and as indicated.

C. Strainers: Install strainers ahead of each control valve (whether shown on drawings or not), and ahead of each steam trap, and as indicated. Provide valve in blow-off connection on strainers, valve shall be same size as blow-off tapping.

D. Unions: Install unions in pipe connections to control valves, coils, regulators, reducers, all equipment, and where it may be necessary to disconnect the

equipment or piping for repairs or maintenance; and as indicated. Where flanged connections occur at equipment additional unions are not required unless indicated otherwise. Dielectric unions shall not be used.

E. Dielectric Connectors: Install connectors between all connections of copper and steel piping (or equipment), and other dissimilar metals. Where flanged connections occur use insulating type flanges. Dielectric unions shall not be used.

F. Test Ports: Install at location shown on drawings and where needed by Balancer to allow measurements for flow adjustments.

G. Access Doors: Provide access doors where indicated on the drawings and where needed to provide access to trap primers, water hammer arresters, cleanouts, valves, coils, controls, mechanical spaces, and similar items requiring service or access that would otherwise be inaccessible. Consult architectural drawings and coordinate location and installation or access doors with trades which are affected by the installation. Access doors are typically not shown in the plans. The Contractor shall review ceiling and wall types and locations of items requiring access to determine quantity and sizes of access doors required.

END OF SECTION

SECTION 15090

HANGERS AND SUPPORTS

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Pipe Hangers and Supports.

B. Duct Hangers and Supports.

C. Mechanical Equipment Anchors and Supports.

1.02 **RELATED WORK**

A. Division 15 – All Piping.

B. Division 15 – All Ductwork.

C. Division 15 – All Mechanical Equipment.

1.03 **QUALITY ASSURANCE**

A. Pipe Hanger Standards: Manufacturers Standardization Society Standards SP-58, SP-89, SP-69, and SP-90.

B. All methods, materials and workmanship shall conform to the International Building Code (IBC) and International Mechanical Code (IMC), Uniform Plumbing Code (UPC), ASME standards, and applicable codes.

1.04 **SUBMITTALS**

A. Submittals shall comply with Section 15010.

B. Submit product data for all hangers, supports, and anchors. Data to include finish, load rating, dimensions, and applicable agency listings. Indicate application for all items by system type, size, and other criteria as appropriate to project.

C. Shop drawings are required for all trapeze hangers, equipment supports, and any fabricated supports or assemblies and any support arrangements to be sued that are not shown on the plans.

1.05 **GENERAL REQUIREMENTS**

A. Seismic: Hangers, supports, and anchors serving as seismic restraints shall comply with Section 15200. Provide seismic restraint calculations for such anchors where required by the local code official (unless noted otherwise); calculations and information shall comply with requirements for Section 15200.

B. Design and Manufacturer: All pipe hangers and supports shall be designed and manufactured in accordance with MSS-SP58.

1.06 **REFERENCES**

A. ASME B31.1: Power Piping.

B. ASME B31.9: Building Services Piping.

C. ASTM A36: Standard Specification for Carbon Structural Steel.

D. ASTM A108: Standard Specification for Steel Bar, Carbon and Alloy, Cold – Finished.

E. ASTM A123: Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

F. ASTM A653: Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc Iron Alloy-Coated (Galvannealed) by Hot-Dip Process.

G. ASTM A907: Standard Specification for Steel, Wire, Epoxy – Coated.

H. ASTM A924: Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot Dip Process.

I. IBC: International Building Code.

J. IMC: International Mechanical Code.

K. Mason: Mason Industries Seismic Restraint Guidelines for Suspended Piping, Ductwork, Electrical Systems and Floor Mounted Equipment, 6th Edition.

L. MSS SP-58: Pipe and Hangers and Supports – Materials, Design and Manufacture.

M. MSS SP-69: Pipe and Hangers and Supports – Selection and Application.

N. MSS SP-89: Pipe and Hangers and Supports – Fabrication and Installation Practices.

O. MSS SP-90: Guidelines on Terminology for Pipe Hangers and Supports.

P. SMACNA: HVAC Duct Construction Standards Metal and Flexible, 3rd Edition.

Q. SMACNA SRM: Seismic Restraint Manual Guidelines for Mechanical Systems, 2nd Edition.

R. UPC: Uniform Plumbing Code.

1.07 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Hangers and Supports: Grinnell, B-Line Systems, Unistrut, Michigan, PHD, Basic Engineering.

C. Anchors: Rawplug, Phillips, Hilti, Michigan, Simpson, Fastenal, Grinnell, B-Line Systems, Unistrut, PHD, Basic Engineering.

2.02 **GENERAL HANGERS AND SUPPORTS**

A. Finish:

1. Indoor Applications: Electro-plated zinc in accordance with ASTM B633, or hot-dip galvanized after fabrication in accordance with ASTM A123; except that hanger straps may be formed from pre-galvanized steel.

2. Outdoor Applications: Hot-dip galvanized after fabrication in accordance with ASTM A123.

3. Fire Sprinkler Hangers: As allowed by NFPA 13, except where exposed to the outdoors shall be hot-dip galvanized after fabrication in accordance with ASTM A123.

B. Identification: Steel pipe hangers and supports shall be stamped with the manufacturers name, part number, and size.

C. Hanger Rods: Threaded hot rolled steel. Hanger rods shall be sized so that the total load (including pipe or duct, insulation, hangers, and fluid) does not exceed the following:

Nominal Rod Diameter	Maximum Load
¼ inch	240 Pounds
5/16 inch	440 Pounds
3/8 inch	610 Pounds
½ inch	1130 Pounds
5/8 inch	1810 Pounds
¾ inch	2710 Pounds
7/8 inch	3770 Pounds
1 inch	4960 Pounds

D. Hanger Straps: Galvanized steel, minimum 1" x 18" gauge, of lock-forming grade conforming to ASTM A924, G60 (minimum) galvanized coating conforming to ASTM A653. Minimum yield strength of 30,000 psi. Straps shall be sized so that the total load does not exceed the following:

Strap Size	Maximum Load
1" x 18 Gauge	380 Pounds
1" x 16 Gauge	630 Pounds
1-1/2" x 16 Gauge	990 Pounds

E. Concrete Inserts: Malleable iron or steel body designed to be embedded in concrete for attachment to suspended hanger rods. Size to match hanger rod size used with.

F. Beam Attachments: Constructed of malleable iron or steel, MSS standard types designed for clamping to building structural support beam. "C" clam type shall have cup point set screws with locknuts and retaining straps. Center loaded type beam clamps shall have horizontally adjustable clamping bolt (or rod with nuts).

G. Concrete Anchors: Wedge type expansion anchors, steel, Grade 5, with hex nut and washer.

H. General Anchor Bolts/Nuts/Screws/Fasteners: ASTM A307, SAE J429, or ASTM A563, with unified inch screw threads (course, UNC).

I. Manufactured "Strut" Systems:

1. Channels: Minimum 12 gauge, 1-5/8 x 1-5/8" (unless noted otherwise), electroplated zinc finish, with slots/holes to suit application.

2. Accessories: Channel nuts press formed, machined and hardened with gripping slot, fabricated from steel conforming to ASTM A108 or ASTM A36. Fittings fabricated from steel in accordance with ASTM A907.

J. Steel: Structural steel per ASTM A36.

K. Wood: Shall be fire treated.

2.03 **PIPE HANGERS AND SUPPORTS**

A. Copper Pipe: All hangers used directly on copper pipe shall be copper plated or have a factory applied 1/16 inch thick (minimum) plastic coating on all contact surfaces.

B. Fire Sprinkler: Fire sprinkler supports shall comply with NFPA-13 and Section 15500.

C. Type: Shall be MSS type selected in accordance with MSS-69; except that MSS type 24, 26, and 34 shall not be used.

D. Trapeze Hangers: Shall be constructed of carbon steel angles, channels or other structural shapes with flat surface for point of support. Trapeze hangers shall be supported with hanger rods suspended from concrete inserts, beam clamps, or other approved method. Provide a steel washer where hanger rod nuts bear on trapeze hanger.

E. Insulated Pipe Supports:

1. Insulation material at pipe support shall consist of expanded perlite (or calcium silicate) insert with flame resistant jacket of nylon reinforced draft paper bonded to aluminum foil cover on insulation, with sheet metal shield. Insulation material shall have no more than 5%

deformation at 100 psi and a thermal conductivity no more than 0.32 Btu/hr-sf-deg F inch.

2. Insert shall be same thickness as adjoining pipe insulation, sized to match pipe used on.

3. Minimum insulation and shield lengths, and shield gauge:

Nominal Pipe Diameter In Inches	Insulation Length In Inches	Shield Length In Inches	Minimum Shield Gauge
½ to 1	*	4	20
1-1/4 to 3-1/2	6	4	18
4 to 5	9	6	18

*Insert not required; shield at insulation is acceptable.

F. Alignment Guides: Carbon steel "spider" type alignment guide, with anchoring legs. Provide with calcium silicate insulation where used on cold pipe lines.

2.04 DUCT HANGERS AND SUPPORTS

A. Hangers: As shown in SMACNA except that wire shall not be used and all materials used shall comply with these specifications.

B. Vertical Duct Supports at Floor: 1-1/2" x 1-1/2" x 1/8" (minimum) galvanized steel angle and to support ducts, maximum 12 foot on center, and as shown in SMACNA. For ducts over 30 inches wide provide riser reinforcing with hanger rods between the riser support and riser reinforcing.

C. Vertical Duct Support at Wall: 1-1/2" x 1/8" (minimum) strap of 1-1/2" x 1-1/2" x 1/8" (minimum) angle bracket and as shown in SMACNA.

D. Hanger Attachments to Structure: As shown in SMACNA to suit building construction and as allowed on structural drawings. Provide washers at all fasteners through hanger straps (regardless of SMACNA allowances). Where C-clamps are provided, retainer clips shall be used. Friction beam clamps shall not be used.

E. Hanger Attachments to Ducts: As shown in SMACNA except that wire shall not be used as any form of support or attachment for ducts.

PART 3 – EXECUTION

3.01 **INSTALLATION – GENERAL**

A. General: Provide all necessary bolts, nuts, washers, turnbuckles, hanger rods, rod connectors, stanchions, wall/roof/floor backing and attachments, bridging between structural members, and any other miscellaneous accessories required for the support and anchoring of all pipes, ducts, and mechanical equipment. All supports, whether from floor, walls, or hung from structure, are Contractor's responsibility.

B. Backing: Install steel or wood backing in walls (anchored to studs) and in ceiling (anchored to joists or trusses), as required to provide support for items.

C. Installation: Install all inserts, anchors, and supports in accordance with manufacturer's instructions, code requirements, and best professional practices. The most restrictive criteria governs.

D. Welded Assembly Finish: All welded steel support assemblies shall have a power wire brush and primer paint finish.

E. Building Attachment: Attach to building structure as shown on drawings (reference structural drawings). Where not detailed on the drawings, the Contractor shall design and submit shop drawings of proposed attachment methods to the Engineer for review and approval.

F. Support Spacing: Maximum spans between supports may be significantly less than the maximum spans allowed herein due to structural limitations of allowable loads on hangers. The most restrictive criteria governs. Reference structural drawings.

G. Building Structural Loads: Where installed items incur loads that exceed the buildings structural capacity (i.e., roof or wall carrying capacity as indicated on structural drawings or otherwise noted in the documents), provide supports to transmit the loads to floors or other parts of structure that can carry load (e.g., bridging between joists to distribute load, added structure between walls to allow walls to carry load, etc.). Such supports shall consist of all welded steel angle iron supports, pipe columns, or similar custom fabricated items. Provide with base plates, U bolts, or similar type accessories to allow proper anchoring and seismic hold-down for all items supported. Where not detailed on the drawings, the selection and design of such supports is the Contractor's responsibility, subject to submittal review and acceptance by the Engineer.

H. Seismic: Provide seismic bracing and added supports per Section 15200.

3.02 **INSTALLATION OF PIPE HANGERS AND SUPPORTS**

A. General: Pipe which is not run underground shall be adequately anchored to the structure to prevent sagging and to keep pipe in alignment, except that piping below structural slabs shall be supported same as for aboveground piping. See structural drawings for extent of structural slab areas.

B. Adjustment: All pipe supports shall be provided with a means of adjustment for the aligning and leveling of the pipe after installation.

C. Applications: Selection, sizing, and installation of pipe supports and accessories shall be in accordance with the manufacturers' recommendations, standards MSS SP-89 and MSS SP-69, NFPA 13 for fire protection piping, UPC, and IMC.

D. Support Spacing: Provided piping support spacing according to the most restrictive of the following: UPC, IMC, ASME B31.1, B31.9, local codes, manufacturers recommendations or Contract Documents specific requirements. Provide supports at each change in direction of piping and at each side of concentrated loads (such as in-line pumps, valves greater than size 5", and similar items). On hubless cast iron piping provide supports at each branch connection; and hubless cast iron piping greater then size 2" shall have supports on both side of piping couplings.

E. Trapeze Hangers: Four (4) or more pipes running parallel may be supported on trapeze hangers provided the slopes of such pipes allow use of common trapeze. Where trapeze width exceeds 28 inches, provide three (3) hanger rod supports.

F. Vertical Piping Supports: Support piping at each floor line with pipe clamps and at intermediate points as required so that hanger spacing does not exceed allowable spacing and as required to prevent excessive pipe movement and so as to comply with the maximum spacings cited above. Support all pipe stacks at their bases with a concrete pier or suitable support. For vertical pipe drops which occur away from a wall or similar anchoring surface, provide angled bracing from nearest structure on two (2) sides of drop to provide rigid anchoring of pipe drop. Provide riser clamps and vertical supports on all vertical vent piping where the vertical pipe length exceeds 5'.

G. Pre-insulated Pipe Supports: Protect all insulated pipe at point of support with pre-insulated pipe supports. Such supports shall be in place at time of installing pipe.

H. Underground Pipe: Shall be evenly supported on approved bedding materials, as appropriate for the type of piping being used. Such bedding and backfilling shall be as specified in Section 15050.

I. Expansion/Contraction: At piping subject to expansion and contraction of ½ inch lengthwise or more, provide system support features to accommodate piping movement. Pipe shall be supported on roll type or anti-friction plate type supports to allow movement of piping toward (and away from) expansion devices. At all expansion devices and provide alignment guides on each side of expansion devices and at intermediate points to maintain pipe alignment. Provide anchors to insure pipe expansion into expansion devices. Anchors shall consist of riser clamp and welded pipe or steel angle anchored to structure, or similar arrangement (unless indicated otherwise). All expansion devices and overall system features to accommodate expansion shall be Contractor designed (unless indicated otherwise), in accordance with MSS SP-69, ASME B31.9, ASME B31.1, and ASHRAE Standards.

3.03 INSTALLATION OF DUCT HANGERS AND SUPPORTS

A. General: Provide anchors and supports for all ductwork. Supports and hangers shall comply with SMACNA, except that hanger spacing and hanger maximum loads shall be governed by whichever is more restrictive between these specifications or SMACNA.

B. Hanger Spacing – Rectangular Duct:

Duct Area	Maximum Spacing
Up to 4 Square Feet	8 Feet
4.1 to 10 Square Feet	6 Feet
10 Square Feet and Up	4 Feet

C. Hanger Spacing – Round Duct:

Duct Area	Maximum Spacing
Up to 24 Inch Diameter	8 Feet
25 Inch to 48 Inch Diameter	6 Feet
49 Inch Diameter and Up	4 Feet

D. Vertical Ducts: Support at each floor level, but in no case less than on 12 foot intervals.

E. Fittings: Provide supports at each change in direction of duct for ducts with 4 square foot area or more, or for ducts larger than 24 inch diameter. Locate hangers at inside and outside corners of elbows – or at each end of fitting on each side.

F. Concentrated Loads: Provide additional supports at each side concentrated loads such as modulating dampers (24" x 24" and larger), duct heaters (18" x 18" and larger), sound attenuators (all sizes), and similar items.

G. Exterior Duct: Provide supports for exterior ductwork as shown in SMACNA HVAC Duct Construction Standards; spacing as specified herein.

H. End of Duct: At end of duct run, hanger shall be located no more and ½ the allowed hanger spacing from the end of the run.

3.04 CEILING AIR INLETS/OUTLETS

A. Ceiling mounted air inlets, outlets or accessories weighting less than twenty pounds shall be positively attached to the ceiling suspension main runners (or ceiling support members) or to cross runners with the same carrying capacity as the main runners (or support members).

B. Terminals or services weighing twenty pounds but not more than fifty-six pounds, in addition to the above, shall have two no. 12 gauge wire hangers connected from the terminal or service to the ceiling system hangers or to the structure above. These wires may be slack.

C. Terminals or services weighing more than fifty-six pounds shall be supported directly from the structure above by approved hangers.

3.05 INSTALLATION OF MECHANICAL EQUIPMENT ANCHORS AND SUPPORTS

A. Provide anchoring and supports for all mechanical equipment. All equipment shall be anchored to building structure.

B. Heating, Ventilating and Air Conditioning equipment where suspended from the structure shall be supported using the methods shown in SMACNA and as shown on the drawings.

C. Roof Mounted equipment shall be installed on roof curbs provided with the equipment (unless indicated otherwise). Such equipment shall be anchored to the curb, with the curb in turn anchored to building structure.

D. Equipment shall be supported and anchored in such a way so that no equipment vibration is transmitted to the building structure (see Section 15200).

E. Added supports and bracing shall be provided to prevent swaying and horizontal movement of equipment (see Section 15200).

END OF SECTION

SECTION 15095

SLEEVES AND SEALS

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Pipe Sleeves.

B. Duct Sleeves.

C. Duct Closure Collars.

D. Division 15 Fire Stop Seals.

E. Division 15 Non-Fire Stop Seals.

1.02 **RELATED WORK**

A. Division 15 – All Piping.

B. Division 15 – All Ductwork.

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **DEFINITIONS**

A. Installed in a specific way in openings in a specific rated assembly to restore the fire rating and smoke resistance properties of the assembly.

B. Fire Stop Seal: Same as “Fire Stop System”.

C. Rated Assembly: Wall, floor, roof, ceiling, roof/ceiling or other construction which is required (by code of the Contract Documents) to have a fire-resistance rating or to be a smoke barrier.

1.05 **SUBMITTALS**

A. Shall comply with Section 15010.

B. Provide product data on all material to be used. Provide MSDS for all sealants, caulks and similar materials. Indicating VOC limits.

C. Provide fire stop system shop drawings showing:

1. Listing agency's detailed drawing showing opening, penetrating items, and fire stop materials. Drawing shall be identified with listing agency's name and number or designation; fire rating achieved, and date of listing for each fire stop system.

2. Identify where each fire stop system is to be sued on the project.

3. Manufacturer's installation instructions.

4. For proposed systems that do not conform strictly to the listing, submit listing agency's drawing marked to show modifications and stamped approval by the fire stop system manufacturer's fire protection engineer.

5. Other data as required by the AHJ.

D. Shop drawings of proposed sealing/flashing assembly for roof and exterior wall penetrations.

1.06 **REFERENCES**

A. ASTM A 36: Standard Specification for Carbon Structural Steel.

B. ASTM E 84: Standard Test Method for Surface Burning Characteristics of Building Materials.

C. ASTM E 814: Standard Test Method for Fire Tests of Through-Penetration Fire Stops.

D. UL 1479: Standard for Fire Tests of Through-Penetration Fire Stops.

E. UL 723: Surface Burning Characteristics of Building Materials.

F. SMACNA-DCS: SMACNA HVAC Duct Construction Standards, 3rd Edition.

G. SMACNA-ARCH: SMACNA Architectural Sheet Metal Manual, 6th Edition.

H. South Coast Air Quality Management District (SCAQMD), Rule #1136, 2005.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Fire Stop Seal Materials: 3M, Dow Corning.

C. Non-Fire Stop Materials: 3M, GE, Dow Corning.

2.02 **PIPE SLEEVES**

A. Size: Inside diameter of pipe sleeves shall be at least ½ inch larger than the outside diameter of the pipe or pipe covering (for covered piping systems), so as to allow free movement of piping. Provide a larger space around pipe exterior where required by code, where noted, or where required to accommodate more than ½ inch piping movement.

B. Ends: Sleeve ends shall be cut flush with finished surfaces, except in rooms having floor drains where sleeves shall be extended ¾ inch above finished floor.

C. Material-Structural: Sleeves through structural elements shall be fabricated from Schedule 40 steel pipe.

D. Material-Non-Structural: Sleeves through non-structural elements shall be fabricated from 18 gauge galvanized sheet metal, 24 gauge spiral duct, or schedule 10 PVC.

2.03 **DUCT SLEEVES**

A. Size: Inside dimension of sleeves shall be at least ½ inch larger than the outside dimensions of the duct or duct covering on all sides. Provide a larger space around duct exterior where required by code, where noted, or where required to accommodate more than ½ inch duct movement.

B. Ends: Sleeve ends shall be cut flush with finished surface.

C. Material – Non-structural: Sleeves shall be fabricated from 20 gauge galvanized steel, shall be continuous around the interior without holes or openings, and shall match the configuration of the item being sleeved.

D. Material-Structural: Sleeves through structural elements shall be fabricated from Schedule 40 steel pipe for round openings, and welded steel supporting elements using 3" x 3" x 3/8" steel angles per ASTM A36 (unless other sizes/arrangements are shown on drawings) for other openings.

2.04 DUCT CLOSURE COLLARS

A. General: Closure collars shall provide closure of opening between duct and opening in element penetrated and shall abut tight up to and overlap duct and shall consist of rolled angle material (for round ducts) and welded framed angles (for rectangular and round ducts).

B. Size: Closure collars shall be sized to match duct and opening applied to and shall have minimum 2-inch overlap on duct side and 2-inch overlap at opening/penetrated element side but shall be completely cover opening in element penetrated with minimum 1-inch overlap to undistributed element (i.e. wall, floor, etc.).

C. Material: Closure collars shall be fabricated of 20 gauge galvanized steel for ducts 15 inches diameter and less and shall be fabricated of 18 gauge galvanized steel duct for all larger ducts and all square and rectangular ducts.

2.05 FIRESTOP SEALS

A. General: Commercially manufactured through-penetration and membrane-penetration fire stop systems to prevent the passage of fire, smoke and gases, and to restore the original fire-resistance rating of the barrier penetrated.

B. Listing: Fire Stopping shall be listed by UL in "Fire Resistance Directory" (category to match the application), or be qualified by another independent agency acceptable to the AHJ.

C. Rating: Fire stop system and devices shall be tested in accordance with ASTM E 814 or UL 1479, with "F" and "T" ratings are required to maintain the fire-resistance rating of the barrier penetrated, and as required by code.

D. Fire Hazard: Materials shall have a flame spread of 25 or less, and a smoke development rating of 50 or less; when tested in accordance with ASTM E 84 or UL 723.

E. Cabling Applications: Fire stop systems used with loose electrical cabling shall be the type that allows for removal of the cable or installation of new cables without damage to the fire stop system, or the need to replace or repair fire stop materials.

F. Insulation: Fire stop system shall be applicable to insulated systems to allow the insulation to run continuous through the fire stop system (unless noted otherwise).

G. Fire stop sealants shall not exceed VOC limits set forth by South Coast Air Quality Management District (SCAQMD), Rule #1136, 2005.

2.06 **NON-FIRESTOP SEALS**

A. General: Sealants shall not exceed VOC limits set forth by South Coast Air Quality Management District (SCAQMD), Rule #1136, 2005.

B. Seals in Exterior Masonry Walls and Floors, and Outside Vaults:

1. Piping:

a. All except Fire Service Lines seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. The seal assembly shall expand when mechanically tightened to provide an absolute water-tight seal between the pipe and the wall opening. Sizing shall be per manufacturer's recommendations. Seal shall be Thunderline "Link-Seal" (or approved).

b. Fire Service Lines: Provide silicone type flexible sealant, to seal pipe annular space but still allow free movement of pipe in case of settlement.

2. Ducts: Silicone type sealant, designed for use with duct material involved as weatherproof sealant and as specified in Section 07900 (07920).

C. Seals in Other Areas: Packed fiberglass or wool insulation, where no weatherproofing or adhesive properties are required; otherwise, sealants shall be silicone type, as specified in applicable.

PART 3 – EXECUTION

3.01 **INSTALLATION OF PIPE SLEEVES**

A. Provide pipe sleeves for all piping passing through walls, floors, partitions, roofs, foundations, footings, grade beams, and similar elements, except that sleeves are not required for penetrations through existing single solid elements, having no voids, at the location where the piping passes through the solid element (e.g., solid wood stud, core drilled solid concrete, plywood, etc.). Where a sleeve is required, such sleeve shall continue all the way through any solid items within that element however.

B. Set sleeves plumb or level (or sloped as required for drainage pipe) in proper position, tightly fitting into the work.

C. Fill openings around outside of pipe sleeve with same materials as surrounding construction, or with material of equivalent fire and smoke rating.

D. Seal around all pipes inside of pipe sleeve.

E. Insulation shall run continuous through sleeves.

3.02 **INSTALLATION OF DUCT SLEEVES**

A. Provide duct sleeves for all round ducts less than 15 inches in diameter where the duct passes through any floors, walls, ceilings, partitions, or roofs and similar elements.

B. Provide duct sleeves for all square and rectangular ducts having their largest dimension 14 inches and less where the duct passes through any floors, walls, ceilings, partitions, roofs, and similar elements.

C. Round ducts larger than 15 inches in diameter, and square or rectangular ducts larger than 14 inches in any dimension, shall have framed openings where the duct passes through any element. Such framed openings shall be of the same type as the structural materials used in the wall and shall comply with materials specified for this project. Sleeves shall be provided in addition to the framed opening where any void space(s) occurs through the penetration (as through CMJ walls, double walls, etc.).

D. Set sleeves plumb or level, in proper position and location, tightly fitted into the work.

E. Fill openings around outside of duct sleeve with same material as surrounding construction, or with material of equivalent fire and smoke rating.

F. Sleeves are not required for penetrations through existing single solid elements, having no voids, at the location where the duct passes through the element (e.g., precast concrete panels with pre-framed openings, core drilled/saw cut solid concrete, etc.). Where a sleeve is required, such sleeve shall continue all the way through any solid items within that element however.

G. Insulation shall run continuous through sleeves.

H. Sleeves for fire dampers shall be as specified for fire dampers and be in compliance with the damper listing (see Section 15860).

3.03 CLOSURE COLLARS

A. Closure collars shall be provided for all exposed ducts on each exposed penetration where the duct passes through any floors, walls, ceilings, roofs, partitions, and similar elements. Closure collars shall additionally be provided where so noted on the drawings and at all duct penetrations into mechanical rooms, boiler rooms, and rooms housing mechanical equipment (on both sides of the penetration).

B. Collar shall be installed tight against surfaces and shall fit snugly around the duct or duct covering.

C. Sharp edges of the collar around insulated duct shall be ground smooth to preclude tearing or puncturing the insulation covering or vapor barrier of insulated ducts.

D. Collars shall be anchored to element penetrated, with fasteners appropriate to material fastening to, on maximum 6 inch centers.

3.04 INSTALLATION OF FIRSTOP SEALS

A. At each Division 15 system through-penetration and membrane-penetration in rated assemblies, provide a fire stop system. Fire stop system shall be installed in accordance with the manufacturer's instructions, listing, and as required by code.

B. Contractor is responsible to select the fire stop systems to be utilized; corresponding to the construction of the assembly penetrated, and types of penetrations for this project. Contractor shall submit proposed fire stop systems

to be utilized, shall also review such systems with the AHJ and obtain AHJ approval.

C. Prepare surfaces as recommended by fire stop material manufacturer. Examine and confirm that conditions are acceptable to proceed with the installation. Provide maskings and temporary coverings to prevent contamination or defacement of adjacent surfaces.

D. Notify Architect/Engineer when fire stopping work is complete and ready for inspection. Provide minimum seven (7) days notice to allow scheduling of review. An independent testing agency may be utilized to perform the inspection.

E. Notify AHJ when fire stopping work is complete and ready for inspection. Provide sufficient advance notice to allow scheduling of the inspection without adversely impacting project schedule.

F. Do not cover or conceal fire stopping until all inspections have been satisfactorily completed.

3.05 **INSTALLATION OF NON-FIRESTOP SEALS**

A. Provide seals around all piping and ducts passing through walls, floors, roofs, foundations, footings, grade beams, partitions, and similar elements.

B. Seals shall be watertight where the penetration may be exposed to water or moisture.

C. Duct penetrations through roof or exterior wall assemblies shall be provided with flashings for a weathertight assembly in accordance with SMACNA-DCS and SMACNA-ARCH. Such openings shall be sealed to be completely weatherproof. Where not detailed on the plans, the Contractor shall detail his proposed sealing/flashing assembly, and submit shop drawings to the Architect/Engineer for review.

END OF SECTION

SECTION 15140

PUMPS

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Domestic Circulators.

B. Wet Rotor Circulators.

C. End Suction Pumps.

1.02 **RELATED WORK**

A. Section 15060 – Pipe and Pipe Fittings.

B. Section 15080 – Piping Specialties.

C. Section 15410 – Domestic Water Piping System.

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **SUBMITTALS**

A. All submittals shall comply with Section 15010.

B. Provide product information and performance data for all pumps.

C. Performance data shall include pump curves, showing pump performance as head vs. GPM, BHP and NPSH vs. GPM, with system operating point clearly marked. (NPSH vs. GPM not required for pumps 1 HP and less.)

1.05 **QUALITY CONTROL**

A. Manufacturer shall be ISO-9001 approved.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Domestic Circulators and Wet Rotor Circulators: Bell & Gossett, Grudfos.

C. End Suction Pumps: Bell & Gossett.

2.02 **GENERAL**

A. Balancing: All rotating parts shall have been statically and dynamically balanced at the factory.

B. Alignment: Pump and motors shall be factory aligned, and have alignment checked and reset once installed in place.

C. RPM: Pumps and motors shall operate at 1750 rpm unless indicated otherwise.

D. Pump Capacity: Shall be no less than the values listed on the Mechanical Equipment Schedule on the drawings.

E. Pump Types: the type of each pump is indicated on the Mechanical Equipment Schedule under the “Type” column, and corresponds to the types specified herein.

F. Motors: Shall comply with Section 15010. Motors shall be of sufficient size so as to be non-overloading at any point on the operating curve and shall be no smaller than the size shown on the drawings. Motors shall be of drip-proof construction (unless indicated otherwise), resilient mounted with oil lubricated journal or ball bearings, and have built-in thermal overload protectors. Motors shall be for use with the voltage and phase as scheduled on the drawings.

G. Domestic Water Applications: Pumps used on domestic water systems shall be of all-bronze construction.

H. Testing: All pumps shall be factory tested per the Hydraulic Institute standards and be thoroughly cleaned.

I. Finish: Pumps shall have minimum one (1) coat high grade machinery enamel finish, factory applied, manufacturer’s standard color.

J. Nameplate: Pumps shall have stamped metal nameplates identifying: manufacturer, model number capacity (gpm and head), and date of manufacturer.

K. Variable Speed Application: Pumps used with variable speed drives shall have motors that are compatible with the variable frequency drive unit and shall have suitable couplings and accessories to suit variable speed duty.

2.03 **DOMESTIC CIRCULATORS**

A. Type: Centrifugal, single stage, close couple, in-line pump for domestic water circulation. Bell & Gossett Series PL (or approved).

B. Operating Range: Pump shall be rated for continuous operation at 150 psi working pressure and 225° F.

C. Construction: Bronze body, mechanical carbon/silicone carbide seal system, stainless steel face plate, and permanently lubricated sealed bearings.

2.04 **END SUCTION PUMPS**

A. Type: Centrifugal, single stage, vertical split, end suction base mounted pump. Pump shall be compatible for use with 15900 variable frequency drive Bell & Gossett Series 1510 (or approved).

B. Operating Range: Pump shall be rated for continuous operation at a minimum of 175 psi and 250° F.

C. Volute: Cast iron construction (except shall be of bronze construction where pump is noted as “all bronze”), with plugged gauge tapings at inlet and outlet, and an integrally cast support foot centered beneath volute. Shall have flanged suction and discharge connections, pressure class to match piping system connected to.

D. Impeller: Cast bronze, fully enclosed, keyed to shaft and secured with stainless steel locking cap screw.

E. Shaft: High strength steel, with bronze or stainless steel replaceable shaft sleeves. Where “all bronze” pump is noted, shaft shall be Type 416 stainless steel. Shaft shall be coupled to motor with flexible, center drop-out type coupler, with coupling guard. Shaft support bearings shall be regreasable roller or ball bearings.

F. Seal: Internally self-flushing mechanical seal, with carbon seal ring and ceramic or tungsten carbide seat, and Buna-N bellows, stainless steel spring, and metal parts of stainless steel or brass construction.

G. Base: Pump and motor shall be mounted on a heavy structural steel baseplate, with welded cross members, fully enclosed sides and ends, and open grouting area.

H. Service: Entire rotating assembly shall be removable for service (back pull-out arrangement) without disturbing pump piping or motor.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Install pumps at locations shown on the drawings.

B. Decrease from line size to pump inlet size with long radius reducing elbows and minimum five-pipe diameter straight pipe into pump (except where suction diffusers are used). Where reducers (in the horizontal) are used on pumps, they shall be the eccentric type installed with taper on the bottom.

C. Provide suction diffusers at entrance to base mounted pumps. Except provide long radius elbows and straight pipe at entrance to base mounted pumps that serve cooling towers.

D. Provide flexible connectors in piping to base mounted pumps.

E. Grout in base mounted pumps after pumps have been set.

F. Check motor alignment after pump installation, re-align as necessary.

G. Check pump operation to ensure that specified flows are provided, without motor unloading or pump cavitation. Notify the Architect/Engineer of any unusual conditions or performance other then as specified.

END OF SECTION

SECTION 15200

SEISMIC CONTROL

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Seismic Restraints.

1.02 **RELATED WORK**

A. Division 15 – Mechanical.

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **DEFINITIONS**

A. “Equipment” is defined to mean any item with power connections (fans, HV units, water heaters, air compressors, etc.), and also to include all hoods; but does not include pumps less than 3 hp.

1.05 **SUBMITTALS**

A. Submittals shall comply with Section 15010.

B. Submit product data on all items to be used.

C. Submit shop drawings for all fabricated support assemblies.

D. Submit calculations showing seismic restraint calculations, restraint selection, proposed locations of all seismic control bracing, and details of bracing construction.

1.06 **GENERAL REQUIREMENTS – SEISMIC RESTRAINTS**

A. Piping and ductwork seismic restraints are typically not shown on the drawings but are to be provided as specified herein.

B. Seismic bracing for fire sprinkler system shall be as specified per NFPA 13 but in no case be less than that required in this Section.

C. Contractor is responsible to select and provide all seismic anchoring devices for all mechanical equipment, all piping, and all ductwork.

1.07 **REFERENCES**

A. IBC: International Building Code.

B. IMC: International Mechanical Code.

C. MASON: Mason Industries Seismic Restraint Guidelines for suspended piping, Ductwork, Electrical Systems and Floor Mounted Equipment, 2005 6th Edition.

D. OSHPD: Office of Statewide Health Planning and Development, State of California, Fixed Anchorage.

E. SMACNA/SRM: Seismic Restraint Manual Guidelines for Mechanical Systems, 2nd Edition.

F. UPC: Uniform Plumbing Code.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Expansion Devices/Flexible Connectors: Unisource Manufacturers and as specified in Section 15080 and 15860.

2.02 **SEISMIC RESTRAINTS**

A. General: Shall be as required by Code, and shown in SMACNA-SRM and MASON.

B. Materials:

1. Steel shall be per ASTM A36; hangers and other devices shall be per Section 15090 and as shown in SMACNA-SRM or MASON. Sheet metal used for bracing shall be no less than 16 gauge. Material for straps shall be galvanized steel, no less than 18 gauge.

2. Cabling: Cables shall be minimum 1/8" diameter, 7 x 19 strand, galvanized steel with clear vinyl coating. Provide with galvanized thimble, clamps, and accessories. End termination and clamping/application shall comply with SMACNA-SRM.

C. Flexible Connectors:

1. Piping Systems:

a. Flexible Connectors: As specified in Section 15080.

b. Seismic "V" Connectors: "V" design connector with braided hose and attachment fittings. Shall be constructed of type 321 stainless steel hose and braid with carbon steel elbows and ends (for steel piping systems); and bronze hose and braid with copper elbows and ends (for copper piping systems). Unit shall allow for 2" movement in all planes, and have minimum 150 psi working pressure at the system temperature installed. Unisource Manufacturing (or approved).

2. Ductwork: Flexible connectors as specified in Section 15860.

PART 3 – EXECUTION

3.01 **SEISMIC RESTRAINTS**

A. Ductwork: Longitudinal and transverse bracing shall be required for all round ducts 28 inches in diameter and larger, for rectangular ducts 6 square feet and larger, and on all duct systems used for life safety and smoke control installed in either the horizontal or vertical position.

Bracing shall be applied as follows:

1. Transverse bracing shall occur at maximum intervals of 30 feet, at each duct turn and at the end of a duct run.

2. Longitudinal bracing shall occur at maximum intervals of 60 feet. Transverse bracing for one duct section may also act as longitudinal bracing for a duct section connected perpendicular to it, if bracing is installed within 4 feet of the intersection and sized and installed on the larger duct.

3. Groups of ducts may be combined in a larger size frame using overall dimensions and maximum weight of ducts. At least two sides of each duct must be connected to the angles of the brace.

4. Walls, including non-bearing fixed partitions which have ducts running through them, may replace a transverse brace.

5. Bracing may be omitted when the top of the duct is suspended 12 inches or less from the supporting structural members and on roof top ductwork.

B. Piping: Longitudinal and transverse bracing shall be required for all piping 2-1/2 inch diameter and larger and on all fuel gas piping 1-inch and larger. Bracing shall be applied as follows:

1. Transverse bracing shall occur at maximum intervals of 40 feet, except on fuel gas piping on maximum intervals of 20 feet.

2. Longitudinal bracing shall occur at maximum intervals of 80 feet, except on fuel gas piping on maximum intervals of 40 feet. Transverse bracing for one pipe section may also act as a longitudinal bracing for a pipe section connected perpendicular to it, if the bracing is installed within 2 feet of the elbow or tee of similar size. Piping conveying fluids at 100° F and higher shall have expansion devices provided in-between longitudinal braces to allow for thermal expansion.

3. Bracing may be omitted when the top of the pipe is suspended 12 inches or less from the supporting structural member and the pipe is suspended by an individual hanger.

C. Equipment:

1. Equipment Not Requiring Vibration Isolation: Shall be rigidly connected to the structure per Section 15090. Equipment anchoring system shall be able to withstand anticipated seismic forces.

a. Base Mounted Equipment: Where the height of the equipment is three (3) or more times the smallest base dimension, provide seismic bracing to resist horizontal forces equal to the weight of the equipment and vertical force equal to the weight of the equipment. Provide elastomeric (or neoprene) pads (1/4” thick) between seismic strap and equipment.

b. Other Equipment: Where equipment is 36” or more from the supporting structure provide seismic bracing to resist anticipated forces; but in no case shall the anticipated forces be less than: horizontal forces equal to the weight of the equipment and vertical force equal to the weight of the equipment (applied at equipment center of gravity).

3. Equipment with External Vibration Isolators:

a. Base Mounted Equipment: Provide spring isolators, seismic snubbers, or padded steel angle restraint assembly (with minimum ¼” clearance between pad and equipment); sized to resist horizontal forces equal to the weight of the equipment and vertical force equal to the weight of the equipment.

b. Other Equipment: Where equipment is 36” or more from the supporting structure provide slacked cable bracing to allow slight movement, but installed so as to prevent more than 2” motion in any direction. Size bracing to resist horizontal forces equal to the weight of the equipment and vertical force equal to the weight of the equipment.

D. Do not use brace ducts or piping to brace main runs.

E. Do not brace same main duct or piping to dissimilar parts of a building or dissimilar building systems that may respond in a different mode during an earthquake. (Examples: wall and roof, solid concrete wall and lightweight roof, existing building structure and new isolated building structure.)

F. At building expansion joint crossings, provide seismic “V” connectors in piping allowing at least 1 inch movement in all directions and flexible connectors in ductwork (on both sides of expansion joint) allowing at least ½ inch movement in all directions.

3.02 **TEST AND INSPECTION**

A. Field Inspections: Prior to initial operation, the seismic devices shall be inspected for conformance to drawings, specifications, and manufacturer’s data and instructions. Check all flexible connectors/expansion devices for proper location, guiding, and end anchoring.

B. Tests: Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels. Re-balance, adjust, or replace machinery with noise or vibration levels in excess of those given in the machinery specifications or machinery manufacturer's data. Check for proper operation of expansion devices and associated items during systems warm-up.

END OF SECTION

SECTION 15205

MECHANICAL VIBRATION CONTROLS

PART 1 – GENERAL

1.01 **RELATED DOCUMENTS**

A. Mechanical system Contractor to furnish, install, and adjust all vibration isolation components and materials required to isolate the building structure and occupied spaces from vibrating equipment, piping and ductwork, as specified by this Section.

B. General Provisions of the Contract and applicable requirements of Division 1 and this Section apply to the Work specified in this Section.

C. Division 24 – Electrical Systems

1.02 **SUBMITTALS**

A. Installing Contractor shall submit complete product data in accordance with the General Provisions of the Specifications before any materials are delivered to the job site.

B. Contractor shall submit to the Acoustical Consultant shop drawings showing the following information so that isolation system can be checked for compliance with the specifications:

1. Sizes, placement and type of isolators, seismic snubbers, and total base mass (weight) if it is a concrete inertia base.

2. Weight distribution on isolators.

3. Equipment operating speed.

4. Isolator schedule to show size, type, load, and static deflection of each isolator.

5. Number and color-code of each isolator to show its location.

6. Isolator adjustment procedures for setting and adjusting the isolation devices so that the isolator mount selections can be checked for compliance with the specification.

C. When manufacturers provide equipment bases, Contractor shall submit calculations verifying factory base stiffness is equal or equivalent to stiffness of base specified in the Vibration Isolation Schedule.

1.03 **EQUIPMENT VIBRATION ISOLATION**

A. The installing Contractor to furnish a balanced set of vibration isolators for each piece of equipment listed in the Vibration Isolation Schedule.

B. Isolation work to include, but not necessarily be limited to, the following:

1. Supported isolation of motor-driven equipment.

2. Inertia base frames in conjunction with isolation.

3. Isolation support of air-handling housings.

4. Isolation support of piping, piping risers, and ductwork.

5. Penetration isolation of pipes and ductwork through walls, floors or ceilings.

6. Flexible connections of ductwork and piping to equipment.

D. Each piece of rotating equipment must meet a reasonable criterion for maximum vibration levels at each bearing, while in operation. The criterion is as follows:

1. Rotating equipment operating peak vibration velocities must not exceed 0.08 in/sec.

2. If it is discovered that the operating vibration velocities exceed this criterion, the equipment shall be repaired or replaced at no expense to the Owner until approval of the equipment is given by the Acoustical Consultant.

E. Installing Contractor to provide any components or materials not specifically mentioned herein, but necessary to the proper vibration isolation of the equipment.

1.04 **ACCEPTABLE MANUFACTURERS**

A. Amber Booth

B. Mason Industries, Inc.

C. Kinetics Corporation

D. Approved equal, meeting all of the conditions and requirements specified herein.

1.05 **PROJECT ACOUSTICAL CONSULTANTS**

A. The Acoustical Consultants for this project are:

Noel Frederick Sparling
720 Olive Way, Suite 1400
Seattle, Washington 98101
Phone: (206) 667-0555
Fax: (206) 667-0554
Email: nfrederick@Sparling.com

1.06 **CONTRACTOR RESPONSIBILITY**

A. All vibration isolation devices, including auxiliary steel bases and pouring forms, shall be designed and furnished by a single manufacturer or supplier.

B. The Contractor shall adequately restrain all equipment, piping, and ductwork to resist seismic forces. Design and select restraint devices to meet seismic requirements as defined in the latest issue of the International Building Code and applicable state and local codes in accordance with project area Seismic Zone with a minimum restraint capability of 1.0 g.

C. The Contractor shall coordinate with the structural engineer to ensure mounting attachment points for seismic restrained springs and seismic snubbers will withstand forces generated from the maximum acceleration rating of the restrained springs and snubbers.

D. In addition, the Contractor shall have the following responsibilities:

1. Select, install, adjust and verify the performance of vibration isolators that will meet the requirements given on the plans or in the specifications.

2. Bring to the Acoustical Consultant's attention any equipment specified for the project that is not covered in the Vibration Isolation Schedule herein.

3. Provide whatever assistance necessary to ensure correct instillation and adjustment of the isolators.

F. Changes or additions necessary to meet the requirements given on the plans or in the specifications are to be made without any expense to the Owner.

1.07 **QUALITY ASSURANCE**

A. Isolators shall operate in the linear portion of their load-versus-deflection curve.

B. The ratio of lateral to vertical isolator stiffness shall be not less than 0.9 nor greater than 1.5.

C. The Contractor shall bring to the attention of the Acoustical Consultant any discrepancies between this Section and other related documents.

PART 2 – PRODUCTS

2.01 **MATERIALS**

A. Where exposed to the atmosphere, all steel shall be finished with dry powder coating for corrosion protection; hardware (bolts and cap screws) shall be zinc electroplated; springs shall be dry powder coated.

2.02 **ISOLATORS**

A. Type S-1: Bare Spring

1. Spring isolator without housings or snubbers.

2. Isolator shall be equipped with leveling bolts and 1 layer ribbed or waffled neoprene pad.

3. Isolator shall be installed with Type WB-1 neoprene washers and bushings at base plate anchor bolts.

4. Isolator shall have minimum operating static deflection as tabulated in the Vibration Isolation Schedule.

5. Spring diameter(s) shall be not less than 0.8 of the compressed height of the spring at rated load.

6. Spring(s) shall have minimum additional travel to solid equal to 50 percent of rated deflection.

7. Acceptable Products:

    a. Model SLF by Mason

    b. Model FDS by Kinetics

B. Type S-2: Housed Spring

1. Spring isolator designed shall be free-standing and laterally stable.

2. Isolator shall be equipped with ¼ inch thick neoprene acoustical friction pads between the base plate and the support, and between top plate and equipment.

3. Isolator shall be equipped with leveling bolts that must be rigidly bolted to the equipment.

4. Isolator shall be installed with Type WB-1 neoprene washers and bushings at base plate anchor bolts.

5. Isolator to have minimum operating static deflection as tabulated in the Vibration Isolation Schedule.

6. Spring housing to include vertical limit stops to prevent spring extension when weight is removed.

7. Limit stops shall not make contact with housing during normal operation.

8. Spring housing to have a minimum clearance of ½ inch around the restraining bolts and between the housing and the spring so as not to interfere with the spring action.

9. Spring diameter(s) shall be not less than 0.8 of the compressed height of the spring at rated load.

10. Spring(s) shall have minimum additional travel to solid equal to 50 percent of rated deflection.

11. All isolators shall be marked to show their height before loading to verity proper isolation after installation.

12. All isolators for a single piece of equipment shall have approximately equal deflection.

13. All equipment shall be mounted level.

14. Acceptable Products:

    a. Model SLR by Mason

    b. Model FLS by Kinetics

C. Type S-3: Spring Seismic Restraint

1. Spring isolator designed to resiliently resist forces in all directions.

2. Snubbing in all modes with adjustment to limit upward, downward and horizontal travel to a maximum rating of 1.0 g.

3. Isolator shall be equipped with ¼ inch thick neoprene waffle pad bonded to the bottom of the base plate.

4. Isolator shall be equipped with leveling bolts that must be rigidly bolted to the equipment with height-saving brackets.

5. Isolator shall be installed with Type WB-1 neoprene washers and bushings at base plate anchor bolts.

6. Isolator to have minimum operating static deflection as tabulated in the Vibration Isolation Schedule.

7. Spring diameter(s) shall be not less than 0.8 of the compressed height of the spring at rated load.

8. Spring(s) shall have minimum additional travel to solid equal 50 percent of rated deflection.

9. Isolators shall have mounting ports for spring inspection.

10. Mounts shall have an anchorage Preapproval “R” Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings.

11. Acceptable Products:

    a. Model SSLFH by Mason

    b. Model FHS by Kinetics

    c. Model FEQ by McDougall Control

D. Type N-1: Double-Deflection Neoprene Mount

1. Isolator shall contain a cast-in tapped steel load plate to permit bolting to the supported equipment.

2. Isolator shall be installed with additional restraints to prevent excess motion during start-up or in response to external loads, such as earthquakes.

3. Isolator shall be selected to provide the minimum operating static deflection tabulated in the Vibration Isolation Schedule, while not exceeding the published load capacity for the isolator used.

4. Isolator shall have a minimum static deflection of 0.35 inch.

5. Each isolator shall be color-coded to identify the load capacity.

6. Acceptable Products:

    a. Model ND by Mason

    b. Model RD, KIP by Kinetics

E. Type N-2: Neoprene Seismic Mount

1. Captive neoprene mounting shall consist of a steel housing with a captive steel insert embedded in neoprene to prevent contact between the housing and the central threaded insert.

2. Isolator shall contain a cast-in tapped steel load plate to permit bolting to the supported equipment.

3. Snubbing to limit deflection in upward, downward, and horizontal directions. Capacity to withstand not less than 1.0 g without noticeable deformation.

4. Isolators shall be selected to provide the minimum operating static deflection tabulated in the Vibration Isolation Schedule, while not exceeding the published load capacity for the isolator used.

5. Isolator shall have a minimum deflection of 0.15 inch.

6. Each isolator shall be color-coded to identify the load capacity.

7. Acceptable Products:

    a. Model RCA, RBA by Mason

    b. Model RQ by Kinetics

F. Type N-3: Neoprene Seismic Mount

1. Captive neoprene mounting shall be arranged in opposition within a steel or ductile iron housing to provide mechanical restraint in all directions.

2. Isolator shall contain a cast-in tapped steel load plate to permit bolting to the supported equipment.

3. Snubbing to limit deflection in upward, downward, and horizontal directions. Capacity to withstand not less than 1.0 g without noticeable deformation.

4. Isolators shall be selected to provide the minimum operating static deflection tabulated in the Vibration Isolation Schedule, while not exceeding the published load capacity for the isolator used.

5. Isolator shall have a minimum static deflection of 0.20 inch.

6. Each isolator shall be color-coded to identify the load capacity.

7. Acceptable Products:

    a. Model BR by Mason

G. Type N-4: Neoprene Pad

1. Isolator shall consist of 5/16 inch to 3/8 inch thick molded neoprene.

2. Pad shall be either a ribbed or waffle type construction.

3. Isolator shall have a 40 to 50 durometer rating.

4. Isolator shall be loaded to limit surface pressure to a maximum of 50 psi.

5. Isolator shall be equipped with a steel plate bonded to the neoprene pad if required for proper load distribution.

6. Acceptable Products:

    a. Model W, WM by Mason

    b. Model NPD, NG by Kinetics

H. Type N-5: Neoprene Pad

1. Isolator shall consist of ¾ inch thick molded neoprene.

2. Pad shall be either a ribbed or waffle type construction.

3. Isolator shall have a 50-durometer rating.

4. Isolator shall be loaded to limit surface pressure to a maximum of 50 psi.

5. Isolator shall be equipped with a steel plate bonded to the neoprene pad if required for proper load distribution.

6. Acceptable Products:

    a. Model Super W by Mason

    b. Model RSP by Kinetics

I. Type H-1: Spring Hanger

1. Hanger to consist of a combination of a steel spring and a fiberglass or neoprene isolator placed in series and encased in a welded steel bracket.

2. Isolator to have minimum operating static deflection as tabulated in the Vibration Isolation Schedule.

3. Isolator shall be designed to carry five (5) times overload without failure.

4. Spring shall have minimum additional travel to solid equal to 50 percent of rated deflection.

5. Isolator shall be installed to allow up to fifteen (15) degrees of rod misalignment without metal-to-metal contact or other isolation short circuit.

6. Acceptable Products:

    a. Model 30N by Mason

    b. Model SRH by Kinetics

    c. Model BSRA by Amber Booth

J. Type H-2: Neoprene or Fiberglass Hanger

1. Hangers to consist of a neoprene-in-shear of fiberglass isolator encased in a welded steel bracket.

2. Hangers to have a minimum operating static deflection of 0.25 inch.

3. Acceptable Products:

    a. Model HD by Mason

    b. Model FH by Kinetics

K. Type H-3: Pre-compressed Spring Hanger

1. Hanger to consist of a combination of a steel spring and fiberglass or neoprene isolator placed in series and encased in a welded steel bracket.

2. Hanger shall be pre-compressed to the rated deflection, so as to keep the supported piping or equipment at a fixed elevation during installation.

3. Hanger shall incorporate a release mechanism to free the spring after the installation is complete and the hanger is subjected to full load condition.

4. Isolator to have minimum operating static deflection as tabulated in the Vibration Isolation Schedule.

5. Acceptable Products:

a. Model PC 30N by Mason

b. Model SRPH by Kinetics

L. Type H-4: Neoprene Hanger Mount

1. Hangers to consist of an isolated neoprene bushing with embedded steel washer.

2. Acceptable Products:

a. Model HMIB by Mason

2.03 **BASES**

A. Type B-1: Integral Structural Steel Frame

1. Structural steel support members with welded isolator support brackets and pre-located and drilled anchor bolt holes, supplied by the equipment manufacturer with the equipment.

2. Frame shall be manufactured of beams or channels or minimum section depth equal to 10 percent of the longest span between support isolators, as indicated on the drawings.

3. Frame size and shape shall be as required for equipment to be supported.

4. Frame shall be equipped with welded isolator support brackets to provide the lowest possible mounting height of supported equipment.

5. Frame to provide a rigid, distortion free mounting base for supported equipment, which allows to excessive differential motion between driving or driven equipment components.

6. Frame shall allow for a minimum operating clearance between structural steel frame and floor or housekeeping pad of 1 inch.

7. Isolation materials manufacturer to coordinate the isolator locations for each piece of equipment as required.

8. Acceptable Products:

    a. Model WF by Mason

B. Type B-2: Concrete Inertia Base

1. Framing as described under Type B-1.

2. Base to provide support for equipment without overhang, including pump suction and discharge elbows.

3. Base shall be equipped with equipment anchor bolts fixed into position and housed in a steel bolt sleeve, allowing minor bolt location adjustment.

4. Base to include reinforced concrete with ½ inch reinforcing rods at a maximum of 8 inches on center.

5. Each piece of equipment with its driving motor shall be bolted and grouted to a spring-supported concrete inertia base, reinforced as required.

6. Base to allow for a minimum operating clearance between concrete inertia base and floor or housekeeping pad of 1 inch.

7. Acceptable Products:

    a. Model K by Mason

C. Type B-3: Vertical Steel Hanger Rods

1. Base to consist of four (4) vertical steel hanger rods attached to structure above.

2. Rods shall be sufficient to carry a five (5) times overload without yielding or failure.

3. Unless otherwise specified, hanger Type H-1 shall be used on all four (4) hanger rods in series with the supported load.

4. Rods shall be attached to the support “ears” of the hung equipment. Support “ears” shall be provided by the equipment manufacturer.

5. Coordination of the location of the ears and the method of attachment is the responsibility of the vibration isolator manufacture or its representative.

6. For horizontally mounted vane-axial fans only, mount thrust restraint rods between the fan and a suitable structural element to limit horizontal motion due to air thrust from startup and normal operation to no more than 3/8 inch. Mount hangers Type H-1 on all thrust restrain rods in series with the thrust load.

7. Provide steel cross-bracing rods to base framework above, if needed, to prevent excess motion during equipment startup and operation. Cross bracing rods should be threaded to allow adjustment of tension at one end.

8. Unless otherwise specified, seismic restraint to consist of stainless steel aircraft cables and steel U-bolt clips (restraint Type E-3) attached to the equipment and the structure above.

D. Type B-4: Structural Steel Support Members Designed to Support Vane Axial Fans

1. Base to consist of two (2) horizontal steel beams or channels with a section depth equal to either 8 percent of the longest span between support isolators or a minimum of 4 inches.

2. Horizontal beams shall be supported on both ends by additional steel channels or beams to raise the point of connection between the isolator and the fan to the height of the axis of the fan shaft.

3. Base legs to have cross-bracing to provide a rigid, distortion-free mounting base for supported equipment.

4. Mount thrust restrain rods between all horizontally mounted axial vane fans and a suitable structural element to limit motion due to air thrust from startup and normal operation to no more than 3/8 inch. Mount hangers Type H-1 in all thrust restraint rods in series with the thrust load.

E. Type B-5: Curb Mounted Isolation Base

1. Base consisting of rooftop tubular steel support frame with removable free-standing springs.

2. Base to allow for a flexible air seal and weather seal on sides and ends.

3. Base springs to have nominal static deflection of 1.0 inch, 2.0 inches, or 3.0 inches as specified in equipment Vibration Isolation Schedule.

4. Acceptable Products:

   a. Model RSC by Mason

2.04 **SEISMIC SNUBBERS**

A. General

1. Provide restraints capable of safety accepting external forces as defined in latest issue of International Building Code and applicable state and local codes without failure, to maintain equipment, piping, duct, and variable volume boxes and fan coil units in a captive position.

2. Seismic devices should not interfere with vibration isolation during normal operation. Conflicts between vibration isolation and seismic restraints shall be brought to the attention of the Acoustical Consultant.

3. All seismic mounts shall have an anchorage Pre-approval "R" Number from OSHPH in the State of California verifying the maximum certified horizontal and vertical load ratings.

4. Submit calculations by registered structural engineer to verify snubber capacities.

B. Type E-1: Seismic Restraint

1. Interlocking steel member restrained by shock absorbent rubber materials compounded to bridge-bearing specifications as tabulated in ASTM D-676, ASTM D-412, ASTM D-573, ASTM D-1149, and ASTM D-395.

2. Restraint shall be equipped with replaceable elastomeric materials with minimum thickness of ½ inch.

3. Restraint shall be adjusted to have an air gap separating hard and resilient material between 1/8 inch and ¼ inch.

4. Number and location of snubbers shall be such that snubber load rating is not exceeded. Minimum of four (4) snubbers required.

5. Snubbers shall not be in contact with equipment during normal operation.

6. Acceptable Products:

   a. Model HS-3 by Kinetics

   b. Model ER by Amber Booth

C. Type E-2: Seismic Restraint

1. All-directional seismic snubbers shall consists of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene.

2. Bushing shall be replaceable and a minimum of ¼ inch thick. Rated loadings shall not exceed 1000 psi.

3. A minimum air gap of 1/8 inch (3 mm) shall be incorporated in the snubber design in all directions before contact between the rigid and resilient surfaces.

4. Snubber end caps shall be removable to allow inspection of internal clearances.

5. Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated.

6. Snubbers shall not be in contact with equipment during normal operation.

7. Acceptable Products:

   a. Model Z-1225 by Mason

D. Type E-3: Seismic Restraint Metal Cable

1. Stainless steel aircraft cables and steel U-bolt clips.

2. Cables to attach to equipment frame and to structure with steel angle clips.

3. Cables shall be installed with enough lack to allow proper functioning of vibration isolators during normal operation and to become tight and restrict excessive motion from seismic input.

4. Cables to have a maximum spacing of 20 feet on center for ductwork and piping.

5. Acceptable Products:

    a. Model SCB/SCBH by Mason

2.05 **PIPING ISOLATORS**

A. Type P-1: Piping Mounts

1. Mount to consist of a prefabricated plastic or metal pipe clamp or penetration mount with an integral resilient, elastomeric isolation pad.

2. Isolation pad shall not deteriorate over time or from normal hot water temperatures.

    a. Isolators shall not be used with PVC or plastic pipes.

3. Acceptable Products:

    a. Isolated Pipe Mounts by Acousto-Plumb System

B. Type P-2: Piping Supports

1. Mount to consist of a carbon steel penetration mount with an integral resilient, felt isolation pad.

2. Isolation pad shall not deteriorate over time or form normal hot water temperatures.

3. Acceptable Products:

    a. Isolators for Copper Tubing or I.P.S. Isolators by Tolco Incorporated.

C. Type P-3: Piping Sleeve

1. Sleeve to consist of a ¼ inch to 5/16 inch thick, flexible, resilient isolation pad.

2. Sleeve shall be wrapped around the entire circumference of the pipe to ensure there is no rigid contact between pipe and support.

3. Limit sleeve surface pressure to maximum of 30 psi.

4. Add an additional sheet metal sleeve wrapped around the padded sleeve if necessary for proper load distribution.

5. Sleeve(s) shall be secured in place using duct tape or fastening strap.

6. Acceptable Products:

    a. Model W by Mason

    b. Model NPD, NG by Kinetics

D. Type P-4: All-Directional Pipe Anchor

1. Anchor to consist of telescopic arrangement of two (2) sizes of steel tubing separated by a minimum of ½ inch thick neoprene.

2. Neoprene shall be heavy duty neoprene and duck or neoprene isolation material.

3. Acceptable Products:

    a. Model ADA by Mason

E. Type P-5: All-Directional Pipe Guide

1. Guide to consist of telescopic arrangement of two (2) sizes of steel tubing separated by a minimum of ½ inch thick neoprene.

2. Neoprene shall be a heavy-duty neoprene and duck or neoprene isolation material.

3. Guide height shall be preset with shear pin to allow vertical motion due to pipe expansion/contraction.

4. Acceptable Products:

    a. Model VSG by Mason

2.05 **MISCELLANEOUS SUPPORT**

A. Type WB-1: Neoprene washers and bushings

1. Washer-bushing shall be manufactured of bridge bearing neoprene.

2. Washer-bushing maximum loading not to exceed 1000 psi.

3. Washer-bushing shall be used such that direct contact between bolt and equipment is eliminated.

4. Acceptable Products:

a. Model HG by Mason

B. Type CS-1: Cushion Sleeve

1. Fiberglass sleeve sized to fit pipe.

2. Acceptable Products:

a. Owens Corning Fiberglass 25 ASJ/SSL Service Jacket.

b. Johns Manville Micro-Lok Fiberglass Pipe Insulation.

2.06 **FLEXIBLE CONNECTORS**

A. Type FC-1: Flexible Duct

1. Flexible duct manufactured of flexible neoprene fabric.

2. Acceptable Products:

a. Model “Ventglas” by Vent Fabrics, Chicago

b. Model NFN, NF6N by Duro-Dyne

B. Type FC-2: Neoprene Connection

1. Flexible neoprene connector manufactured of multiple piles of Kevlar fabric and neoprene both molded and cured in hydraulic rubber presses.

2. Connector to have no steel wire, metal braiding, or rings as pressure reinforcement.

3. Straight connector to have twin-sphere cross-section.

4. Elbow connector to have single sphere cross-section forming the corner of the joint.

5. Connector with diameter less than 2-1/2 inches may have threaded ends.

6. Connector 2-1/2 inches diameter and larger to have floating steel flanges recessed to lock the connector's raised face neoprene flanges.

7. Connector shall be installed on the equipment side of the shut-off valves.

8. Connector shall be rated at a minimum of 150 psi at 220° F.

9. Straight connector shall be installed with twin spheres properly pre-extended as recommended by the manufacturer to prevent additional elongation under pressure.

10. Connector shall be equipped with control cables with end fittings isolated from the anchoring plated by means of washers and bushings designed for a maximum of 1000 psi for sizes 8 inches and larger, operating at pressures above 100 psi.

11. Acceptable Products:

    a. Model SFDEJ or SFU by Mason

    b. Control Assemblies Model ACC by Mason

C. Type FC-3: Flexible Stainless Steel Hose

1. Braided flexible stainless steel hose.

2. Hose shall be rated at a minimum of 250 psi at 250° F.

3. Hose shall be installed horizontally and parallel to equipment shaft.

4. Hose shall have a minimum length of 18 inches.

5. Hose for 2 inch pipe size and smaller shall be equipped with male nipple fittings.

6. Hose for 2-1/2 inch pipe size and larger shall be equipped with fixed steel flanges.

7. Hose shall be selected for operating pressure with 4:1 minimum safety factor.

8. Acceptable Products:

a. Model BSS by Mason

2.07 MISCELLANEOUS PRODUCTS

A. Acoustical Insulation

1. Fiberglass

a. ½ to 6 inch thick low density unfaced fiberglass batts.

b. Acceptable Products:

1) Standard by Owens Corning

2. Mineral Fiber

a. 2 to 3 inch thick mineral fiber insulation batts.

b. Acceptable Products:

1) "Thermafiber" by U.S. Gypsum Company, or equal – fire rated.

B. Acoustical Sealant shall meet the following requirements:

1. Sealant shall be a paintable, non-hardening, non-bleeding, non-drying, resilient caulk.

2. Acceptable Products:

a. Acoustical Sealant by U.S. Gypsum Company – paintable

b. 790 Silicone Building Sealant by Dow Corning

c. "Fire Barrier 2000" by 3M Vibration Control Systems – fire rated, paintable with special primer.

d. Non Sag Fire stop Caulk (Part #AA-529/569/542/492) by Nelson – fire rated.

e. CP 606 by Hilti – fire rated, paintable

f. Acoustical Sealant by Tremco – LEED Approved, paintable.

3. Substitutions:

a. Substitutions shall comply with requirements in Division

b. Contractor shall submit the following to the Acoustical Consultant for review and approval of all substitutions for Acoustical Sealant:

1) Manufacturer's product information

2) Manufacturer's product specifications

3) Product sample consisting of a bead of caulk, approximately 3 inches long, ¼ inch high, and ½ inch wide, applied to a portable substrate (i.e. cardboard or paper) and cured according to manufacturer's instructions.

C. Mass-Loaded Vinyl Sheet shall be equivalent to the following products:

1. Sheet shall have a surface weight of at least 1 pound per square foot.

2. Acceptable Products:

a. KNM-100, KNM-100AL, or KNM-100ALQ vinyl sheet by Kinetics

PART 3 – EXECUTION

3.01 **GENERAL**

A. Isolate mechanical equipment from the building structure by means of vibration isolators as scheduled herein and on the Drawings. If there is a conflict between the drawings and the Vibration Isolation Schedule herein, bring this conflict to the Architect and/or the Acoustical Consultant's attention.

B. Install isolation systems (isolators, bases, and related hardware) in accordance with the manufacturer's written Installation Instructions. The Contractor shall procure the written installation instructions from the isolator manufacturers.

C. Vibration isolators must not cause any change in position of equipment or piping resulting in piping stresses or misalignment.

D. Isolated equipment mounting systems must permit equipment motion in all directions.

E. Adjust or provide additional resilient restraints to flexibly limit equipment lateral motion to ½ inch during startup and operation.

F. Prior to startup, clean out all foreign matter between base, isolator, equipment, and mounting surfaces. Verify that there are no rigid connections between equipment and building structure that degrade the vibration isolation systems specified herein.

G. Align isolator rods to clear the isolator housing.

H. Unless otherwise directed by this document, suspend isolators with the isolator hanger housing attached to, or hung as close as possible to, the structure.

I. Do not use wall, floor, or ceiling penetrations to support pipework or ductwork. Support pipe or duct just prior to and just after the penetration, so that the pipe or duct is centered in penetration.

J. Coordinate piping supports with equipment supports to maintain uniformly efficient isolation, expansion, and contraction, without creating excessive stresses at any equipment connection or in any portion of the piping.

K. All ductwork within the shafts shall not be in contact with the walls and shall be anchored to the building structure at the concrete floor only.

L. Do not allow contact between isolated ducts or pipes and non-isolated equipment or structure. “Isolated ducts or pipes” include the isolated portions of their supports or hangers.

M. Non duct elements should not be in contact with any duct hangers.

N. Provide a minimum 2 inch gap between the top of the ductwork and the underside of the floor structure above within all the mechanical rooms.

O. Bring to the Acoustical Consultant’s attention prior to installation any conflicts with other trades which will result in unavoidable rigid contact with equipment or piping as described herein, due to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation will be at the responsible Contractor’s expense.

P. Size anchoring bolts to isolators or snubbers withstand seismic lateral shear and tensile failure and isolate bolts from direct contact with structure using Type WB-1 isolator.

3.02 **VIBRATION ISOLATION SCHEDULE**

A. Water Pumps

Equipment	Isolator	Minimum Deflection	Base	Flexible Connectors	Motion Restraint Snubber	Notes
Circ Pumps	Circ Pumps	S-1	1.0”	B-2	FC-2	E-2

B. Duct Work

Equipment	Isolator	Minimum Deflection	Base	Flexible Connectors	Motion Restraint Snubber	Notes
Supply & Return	H-1	1.0”	N/A	FC-1	-	1

C. Air Conditioning Condensers

Equipment	Isolator	Minimum Deflection	Base	Flexible Connectors	Motion Restraint Snubber	Notes
AC	N-4	N/A		N/A	N/A	- 1, 2

D. Heat Pumps Option 1

Equipment	Isolator	Minimum Deflection	Base	Flexible Connectors	Motion Restraint Snubber	Notes
HP	H-2	0.25”		B-1	FC-3	E-3 1,3 &4

E. Heat Pumps

Equipment	Isolator	Minimum Deflection	Base	Flexible Connectors	Motion Restraint Snubber	Notes
HP	WB-1	N/A		B-1	FC-3 -	1, 3 & 4

F. Notes:

1. See Section 15200 of this specification for the seismic restraints required

2. AC units will be mounted on a concrete pad

3. Bases specified in the schedule can be supplied by the manufacturer of the equipment if they meet the specifications given herein.

4. Attach flex connectors where ductwork attaches on both upstream and downstream sides of unit.

3.03 DUCTWORK ISOLATION

A. If necessary to avoid excessive movement of the ductwork, use Type H-1 isolator as a thrust restraint between high pressure ductwork and mechanical equipment where Type FC-1 flex connector is used between the high pressure duct and the mechanical equipment.

B. Isolate vertical ductwork at floors other than the mechanical room from direct contact with the floor using isolator using Type S-1 with minimum static deflection of 1.0".

C. Different sections of ductwork requiring the same type of isolator with the same minimum static deflection may be supported on a common Unistrut support that is isolated with the same type of isolator.

D. Isolate ductwork penetrations as described under Penetration Isolation.

3.04 PIPEWORK ISOLATION

A. Isolate pipework within the mechanical room(s) or within 50 feet of vibration isolated equipment, whichever is greater, using isolator Type H-1, with minimum static deflection of 1.0 inch, and seismic restraint E-3.

B. Different sections of pipework requiring the same type of isolator with the same minimum static deflection may be supported on a common Unistrut support that is isolated with the same type of isolator.

C. Support vertical piping loads, including water strainers, and valves between pump base elbow supports and the suction and discharge header piping by means of the pump base spring isolators without stress or strain to the pump housing.

D. Isolate all pipework penetrations through mechanical room and mechanical shaft walls, ceilings, or floors as described under Penetration Isolation.

3.05 **PENETRATION ISOLATION**

A. Scope:

1. Penetration requirements identified in this Section will be applied to all walls, floors, and ceilings of the following rooms:

a. Air Control 2

b. Main Production

c. Air Control

d. Production 1 & 2

e. Elevator Equipment Rooms

B. Method:

1. Isolate all ductwork and pipework over 2 inches in diameter (including sprinkler system) at penetrations as follow:

a. Provide a sheet metal (22 gauge) sleeve to cover the entire perimeter of a 1 inch to 1-1/2 inch (1/2inch to ¾ inch on each side) oversized penetration cut.

b. Plaster or caulk sleeve to the wall, ceiling, or floor, to ensure an airtight seal.

c. If ductwork or pipework penetrates a double wall, use a separate sleeve at each side of the wall (allow no sleeve connection between walls).

d. Pack the gap between the penetrating duct or pipe and the sleeve with Acoustical Insulation and seal airtight on both sides of the wall, floor, or ceiling with an outer layer of Acoustical Sealant.

e. Do not use wall, floor, or ceiling penetrations to support pipework or ductwork. Support pipe or duct just prior to and just after the penetration, so that the pipe or duct is centered in penetration.

f. Use the above penetration treatment regardless of the existence of external duct or pipe insulation. Size penetration large enough to pack additional Acoustical Insulation and apply Acoustical Sealant between the external insulation and the sheet metal sleeve.

2. Isolate all pipework 2 inches or less in diameter (including sprinkler System) at penetrations as follows:

a. Oversize penetration cut by ¼ inch (1/8 inch each side).

b. Seal airtight on both sides of the wall, floor, or ceiling with Acoustical Sealant.

c. Do not use wall, floor, or ceiling penetrations to support pipework. Support pipe just prior to and just after the penetration, so that pipe is centered in penetration.

d. Use the above penetration treatment regardless of the existence of external pipe insulation. Size penetration large enough to apply Acoustical Sealant between the external insulation and the pipes.

3.06 **ELECTRICAL EQUIPMENT ISOLATION**

A. Conduit Isolation

1. Use flexible electrical conduit to isolate all electrical connections to vibration isolated equipment.

2. Do not use conduit clamps or hangers between the flex conduit and equipment.

3. Flex conduit shall be minimum three (3) feet long.

3.07 **MISCELLANEOUS**

A. The Contractor providing vibration isolation equipment shall coordinate with General Contractor and structural engineer to ensure mounting attachment points for seismic restrained springs and seismic snubbers called out in the

Vibration Isolation Schedule, will withstand forces generated from the maximum acceleration rating of the restrained springs and snubbers.

B. Any and all equipment, ductwork, or piping within mechanical rooms or mechanical areas, not isolated via spring isolators given above, shall be separated from contact with the structure via isolator Type N-4, plus neoprene washers and bushings Type WB-1, if equipment is bolted to structure. Size pads and use metal plates or washers to limit surface pressure on neoprene to 45 psi.

END OF SECTION

SECTION 15250

MECHANICAL INSULATION

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Duct Insulation.

B. Pipe Insulation.

C. Equipment and Specialties Insulation.

D. Acoustical Wrap.

1.02 **RELATED WORK**

A. Section 15010 - Mechanical , General

B. Section 15090 – Hangers and Supports

C. Section 15095 – Sleeves and Seals

D. Section 15140 – Pumps

E. Section 15410 – Domestic Water Piping System

F. Section 15750 – Refrigerant Piping System

G. Section 15840 – Ductwork.

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **DEFINITIONS**

A. R: Thermal resistance of insulation, in units of hr-sf-deg F/Btu.

B. Run-out: Piping not more than 12 feet long that runs to an individual fixture or unit.

C. Rainleader Piping: Any piping or conduit that is used to carry rain water, including overflow drain piping.

D. Subject to Damage: Items installed exposed less than 8 feet above the walking surface (i.e. floor platform, roof, grade, etc.) adjacent to the item.

1.05 **QUALITY ASSURANCE**

A. All insulation and materials shall have a fire hazard rating not to exceed 25 for flame spread and 50 for smoke development, as tested by ASTM E 84, NFPA 255, and UL 723.

1.06 **SUBMITTALS**

A. All submittals shall comply with Section 15010.

B. Provide product data on all insulation materials to be used. Indicate thickness to be used.

1.07 **GENERAL REQUIREMENTS**

A. Code Compliance: Contractor shall insulate all systems with the materials and thicknesses as required by code, but in no case shall the insulation be less than that specified herein. In some cases the specified insulation exceeds code, and shall be provided as specified. Not all systems requiring insulation by code are specified, but shall be provided with insulation where required by code.

B. Insulation at Hangers: Insulation shall be continuous through hangers on all insulated systems (except ductwork). Inserts at hangers are specified in Section 15090 and are considered as part of the hanger and support system. Inserts are required to be installed at the time of pipe installation and are intended to be installed by the Contractor installing the pipe hanger/supports. See Section 15090.

C. All adhesives, sealants, mastics and similar materials shall be low-VOC type, and comply with Section 15010 low-VOC requirements.

1.08 **REFERENCES**

A. ASTM A 653: Standard Specification For Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot Dip Process.

B. ASTM B 209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

C. ASTM C 547: Standard Specification for Mineral Fiber Pipe Insulation.

D. ASTM C 1136: Standard Specifications for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.

E. ASTM C 1290: Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.

F. ASTM E 84: Standard Test Method for Surface Burning Characteristics of Building Materials.

G. NCIIS: National Commercial & Industrial Insulation Standards, published by Midwest Insulation Contractors Association, 5th Edition.

H. NFPA 255: Standard Method of Test of Surface Burning Characteristics of Building Materials.

I. UL 723: Tests For Surface Burning of Building Materials.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph Part 2.01, Acceptable Manufacturers.

B. Insulation: Johns Manville, Armacell, Owens-Corning, Knauf, Rubatex, Pittsburgh Corning, GLT, Halstead, Gilsulate.

C. Accessories: Johns Manville, Armacell, Owens-Corning, Knauf, Rubatex, Pittsburgh Corning, GLT, Halstead, Duro Dyne, Gustin Bacon, Childers, RPR, Tee Cee, JPS, Buckaroos.

D. Acoustical Wrap: Kinetics Noise Control.

E. Fire Protection Duct Wrap: 3M.

2.02 **DUCT INSULATION**

A. Flexible Glass Fiber:

1. Type: Flexible blanket type, constructed of inorganic glass fibers bonded by a thermosetting resin, complying with ASTM C 1290, Type III. Johns Manville “Microlite” (or approved).

2. Jacket: FSK type, vapor proof, consisting of an aluminum foil cover reinforced with glass fiber mesh, and laminated to kraft. Water vapor permeance shall not exceed 0.05 perms. Provide with joint sealing tape, minimum 2 inches wide, constructed of jacket material with adhesive to seal all joints.

3. Thermal Conductivity: Shall not exceed 0.27 Btu-in/hr-sq ft-deg F at 75° F.

4. Operating Limits: 40° F to 250° F.

B. Duct Insulation Thickness:

1. General: Provide insulation densities and thicknesses to achieve the following R values. R values are for the insulation only, in their installed thickness, considering installed duct wrap stretch and in accordance with code.

2. Lining: Where ducts have internal lining, the insulating properties of the lining may be credited toward meeting the required insulation R value; use R-4 per inch of installed liner.

3. Supply Air Ductwork:

a. Inside Building and within Building’s Thermal Envelope: R-3.3 (except where ran exposed in conditioned spaces, no insulation is required).

b. Inside Building But Not Within Building’s Thermal Envelope: R-7.

4. Return Air Ductwork:

a. Inside Building and Within Building’s Thermal Envelope: No insulation required.

b. Inside Building But Not Within Building’s Thermal Envelope: R-7.

5. Outside Air Ductwork: Shall be insulated same as required for the building envelope; except where allowed by code to be insulated less then than the building envelope, shall be R-7.
6. Exhaust and Relief Ductwork:

    a. Inside Building and Within Building's Thermal Envelope: No insulation required except ductwork from the system's backdraft damper (or motorized damper) to outside the building shall be insulated same as required for the building envelope.

    b. Inside Building But Not Within Building's Thermal Envelope: R-7.

2.03 **PIPE INSULATION**

A. Glass Fiber:

1. Type: Rigid molded type, constructed of glass fibers bonded by a thermosetting resin, complying with ASTM C 1290, Type III. Insulation factory molded to match pipe size applied to. Johns Manville "Micro-Lok" (or approved).

2. Jacket: ASJ type, vapor proof, consisting of a white kraft paper cover reinforces with glass fiber and bonded to aluminum foil, with longitudinal self-sealing closure system. Provide with butt strips constructed of jacket material with adhesive to seal all joints. Water vapor permeance shall not exceed 0.02 perms.

3. Thermal Conductivity: Shall not exceed 0.24 Btu-in/hr-sq ft-deg F at 75° F.

4. Operating Temperature Limits: 0° F to 850° F.

B. Elastomeric Insulation:

1. Type: Flexible cellular elastomeric insulation, factory formed to match pipe sizes applied to, complying with ASTM C 534, Type 1. Armacell "AP/Armaflex SS" (or approved).

2. Thermal Conductivity: Shall not exceed 0.27 Btu-in/hr-sq ft-deg F at 75° F.
3. Water Vapor Transmission: Water vapor permeance shall not exceed 0.08 perms.

4. Operating Temperature Limits: -20° F to 180° F.

5. Weather Protection: Where installed outdoors provide with manufacturer's weather proof coating to protect from UV and weather exposure.

C. Pipe Fittings: Shall be covered using any one of the following methods of the Contractor's choice:

1. Prefabricated segments of pipe insulation of same materials and thickness as the adjoining pipe insulation, formed to match pipe fitting.

2. Pre-cut fiberglass insulation and pre-molded high impact, gloss white, UV resistant, minimum 20 mil thick, PVC covers suitable for the pipe size and insulation thickness application, PVC cover shall be Johns Manville "Zeston 2000 PVC" (or approved).

3. Insulating plastic cement brought up the full height of the adjacent covering.

4. Except, where colored PVC jacketing is applied to piping, fittings shall use PVC covers of the same thickness and color as the PVC jacketing specified for the piping.

D. Metal Jacket: Aluminum roll jacketing, factory formed to match pipe size and insulation application, with smooth surface, manufactured from 3003 or 5005 aluminum alloy, H-14 temper, conforming to ASTM B 209. Shall be minimum 0.020 inches thick, with an integrally bonded interior 1 mil thick heat bonded polyethylene moisture barrier over the entire surface in contact with the insulation. Fitting covers shall be fabricated of same material as pipe runs, factory formed to match fitting.

E. Pipe Insulation Types:

1. Aboveground-Inside Building:

a. Domestic Water and Hydronic Piping Systems: Glass fiber.

b. Cooling Coil Condensate: Glass fiber or elastomeric.

c. Refrigerant Piping: Elastomeric.

d. Other Systems: Glass fiber.

2. Underground Hydronic Piping: Elastomeric with jacket/wrap suitable for burial.

F. Pipe Insulation Thickness:

1. Provide minimum piping insulation thickness indicated, in inches.

INSULATION THICKNESS (INCHES)

	Pipe Diameter (Inches)					
Fluid Design Operating Range, Deg F	Runouts Up to 2	1 and Less	> 1 To 2	> 2 To 4	> 4 To 6	> 6
Above – 350	1.5	2.5	2.5	3.0	3.5	3.5
251 – 350	1.5	2.0	2.5	2.5	3.5	3.5
201 – 250	1.0	1.5	1.5	2.0	2.0	3.5
141 – 200	0.5	1.5	1.5	1.5	1.5	1.5
105 – 140	0.5	1.0	1.0	1.0	1.5	1.5
56 – 104	0.5	0.5	0.5	0.5	0.5	0.5
40 – 55	0.5	0.5	0.75	1.0	1.0	1.0
Below 40	1.0	1.0	1.5	1.5	1.5	1.5

2. Where a system operates over temperature ranges calling for different insulation thicknesses, the thicker insulation requirements shall be met.

3. Cooling system condensate piping (i.e. from a cooling coil) shall be considered to operate at 53° F.

4. Rainleader piping shall be considered to operate at 56° F.

5. Refrigerant piping (RG or RS piping) returning from an evaporator (i.e. cooling coil) to a compressor shall be considered to operate at 40° F. Refrigerant piping (RL piping) from a condenser to an evaporator does not require insulation (unless noted otherwise).

6. Outdoor Piping: Piping exposed to outside air or, located outside the building/thermal envelope, shall have insulation thickness increased by 0.5 inch from that indicated above.

7. Hydronic heat pump piping shall be considered to operate at 120° F (unless noted otherwise).

8. Cold water piping shall be considered to operate at 56° F (unless noted otherwise).

9. Underground hydronic piping shall be insulated where located within five (5) feet of building footings or water piping.

2.04 **EQUIPMENT AND SPECIALTIES INSULATION**

A. P-traps and HW/CW Lines on Handicap Lavatories: Prefabricated insulation specially designed for p-trap application, with white elastomeric insulation, white high gloss PVC cover, and Velcro closure. Provide section for insulating HW stop and CW stop and associated piping of same material. Buckaroos (1-800-969-3113) "Trap Guard" (or approved).

B. Flexible Glass Fiber:

1. Type: Flexible blanket insulation, constructed of inorganic glass fibers bonded by a thermosetting resin, complying with ASTM C 553, Type III. Johns Manville "812 Spin-Glas" (or approved).

2. Jacket: FSK type, vapor proof, consisting of an aluminum foil cover reinforces with glass fiber mesh, and laminated to kraft. Water vapor permeance shall not exceed 0.05 perms. Provide with joint sealing tape constructed of jacket material with adhesive to seal all joints.

3. Thermal Conductivity: Shall not exceed 0.24 Btu-in/hr-sq ft-deg F at 75° F.

4. Operating Temperature Limits: 40° F to 450° F.

5. Density: 1.5 lb/cu ft.

C. Elastomeric:

1. Type: Flexible cellular elastomeric insulation, complying with ASTM C 534, Type II.

2. Thermal Conductivity: Shall not exceed 0.30 Btu-in/hr-sq ft-deg F at 75° F.

3. Water Vapor Transmission: Water vapor permeance shall not exceed 0.08 perms.

4. Operating Temperature Limits: -20° F to 220° F.

5. Weather Protection: Where installed outdoors provide with manufacturer's weather proof coating to protect from UV and weather exposure.

D. Removable Insulation Blankets:

1. Type: Flexible blanket insulation pads, for insulating valves, unions, strainers and similar items. Constructed of exterior fabric enclosure sewn around interior insulation, held in position with a closure system that allows for removal of the blanket. Contractor or factory fabricated.

2. Enclosure:

a. Hot Applications: Glass fiber mat, ¼ inch thick, noncombustible, service temperature up to 1200° F. JPS Glass Fabrics "Glastex 2025" (or approved).

b. Cold Application: Silicone impregnated glass fiber cloth, water resistant, ¼ inch thick. Claremont "Claretex SL" (or approved).

3. Insulation: Thermal insulating wool, 1-inch thick, complying with ASTM C 553. Maximum thermal conductivity 0.22 Btu-in/hr-sq ft-deg F at 75° F. Provide in layers to give equivalent R value to the adjacent insulated piping. Owens Corning "Fiberglass Brand TIW, Type II".

4. Closure System: Steel lacing anchors with spindles and self-locking washers, fabricated of minimum 14 gauge stainless steel, with stainless steel wire ties. AGM Industries "Series NLA" (or approved).

E. Metal Jacket:

1. Steel: Minimum 24 gauge galvanized steel complying with ASTM A 653. Provide with longitudinal slip joints and 2-inch laps.

2. Aluminum: Minimum 0.020-inch thick aluminum, alloy 3003 or 5005, complying the ASTM B 209. Provide with longitudinal slip joints and 2-inch laps.

F. Equipment and Specialties Insulation Types and Thickness:

1. Unless a specific type of insulation is specified or noted, any of the insulation materials specified in this specification section may be used provided such application is in conformance with NCIIS.

2. Insulation Thickness: Insulation thickness shall be the same as that specified for the piping or ductwork connected to item, or as specified for the system the item is installed in (unless noted otherwise). Insulation thickness shall in no case be less than 1 inch thick.

3. Valves:

   a. 2 inches and Smaller: Insulate with same material as piping system.

   b. 2-1/2 inches and Larger: Removable blanket insulation.

4. Control Valves: Removable blanket insulation.

5. All equipment and specialties where access is required shall have removable insulation blankets; other removable insulation materials per NCIIS may be used where pre-approved by the Engineer. Items requiring such removable insulation include, but are not limited to, the following:

   a. Strainers.

   b. Pumps.

   c. Balancing valves.

   d. Pressure/temperature/flow measuring devices.

   e. Pump suction diffusers.

   f. Heat exchanger heads.

6. Roof Drains: 1 inch thick glass fiber

2.05 **ACCESSORIES**

A. Adhesive, Caulks, Mastics, and Coatings: As recommended by insulation material manufacturer and suited for the application.

B. Bands: ½ inch wide, of stainless steel, galvanized steel, or aluminum construction, to match with materials used with.

C. Weld-Attached Anchor Pins and Washers: Copper-coated steel pin for capacitor-discharge welding and galvanized speed washer. Pin length shall be as required for insulation thickness used with. Welded pin holding capacity 100 lb., for direct pull perpendicular to the attached surface. Style and type to suit application.

D. Adhesive-Attached Anchor Pins and Speed Washers: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness used with. Adhesive as recommended by the anchor pin manufacturer as appropriate for surface temperatures and materials used with, and to achieve a holding capacity of 100 lb for direct pull perpendicular to the adhered surface. Style and type to suit application.

2.06 **ACOUSTICAL WRAP**

A. Type: Composite material having an outer foil faced sound barrier wrap with an internal sound decoupling insulation. Kinetics Noise Control KNM-100ALQ (or equal).

B. Construction: Outer sound barrier material shall be flexible 1.10 inch think, 1 lb/sf (minimum) barium sulfate loaded limp vinyl sheet, bonded to an outside layer of aluminum foil. Interior sound decoupling insulation shall be 1 inch thick fiberglass batting quilted to a non-woven porous scrim-coated glass cloth in a 4 inch diamond stitch pattern. Material shall be suitable for temperatures form 40 to 200 degrees F.

C. Acoustic Rating: STC (sound transmission coefficient) 28 (or better).

D. Vibration Damping Material: Kinetics Noise Control KDD or DKC-E-162.

PART 3 – EXECUTION

3.01 **GENERAL**

A. Pre-Insulation Review: No covering materials shall be applied until systems to be covered have had all tests satisfactorily completed, have had all required inspections, and have been satisfactorily reviewed by the Architect-Engineer. All systems shall be examined by the Contractor to confirm cleanliness and other conditions are appropriate to allow for insulation installation.

B. Insulation Work Review: No insulated items shall be concealed in the building structure or buried until the insulation work has been satisfactorily reviewed by the Architect-Engineer, and has had all required inspections.

C. Standards: Materials shall be installed in accordance with manufacturers' written instructions, NCIIS, and shall comply with materials and methods specified herein. The more stringent requirements govern.

D. Joints/Seams: Joints shall be staggered on multi layer insulation. Locate seams and joints in least visible location.

E. Insulation Protection: Insulation shall be kept clean and dry and shall be protected from dirt, damage, and moisture. Insulation that becomes dirty, damaged, or wet and cannot be restored to like new condition will be rejected, and shall immediately be removed from the jobsite.

F. Insulation Interruptions: Insulation shall be neatly finished at all supports, protrusions and interruptions. Provide adhesive and tape seal to maintain vapor barrier integrity.

G. Equipment and Floor Protection: Cover existing equipment and finished floors to protect such items from insulation fiber and dust. Keep all such existing areas in a "broom clean" condition at the end of each day. Take precautions in these areas to prevent glass fiber and insulation dust from entering ventilation systems or areas adjacent to the work.

H. Glass Fiber Insulation – General:

1. Finish all insulation ends with joint sealing tape or vapor barrier mastic, no raw edges allowed.

2. Joints: Tightly butt adjacent insulation sections together without any voids. Provide overlap of jacket material over all joints.

I. Items To Be Insulated: Provide insulation on all ductwork, all piping, all items installed in these duct and piping systems, all air and liquid energy conveying systems and components, all air and liquid energy storage, all equipment, and all energy consuming devices specified as part of Division 15, except where such insulation has been specifically excluded.

J. Items Excluded From Being Insulated:

1. Fire Sprinkler piping (except where heat traced).

2. Sanitary sewer drain lines (except traps at handicap accessible fixtures).

3. Factory pre-insulated underground piping.

4. Stops and risers at plumbing fixtures (except at handicap accessible fixtures).

5. Factory insulated water heaters (ex except for base on electric water heaters).

6. Factory insulated tanks.

7. Electric motors.

8. Fans.

9. Factory insulated or factory lined air handler (heat pumps).

10. Overflow condensate drains.

11. Pumps.

12. Relief valves and associated drain piping.

13. Hose bibs (except where used as drains hot water systems).

14. Water meter.

15. Underground cold water piping and associated underground items.

16. Underground hydronic system piping, 5 feet beyond building foundation wall.

3.02 **DUCT INSULATION INSTALLATION**

A. Types and Thickness: Insulate all ducts with insulation type and thickness (to provide the required R value) as specified in "Part 2 – Products".

B. General: Insulation shall be firmly butted at all joints. All longitudinal seams for flexible insulation shall overlap a minimum of 2 inches. All joints and seams shall be finished with appropriate joint sealing tape.

C. Attachment: For rectangular ducts over 24 inches wide, duct insulation shall be additionally secured to the bottom of the ductwork with mechanical fasteners

on 18 inch centers to reduce sagging. Washers shall be applied without compressing the insulation. Protruding ends of fasteners shall be cut off flush after washers are installed. All seams, joints, penetrations, and damage to the facing shall be sealed with joint sealing tape or vapor retardant mastic or appropriate joint sealing tape.

3.03 **PIPE INSULATION INSTALLATION**

A. Types and Thickness: Insulate all piping with insulation type and thickness as specified in "Part 2 – Products". All piping shall be insulated except where specifically excluded.

B. General: All ends shall be firmly butted together and secured with joint sealing tape. All jacket laps and joint sealing tape shall be secured with outward clinch staples at 4 inch spacing, or by use of a suitable adhesive. Seal all jacket penetrations with vapor barrier mastic.

C. Elastomeric Pipe Insulation: Flexible elastomeric cellular insulation shall be installed with seams and joints sealed with rubberized contact adhesive. Insulation with pre-applied adhesive is not permitted. Insulation exposed to weather and not shown to have jacketing shall be protected with two (2) coats of UV resistant finish or PVC or metal jacketing as recommended by the manufacturer after the adhesive is dry and cured. A brush coating of adhesive shall be applied to both butt ends to be joined and to both split surfaces to be sealed. The adhesive shall be allowed to set until dry to touch but tacky under slight pressure before joining the surfaces. Insulation seals at seams and joints shall not be capable of being pulled apart one (1) hour after application. Insulation that can be pulled apart one (1) hour after installation shall be replaced.

D. Pipe Hangers: Provide insulation tight up to pre-insulated pipe supports at pipe hangers; seal all joints with joint sealing tape. Pre-insulated pipe supports are specified in Section 15090.

E. Pipe Sleeves: Run insulation continuous full size through sleeve. Coordinate work with fire seal work and confirm fire sealant system is approved for u se with insulated pipes; see Section 15095.

F. Metal Jacketing: Provide metal jacket on all piping below ten feet in the main mechanical room.

3.04 **EQUIPMENT AND SPECIALTIES INSTALLATION**

A. Types and Thickness: All equipment and items installed in insulated duct and piping systems shall be insulated except where specifically noted not to be; reference paragraph 3.01. Insulation type and thickness shall be as specified in "Part 2 – Products".

B. General: Apply insulation as close as possible to equipment by grooving, scoring, and beveling as necessary. As required, secure insulation to equipment with studs, pins, clips adhesive, wires or bands. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. Comply with NCIIS.

C. Removable: All equipment and specialties where access is required for maintenance, repair, service, or cleaning shall have insulation installed so that it can be easily removed and reinstalled without being damaged and without requiring new insulation.

D. Handicap Lavatories: Insulate P-trap and HW supplies below lavatory where exposed.

E. Nameplates: Do not insulate over nameplate or ASME stamps; bevel and seal insulation around.

F. Jacketing: Provide all equipment with vapor retardant jackets.

3.05 **ACOUSTIC WRAP**

A. Install in accordance with manufacturers written instruction and NCIIS.

B. On ductwork less than 20 gauge, apply vibration damping material on outside of duct before applying thermal insulation or acoustic wrap.

C. Overlap all interior sound insulation joints with a minimum 2 inch overlap of the exterior sound barrier.

D. Acoustical insulation shall not be compressed.

E. Where installed on ducts requiring thermal insulation, install thermal insulation over acoustic wrap.

F. Provide acoustic wrap on all supply duct for heat pumps serving the studios, from heat pump up to and including sound attenuator, and at locations noted on plans.

END OF SECTION

SECTION 15410

DOMESTIC WATER PIPING SYSTEM

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Domestic and Non-Potable Water Piping.

B. Valves.

C. Water Hammer Arrestors.

D. Trap Primers.

E. Non-Potable Water Meters.

F. Domestic Water Expansion Tanks.

G. Water Service Connections.

H. Testing and Inspection.

I. Sterilization.

J. Reverse Osmosis Water Systems

1. The Unit shall be housed in a fully enclosed cabinet with accessible instrumentation which includes: a lighted on/off indicator; flow meters for product and waste; an adjustable flow control for fine tuning; a manual on/off switch; and a water quality monitoring system.

2. A power disconnect shall be installed remote from the unit for isolation.

3. The unit shall include a pump capable of design flow at 200 PSI and rated for continuous duty.

4. The process water storage take shall be a covered unit of suitable capacity and be installed with an overflow line piped to a drain.

5. The entire system shall be provided with start-up service by an authorized dealer.

1.02 **RELATED WORK**

A. Section 15060 – Pipe and Pipe Fittings.

B. Section 15080 – Piping Specialties.

C. Section 15090 – Hangers and Supports.

D. Section 15450 – Plumbing Fixtures and Trim.

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **SUBMITTALS**

A. Submittals shall comply with Section 15010.

B. Submit product information on all items to be used.

C. Piping submittals shall be made with Section 15060; additional piping submittals under this Section are not required. However, indicate piping material to be used and reference corresponding item submitted per Section 15060.

1.05 **REFERENCES**

A. AWWA B300, Hypochlorites.

B. AWWA B301, Liquid Chlorine.

C. AWWA M20, Water Chlorination Principles and Practices.

1.06 **GENERAL REQUIREMENTS**

A. Solder: Only lead-free solder shall be used on potable water systems.

B. All work and products shall comply with the governing codes (reference Section 15010).

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, 2.01, Acceptable Manufacturers.

B. Valves: Nibco, Milwaukee, Watts, Apollo.

C. Pressure Reducing Valves: Watts, Cla-Val, Bell & Gossett.

D. Pressure Relief Valves: Kunkle, Bell & Gossett, Watts.

E. Backflow Preventers: Febco (exterior systems), Watts (interior systems), Ames (fire systems).

F. Balancing Valves: Bell & Gossett, Armstrong.

G. Additional manufacturers are as listed for each individual item.

2.02 **PIPE AND FITTINGS**

A. Pipe and fitting standards shall be specified in Section 15060, Pipe and Pipe Fittings.

B. Domestic Water Piping Located Above Ground: Type L copper tubing with solder joints and wrought copper or cast brass fittings. Where exposed to view in finished areas provide with chrome plated sleeve, or use chrome plated piping.

C. Domestic Water Piping Located Below Ground: Type K copper tubing with silver brazed joints and wrought copper or cast brass fittings.

D. Non-Potable Water Piping Above Ground: Type L copper tubing with solder joints and wrought copper or cast brass fittings.

E. Trap Primer Piping: Type L or K “soft” or “hard” (bending temper) copper, with compression fittings or soldered joints.

2.03 **VALVES**

A. Globe Valves:

1. 2-1/2 Inches and Smaller: 125 psi-swp bronze globe, threaded bonnet, Teflon or bronze disc, solder or threaded connection.

2. 3 Inches and Larger: 125 psi-swp iron body globe, bronze mounted, bronze or Teflon disc, flanged.

B. Ball Valves: 125 psi-swp bronze ball, standard port, two piece construction, anti-blowout stem, Teflon seats, stainless steel or chrome plate ball, extended stem, memory stop, solder or threaded connections as required.

C. Balancing Valves: Calibrated balance valve, with brass readout valves with integral EPT insert and check valve to minimize fluid loss during balancing. Valve shall have calibrated nameplate and memory stop. Valve shall have a preformed polyurethane insulation. Valve shall be same size as pipe installed in. Bell & Gossett "Circuit Setter" or equal.

D. Pressure Reducing Valves: Bronze body construction, renewable nickel alloy seat, with integral strainer and union inlet connections. Adjustable range 25 to 75 lbs. Watts U5 or approved.

E. Pressure Relief Valves: ASME rated pressure relief valve, set for pressure indicated or as required to protect system from over pressure. Valve shall have minimum 400,000 Btu/HR relief capability and no smaller then 1-inch connection sizes.

F. Drain Valves: Apollo 78-100 series ball valve, with ¾" male hose end connection and dust cover.

G. Check Valves:

1. 2 Inches and Smaller:

a. Horizontal: 125 psi-swp bronze body horizontal swing check valve, regarding type, y-pattern, renewable seat and disc, solder or threaded connection. Nibco S-413 or T-413 (or approved).

b. Vertical: 125 psi-swp bronze body vertical inline check valve, stainless steel or bronze disk holder, Buna-N disk, stainless steel spring actuated, solder or threaded connection. Nibco S-480 or T-480 (or approved).

2. 2-1/2 Inches and Larger:

a. Horizontal: 125 psi-swp iron body vertical inline "silent" check valve, wafer or flanged style, renewable seat and disk, stainless spring actuated, bronze disk. Nibco W-910 (or approved).

b. Vertical: 125 psi-swp iron body vertical inline "silent" check valve, water of flanged style, renewable seat and disk, stainless spring actuated, bronze disk. Nibco W-910, F-910 (or approved).

2.04 **SPECIALTIES**

A. Water Hammer Arrestors: All metal, factory pre-charged with inert gas, sealed internal bellows; 125 psi working pressure. All wetted parts shall be type 300 stainless steel, brass or copper. Zurn "Shoktrol", Wade "Shokstop", J.R. Smith "Hydrotol", or Josam equivalent; in P.D.I. (Plumbing and Drainage Institute) sizes as indicated.

B. Trap Primer Valve: Manufactured of corrosion resistant copper and brass, with valve and line pressure adjustment with manifold for serving multiple drains. Primer valve activated by drop-in water pressure.

2.05 **BACKFLOW PREVENTERS**

A. Washington State approved, with air gap drain and resilient seated full flow shutoff valves and test cocks. Type and size shall be shown on drawings. Shall be reduced pressure type unless otherwise noted. Febco Models 825Y, 825 or approved.

2.06 **DOMESTIC WATER DIAPHRAGM TANK**

A. Diaphragm type thermal expansion absorber. Amtrol or equal.

B. Construction: Welded steel construction, with rigid polypropylene liner, butyl diaphragm, air charging valve, and ASME certified.

C. Capacity: 4.7 gallon tank volume (minimum).

PART 3 – EXECUTION

3.01 **INSTALLATION OF PIPING AND FITTINGS**

A. Installation and joining of all piping shall comply with Section 15060.

B. Provide all domestic hot water and cold water piping as indicated and as required to allow supply connections to each fixture and equipment item requiring water supply. Provide non-potable water system to service heating/cooling system.

C. Run all piping concealed unless piping is specifically noted as to be run exposed. Where piping is exposed in finished areas, it shall be chrome plated or covered by a chrome sleeve. See Section 15450 for chrome plated supplies to fixtures.

D. Provide supply connections to equipment furnished by others in accordance with Section 15010.

E. Install all piping sloped to low points to allow the system to be drained.

F. No piping shall be concealed in the structure until reviewed by the Engineer.

3.02 **INSTALLATION OF VALVES**

A. All valves shall be the ball type, except that Contractor shall use the globe type where specifically noted.

B. Provide isolation valves as shown on the drawings. In addition to those shown, provide added valves to allow for the isolation of each group of fixtures and all individual equipment items.

C. Install valves so as to be easily accessible and oriented to permit ease of operation. Valve stem shall be directed toward operator in either the vertical or horizontal direction. Provide access doors or panels to valves built into construction.

D. Provide drain valves at the base of all risers.

E. Provide drain valves at piping low points where the piping cannot be drained through fixtures or hose bibs.

F. Provide balancing valves in hot water circulation piping where indicated and where required to allow for equal distribution of hot water circulation flows.

3.03 **INSTALLATION OF SPECIALTIES**

A. Water Hammer Arrestors: Install per manufacturer's instructions in locations shown on the drawings and where required to absorb water hammer. Provide ball isolation valve in piping to arrestor. Where access cannot be provided at water line location, extend water hammer arrestor piping and locate above ceiling outside of plumbing chase. Provide building access doors as required for access.

B. Trap Primers: Provide trap primers to all vented floor drains and where required by the governing code. Install as shown on drawings and provide with an isolation valve in the branch line to the trap primer valve.

C. Access Doors: Provide access to all valves, water hammer arrestors, trap primers, backflow preventers, and any other piping accessories which would otherwise be inaccessible. See Section 15080, Piping Specialties, for access door specifications.

D. Provide backflow preventers of type, and in locations, as shown on the drawings. Backflow devices shall be installed, inspected, and tested in accordance with the applicable portions of the Washington Administrative Code and other applicable regulations as set forth by the Washington State Department of Social and Health Services.

3.04 WATER SERVICE CONNECTIONS

A. Provide connection to water main outside the building as shown on the drawings.

B. Provide sleeve in floor for entrance of service main into building, seal watertight; anchor service main firmly to building floor and walls. Seals shall comply with Section 15095, Sleeves and Seals.

3.05 TESTING AND INSPECTION

A. All piping shall be tested, inspected, and approved (by the local authority having jurisdiction and Engineer) prior to being concealed or covered.

B. Testing shall be witnessed by the plumbing inspector and the Architect/Engineer. Notify Architect/Engineer 48 hours prior to date of testing.

C. Piping shall by hydrostatically tested for a period of two hours, during which time no drop in pressure or leakage shall occur.

D. Test pressure shall be not less than 150 percent of the maximum to which the pipe will ordinarily be subjected; but in no case less than 150 psig.

E. Any leaks or defective piping disclosed by testing and inspection shall be repaired with new materials and the system re-tested.

F. Provide documentation of testing and inspections including dates and results of the testing and inspections.

3.06 **FLUSHING AND DISINFECTION**

A. System Flushing: After tests are completed, all water piping shall be flushed. In general, sufficient water shall be used to produce a minimum water velocity of 2.5 feet per second through piping being flushed. Flushing shall be continued until discharge water show no discoloration. System shall be drained at low points. Strainer screens shall be removed, cleaned, and replace in line. System valves and fixture faucets shall be opened and reclosed to completely flush system. After flushing and cleaning, systems shall be prepared for disinfection service by immediately filling water piping with clean, fresh potable water. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building, due to the Contractor's failure to properly clean the piping system, shall be repaired by the Contractor.

B. Adjust the hot water circulation system for uniform circulation throughout the system. Adjustment of fixture valves and faucets is specified in Section 15450, Plumbing Fixtures and Trim.

C. Upon completion of the job and prior to final acceptance, the plumbing system shall be disinfected with Chlorine solution. The chlorinating material shall be either liquid chlorine conforming to AWWA B301 or hypochlorite conforming to AWWA B300. Water chlorination procedure shall be in accordance with AWWA M20. The chlorinating material shall provide a dosage of not less than fifty parts per million and shall be introduced into the system in an approved manner. The treated water shall be retained in the pipe long enough to destroy all non-spore-forming bacteria.

D. The retention time shall be at least twenty-four hours and shall produce not less than ten ppm of chlorine at the extreme end of the system at the end of the retention period. All valves in the system being sterilized shall be opened and closed several times during the contact period. The system shall then be flushed with clean water until the residual chlorine is reduced to less than 1.0 ppm. During the flushing period all valves and faucets shall be opened and closed several times.

E. The Contractor shall employ an approved agency to take test samples at several points of the system in properly sterilized containers and arrange with the Health Department having jurisdiction to test the samples. Should the samples not test satisfactory, the system shall be re-sterilized and re-flushed until satisfactory samples are obtained.

F. The Contractor shall furnish a letter to the Engineer stating that Chlorination has been completed. The letter shall also include a copy of a certificate from the

Health Department having jurisdiction stating that samples taken have been found acceptable.

END OF SECTION

SECTION 15420

SOIL, WASTE AND VENT PIPING SYSTEM

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Soil, Waste and Vent Piping.

B. Miscellaneous Drains.

C. Cleanouts.

D. Vent Caps.

E. Vent Flashing.

F. Testing and Inspection.

1.02 **RELATED WORK**

A. Section 15410 – Domestic Water Piping System

B. Section 15420 – Soil, Waste and Vent Piping System

C. Section 15500 - Fire Protection Sprinkler System

D. Section 15755 – Hydronic Heat Pump Ground Coupled Piping System

1.03 **SUBMITTALS**

A. Submittals shall comply with Section 15010.

B. Submit product information on all items to be used.

C. Piping submittals shall be made with Section 15060; additional submittals under this Section are not required. However, indicate piping material to be used and reference corresponding item submitted per Section 15060.

1.04 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, 2.01, Acceptable Manufacturers.

B. Cleanouts: Josam, Zurn, J.R. Smith, Wade.

2.02 **PIPE AND FITTINGS**

A. Pipe and fitting standards shall be as specified in Section 15060, Pipe and Pipe Fittings.

B. Piping 2-1/2 Inches and Smaller Located Above Ground:

1. Service weight no-hub cast iron pipe with mechanical joints; or copper DWV.

C. Piping 3 Inches and Larger Located Above Ground and All Piping Located Below Ground:

1. Service weight no-hub cast iron pipe with mechanical joints. Underground piping shall use Husky Model DS 4000 coupling.

D. Piping Exposed in Finished Areas: Chrome or nickel plated brass; piping 2 inches and larger may be provide with chrome or nickel plated brass sleeves to conceal pipe and fittings.

E. Miscellaneous Drains: Copper DWV, or type M copper, with soldered joints.

F. Condensate Drains:

1. In Occupied Areas, Exposed: Copper DWV or type M copper with soldered joints.

2. Other Areas: Copper DWV or type M copper with soldered joints, or schedule 40 PVC with solvent joints.

2.03 **CLEANOUTS**

A. General:

1. All cleanouts shall have cast iron bodies with bronze countersunk rectangular slotted plugs, lubricated with a non-hardening teflon base thread lubricant and having a gasket seal.

2. Cleanouts located in waterproof membrane floors shall be provided with an integral cast flange and flashing device.

3. All cleanouts shall be the same size as the pipe which they are intended to serve (but not larger than 4-inch).

4. Pipe fittings for cleanouts which turn through walls or up through floors shall use long sweep ells or a "Y" and 1/8 bend.

B. Floor Cleanouts: J.R. Smith Nos. 4026 or 4021 Series adjustable floor level cleanout with round heavy duty polished bronze top. Provide with carpet clamp (J.R. Smith No. 4020-X series where installed in carpeted areas).

C. Wall Cleanouts: Cast iron ferrule with cast bronze taper threaded plug, tapped to accept access cover screw; with round chrome plated access cover and attaching vandal proof screw.

D. Outside Cleanouts: Heavy duty, round, cast iron, double-flanges housing having scoriated cast iron cover with lifting device, ferrule and bronze closure plug. Housing and lid shall be galvanized and have vandal resistant screws. J.R. Smith No. 4251 or 4256 Series.

2.04 **VENTS**

A. Flashing: Type to suit roof construction, size to match vent size.

1. EPDM or compression molded rubber; suitable for temperatures from -60°F to 270°F, resistant to ozone and UV light. Flashings shall have aluminum or galvanized steel base for flashing or attachment to roof (style to suit roof type). Provide stainless steel clamp.

2. 4 lb. sheet lead, extending as a sleeve all around vent pipe; turn top down to overlap 2" inside vent pipe. Flashing shall have lead base of adequate size for flashing into roof system.

B. Vent Caps: Galvanized cast iron vandal proof vent cap, with concealed allen key set screw. J.R. Smith Figure 1748.

PART 3 – EXECUTION

3.01 **INSTALLATION OF PIPE AND FITTINGS**

A. Installation and joining of all piping shall comply with Section 15060, Pipe and Pipe Fittings.

B. Provide all soil, waste and vent piping as indicated and as required to allow waste and vent connections to each fixture and equipment item requiring connection.

C. The work of this Section shall include all sanitary sewer lines inside of the building and 5-feet outside sanitary sewer lines or sanitary sewer manholes.

D. The installation of all piping shall be in compliance with the Governing Codes.

E. Install all horizontal soil or waste lines with a slope of ¼ inch per foot (unless noted otherwise). Exceptions require written approval of the Administrative Authority, prior to installing.

F. Make all changes of direction and junctions with Y fittings and 1/8 bends; use sanitary tee fittings in vertical pipe only.

G. Consult manufacturer's data and architectural drawings for information on plumbing fixtures before beginning rough-in.

H. Verity points of connection, invert elevations, and grade requirements before beginning installation.

I. Coordinate installation of piping with all trades affected by installation.

J. Stud all piping for all items requiring connection through wall or floor; cap and protect until connection to items is complete.

K. Vents extending through roof shall terminate at least 10 inches above roofing; and not less than 10 feet from and 3 feet above any building opening. Provide vent caps on all vent terminations.

L. Vent Flashing: Provide vent flashing at each vent through roof; utilize water-proof method as required to best suit roofing material/manufacturer.

M. Connect equipment furnished by others in accordance with Section 15010. Provide miscellaneous drains for all items.

N. Trap all fixtures and equipment items as required by governing code; provide proper venting for each trap.

O. All excavation, trenching and backfilling shall comply with Section 15050.

3.02 INSTALLATION OF CLEANOUTS

A. Install cleanouts in all soil and waste piping:

1. At no more than 100 foot intervals on horizontal runs;

2. At the end of all piping runs;

3. At the base of all vertical risers.

4. At all changes of direction for a run of 10 feet or over;

5. At all locations shown on the drawings and where needed to correct possible stoppage and as required by governing code.

B. Where cleanouts occur in concealed spaces provided extensions to floors above or to walls to allow access.

C. Provide wall access covers for all wall cleanouts. See Section 15080, Piping Specialties for specification of wall access covers.

D. Floor cleanouts shall be installed so as to be flush with the finished floor.

E. Install cleanouts so as to assure proper clearances as required by governing code.

F. All cleanouts located outside shall be provided with an access housing located in a 24” x 24” x 6” thick concrete pad, flush with the adjacent finished grade. The pipe and cleanout shall be independent of this access housing and pad.

3.03 TESTING AND INSPECTION

A. All piping shall be tested, inspected and approved prior to being concealed or covered.

B. Testing shall be by water or air, and shall comply with governing code.

C. Testing shall be witnessed by the plumbing inspector and the Engineer's representative.

D. Provide documentation of testing and inspections include dates and results of the testing and inspections.

E. Water Testing:

1. Fill system with water so that there is no less than 10 feet of head above the highest system section being tested.

2. System shall hold pressure for a period of at least 15 minutes with no leakage before the inspection starts.

3. The system shall be inspected and shall hold tight with no leakage at all points.

G. Air Testing:

1. Pressurize system with air so that there is no less than five psig of air pressure in the system.

2. System shall hold pressure for a period of at least fifteen minutes without the introduction of additional air before the inspection starts.

3. The system shall be inspected and shall hold tight with no leakage at all points.

H. All leaks shall be eliminated and the system re-tested before proceeding with work or concealing pipe.

I. All repairs to piping shall be with new material and no caulking of screwed joints or holes is allowed.

END OF SECTION

SECTION 15450

PLUMBING FIXTURES AND TRIM

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Plumbing Fixtures and Trim.

B. Water Heaters.

C. Adjustment and Cleaning.

1.02 **RELATED WORK**

A. Section 15080 – Piping Specialties.

B. Section 15410 – Domestic Water Piping System.

C. Section 15420 – Soil, Waste and Vent Piping System.

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **DEFINITIONS**

A. “Plumbing Brass” means “P-traps, stops, strainers, tailpieces, flanges, and other brass fittings and accessories NOT including faucets or stops.”

B. “Trim” includes all plumbing brass items, faucets, and any fixture accessories.

1.05 **REFERENCES**

A. Uniform Plumbing Code.

1.06 **SUBMITTALS**

A. All submittals shall comply with Section 15010.

B. Submit product data for all plumbing fixtures, plumbing trim, and water heaters.

C. Submit shop drawing of Flue and Flashing; showing support and flashing details.

1.07 **GENERAL REQUIREMENTS**

A. Provide new fixtures and fittings, approved, free from flaws and blemishes with finished surfaces clear, smooth and bright. Visible parts of fixture brass and accessories, and all items located in accessible cabinet spaces, shall be heavily chrome plated. All stops risers, P-traps shall be chrome plated.

B. All products and connections shall be in compliance with the Governing Code, the local Health Department, and Public Utilities Department.

C. Prior to ordering any fixtures or making submittals, Contractor shall check plans and verify that all fixtures will fit the space available (cabinets to be installed install dimension provided, etc.). By submitting products for Engineer's review, the Contractor is confirming that such checks have been performed and that the products are suitable for the intended installation and use.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Water Closets: Kohler.

C. Urinals: Kohler.

D. Vitreous china (other than water closets) and enameled cast iron fixtures: Kohler.

E. Water Closet Seats: Church; Beneke; Olsonite; Kohler; Bemis.

F. Carriers: Josam; J.R. Smith; Wade; Zurn; Watts Drainage.

G. Stainless Steel Sinks: Just; Elkay.

H. Service Sinks: Mustee.

I. Drinking Fountains: Haws; Halsey-Taylor.

J. Hydrants and Hose Bibbs: Woodford.

K. Floor Drains: J.R. Smith; Wade.

L. Water Heaters: A.O. Smith; Rheem; Chronomite.

M. Plumbing Brass: American Standard; Brasscraft; Chicago Faucet; Crane; Eljer; Frost; Kohler; Speakman; Symmons; T & S Brass; McGuire; Elkay.

N. Faucets: Sloan.

O. Stops: Aquaflo (ball type); Brasscraft (ball type).

P. Flush Valves: Sloan.

2.02 **PLUMBING FIXTURES**

A. General:

1. Plumbing Fixtures are listed below by reference numbers, corresponding to the reference number adjoining these items on the drawings.

2. All vitreous china and enameled cast iron fixtures shall be finished white unless specifically noted otherwise.

3. All stainless steel sinks shall be sound deadened, and shall have faucet ledge (except where noted specifically without ledge).

4. In interests Owner's Standardization, fixtures of similar type shall be product of one manufacturer; trim of similar type shall be product of one manufacturer.

B. Water Closets:

1. <u>P-1A Water Closet – Wall Hung – Handicap:</u>

a. Water Closet: Kohler "Kingston-Lite", NO. K-4330, vitreous china, elongated bowl, wall mounted, siphon jet action bowl with 1-1/2" top spud, and 1.6 gallon flush.

b. Flush Valve: Sloan "G2 Optima Plus 8111" chrome-plated, sensor operated flush valve with vacuum breaker, quiet-action, and screw driver stop. Provide with ADA compliant, battery operated

infrared sensor for “no h ands” automatic flushing and manual override flush button.

c. Seat: Kohler “Lustra”, No. K4670-SC, white plastic seat, open-front and stainless steel self-sustaining check hinge.

d. Carrier: Cast iron or steel construction, adjustable to support fixture. J.R. Smith “Linebacker” Figure 115 to 280, type to suit application. Provide with rear anchoring lug on single units.

C. Urinals:

1. P-2A Urinal – Wall Hung:

a. Urinal: Kohler “Bardon”, No. K-4960-T, with ¾” top inlet spud and wall hangers, and 0.5 gallon flush.

b. Flush Valve: Sloan “G2 Optima Plus 8186-0.5” chrome-plated, sensor operated flush valve with vacuum breaker, quiet-action, and screw driver stop. Provide with ADA compliant, battery operated infrared sensor for “no hands” automatic flushing and manual override flush button.

c. Carrier: Steel construction, adjustable, with bottom bearing plate, anchored in floor, concealed for fixture support. J.R. Smith Figure 637.

D. Lavatories:

1. P-3A Lavatory – Wall Hung – Handicap:

a. Lavatory: Kohler “Hudson”, No. K-2861, 19” x 17”, enameled cast iron lavatory with 4” faucet centers, for use with concealed arm carrier.

b. Plumbing Brass: Kohler No. K-7715 lavatory drain with perforated grate and 1-1/4” tailpiece; Kohler No. 9000, 1-1/4” Cast brass “P” trap with cleanout; and Chicago Faucet No. 1017 MM loose key, metal-to-metal stops and flexible risers.

c. Faucet: Sloan “Optima Plus”, No. EBF-650 chrome plated, sensor operated faucet with 4” centers, and 0.5 gpm vandal resistant spray head. Provide with ADA compliant, battery operated sensor for use with tempered water. Provide with battery pack,

below-deck thermostatic mixing valve, and all features necessary to provide a complete and operational faucet.

d. Carrier: Steel construction, adjustable, anchored to floor, with concealed arms for high back lavatory support. J.R. Smith Figure 700 with accessories to suit application.

E. Sinks:

1. P-5A Sink:

a. Sink: Elkay No. LR-2219 multi-hole drill, 18 gauge, Type 304 stainless steel, 19-1/2" front to back x 22" left to right x 7-1/2" deep self-rimming sink with rear faucet ledge.

b. Plumbing Brass: Elkay No. LK35 stainless steel cup strainer with 1-1/2" tailpiece and 1-1/2" cast brass "P" trap with cleanout and Chicago Faucet No. 1017 MM loose key, metal-to-metal stops.

c. Faucet: Sloan No. QT-1528-8 top mount, single lever, sink faucet, with chrome plated brass body, ceramic cartridge, and 0.5 gpm aerator.

F. Serviced Sinks:

1. P-6A Service Sink – Floor Mount:

a. Sink: Swan No. MS-2436 molded fiberglass sink basin, 24" x 36" x 10" high, color white, with minimum 30" long heavy duty reinforced 5/8" diameter flexible hose for connection to ¾" hose thread, spring loaded stainless steel hose bracket, vinyl rim guards.

b. Plumbing Brass: Combination dome strainer and lint bucket of minimum 16 gauge 302 stainless steel, with stainless steel screws and 3" drain connection.

c. Faucet: Chicago Faucet No. 897 combination service sink fitting with ¾" hose thread on spout, No. 369 handles, wall brace, pail hook, No. R-1/2" flanged female adjustable arms, integral stops, polished chromium-plated.

G. Drinking Fountains:

1. P-8A Water Cooler – Dual Handicap:

a. Haws Model NO. H1011 barrier-free dual drinking fountain, rounded corners, 14" diameter round sculpted basins mounted on support arms, stainless steel, Type 304, 18 gauge construction, with #4 satin finish, front push button operation, one-piece chrome-plated anti-squirt bubblers, anti-splash ridge, cabinet located automatic stream height regulator screwdriver stop, waste strainer, 1-1/4" O.D. tailpiece, incline lead removal filter, front stainless steel access panel with slotted grille, and remote chiller. Unit shall comply with Washington State Handicap Access Regulations. Provide with mounting plate and supporting wall carrier No. 6800. Unit shall have minimum 8 gph cooling capacity, with water cooled from 80°F to 55°F (minimum).

H. Hydrants and Hose Bibbs:

1. P-10A Wall Hydrant – Non-Freeze:

a. Woodford No. B65 recessed box type wall hydrant, non-freeze type, with polished bronze box and bronze hinged cover, bronze hydrant and casing, integral vacuum breaker, "T" handle key and ¾" inlet, ¾" hose outlet, and overall depth to suit wall thickness and provide suitable freeze protection.

I. Floor Drains:

1. P-11A Floor Drain:

a. J.R. Smith No. 2010-A cast iron body floor drain, with nickel bronze adjustable strainer head, round nickel bronze grate, vandal proof screws, and trap primer connections. Size outlet to match pipe size shown on drawings.

2. P-11B Drain – Funnel:

a. J.R. Smith Figure 3821 cast iron condensate funnel drain, with 6" diameter funnel, P-trap, size as noted on the drawings.

3. P-11C Floor Receptor:

a. J.R. Smith Figure 3100 series, enamel coated floor receptor, 10" deep, with 12" square nickel bronze half grate and rim, sediment bucket, trap primer connection, vandal-proof screws. Size outlet to match pipe size noted on drawings. Where used at dishwasher, provide with ½ grate. Where serving boilers leave grate off (turn over to Owner).

J. Water Heaters:

1. Tank Type, Electric:

a. Tank Type, Electric, A.O. Smith model and capacity noted on plans, provide with ASME listed relief valve, thermostat, and drain valve.

b. All internal circuits shall be fused. The outer jacket shall be of baked enamel finish and shall be provided with full size control compartment for performance of service and maintenance through hinged from panel and shall enclose the tank with vermin proof fiber glass insulation. Electrical junction box with heavy duty terminal block shall be provided. The drain valve shall be located in the front for ease of servicing. Heater tank shall have a three year limited warranty. Manufacturer shall supply ASME rated included. Tank shall meet or exceed ASHRAE 90A-1980 Standard for energy efficiency, be of size and capacity indicated, and shall be for use with the voltage and the most remote fixture. Water heaters shall have all internal surfaces glass lined with extruded magnesium anode. Heating elements to be heavy duty medium watt density immersion type with sheathing.

2. Tankless, Electric:

a. Chronomite tankless water heater, capacity noted on drawings.

2.03 **SPECIALTIES**

A. Unless indicated otherwise, the following fittings and materials shall be used:

1. Fixture Traps: 17 gauge seamless chrome plated cast brass tubing, with 2 inch minimum seal, and cleanout, size as required by Uniform Plumbing Code and to suit construction.

2. Exposed piping and fittings in finished areas and in accessible cabinets: Chrome plated or sleeved with chromed sleeves; all chrome to have a bright polished finish. No exposed copper allowed (includes accessible cabinet areas).

3. Stops: Quarter-turn ball type, Loose key.

4. Escutcheons: Chrome plated, one piece.

5. Wall Box: 20 gauge hot dipped galvanized steel box with 18 gauge face plate, ½" inlet x ¼" outlet compression angle valve. Guy Gray Model BIM875.

B. Rims: Lavatories and sinks mounted in the counter work shall be self-rimming or equipped with deck stainless steel rims similar and equal to the Hudee Rim.

C. Vacuum Breakers: Anti-siphon vacuum breaker, by same manufacturer as flush valve or faucet with which used.

D. Carriers: Provided for wall mounted fixtures, type to suit construction. J.R. Smith or equal.

E. Sealant: Silicone type, General Electric or Dow Chemical, color to match fixture.

F. Fixture Risers: Flexible braided Stainless steel.

PART 3 – EXECUTION

3.01 **INSTALLATION OF FIXTURES**

A. All fixtures shall be completely connected to piping as needed to make a complete and operable installation.

B. All wall mounted water closets, urinals, lavatories, drinking fountains and sinks shall be installed with supporting carriers that transmit the load to the floor.

C. All wall mounted fixtures that standard carriers are not manufactured for, shall be supported with bolts through the wall which attach to a 3/16" thick steel back plate for block walls and wood stud walls; or a 2" x 2" x ¼" angle welded to at least four studs for metal stud walls.

D. Where plumbing fixtures abut to walls and floors, seal all joints with a uniform fillet bead of silicone sealant.

E. Mounting heights and locations of fixtures shall be as shown on the Architectural drawings; these locations shall be verified and coordinated with the various trades affected by the installation of these fixtures. When no indicated or shown, obtain mounting location and heights from the Architect/Engineer prior to installation.

F. Protect fixtures against use and damage during construction; provide guards and/or boxing as required.

G. Pipe all pressure relief valve to nearest floor drain.

3.02 **INSTALLATION OF SPECIALTIES**

A. Escutcheons: Provide escutcheons at each point where an exposed pipe or other fitting passes through walls, floors, backs of cabinets or ceilings.

B. Stops: Provide stops in all water connections to all lavatories and sinks.

C. Vacuum Breakers: Provide vacuum breakers with all flush valves and service sink faucets and where indicated on the drawings.

3.03 **ADJUSTMENT AND CLEANING**

A. After completion of installation remove all labels and thoroughly clean all fixtures, trim and fittings.

B. Adjust all flush valves, fixture stops, valves, and associated plumbing items as necessary for the proper operation of all equipment.

END OF SECTION

SECTION 15745

HYDRONIC HEAT PUMP WATER PIPING SYSTEM

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Hydronic Heat Pump Water Piping.

B. Valves.

C. Balancing Valves.

D. Constant Flow Valves.

E. Heat Pump Hose Connection Kits.

F. Flow Measuring Devices.

G. Expansion Tanks.

H. Air Separator.

I. Mock-Up.

J. Glycol Feed System.

K. Air Vents.

L. Flushing and Testing.

M. Chemical Cleaning and Treatment.

1.02 **RELATED WORK**

A. Section 15060 – Pipe and Pipe Fittings.

B. Section 15080 – Piping Specialties.

C. Section 15090 – Hangers and Supports.

D. Section 15095 – Sleeves and Seals.

E. Section 15815 – Hydronic Heat Pumps.

1.03 DEFINITIONS

A. "Balancing Valve" is defined as, "a valve having as an integral factory manufactured part of the valve a means to measure the pressure drop across the valve to determine the flow rate through the valve (with the use of factory calibrated pressure drop versus flow charts), and having a means to adjust the flow rate through the valve." Ball valves and butterfly valves by themselves are not considered balancing valves.

1.04 SUSTAINABLE BUILDING REQUIREMENTS

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.05 SUBMITTALS

A. All submittals shall comply with Section 15010, Submittals.

B. Submit product information data for all products to be used.

C. Piping submittals shall be made with Section 15060; additional piping submittals under this Section are not required. However, a submittal indicating the piping materials to be used and references to the corresponding items submitted per Section 15060 is required.

D. Submit name and qualifications of Water Treatment Specialist and chemical product data to Architect/Engineer for review.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Valves: Stockham, Milwaukee, Red-White, Nibco, Keystone, Watts.

C. Balancing Valves: Bell and Gossett, Armstrong.

D. Constant Flow Valves: Griswold.

E. Expansion Tanks: Bell and Gossett, Amtrol, Armstrong, Taco.

F. Air Eliminator: Thrush.

G. Glycol Feed System: J.L. Wingert, IAT, Neptune.

2.02 PIPE AND PIPE FITTINGS

A. General: Pipe

B. Pipe and Fittings: Schedule 40 black steel pipe or Type L or K copper. Steel piping systems shall have threaded cast iron fittings on pipe 2-1/2 inch and smaller; butt-welding type welding fittings on pipe 3-1/2 inch and larger. Copper piping systems shall have soldered pipe joints. The Contractor, at his option, may use mechanically coupled piping system in lieu of threaded or welded piping.

C. Automatic Air Vent Drain Piping and Miscellaneous Drain Piping: Type L copper.

D. Flanges: Welding neck or threaded type, class 125, conforming to ANSI B16.1.

E. Bolts: Machine bolts, heavy pattern, semi-finish hexagon nuts, steel conforming to ASTM A307, Grade B.

2.03 VALVES

A. Check Valves:

1. 2 Inches and Smaller: 125 pound bronze check, “Y” pattern, horizontal wing, renewable discs, bronze trim, screwed or soldered connections. Nibco T-413, S-413 or approved.

2. 2-1/2 Inches and Larger: 125 pound iron body check, horizontal swing check, bronze trim, bolted bonnet, flanged end connections. Nibco F-918 or approved.

3. Non-Slam Check Valves: 125 pound class, cast iron body, bronze seat and disc, spring actuated renewable seat and disc, water style, silent check valve. Nibco W-910 or approved.

B. Drain Valve: Boiler drain compression faucet, rated 150 pound working pressure up to 200 degrees F, round handle, rough brass finish; size ½ inch where serving piping ½ inch through 1 inch in size; size ¾ inch for larger piping.

C. Butterfly Valves:

1. 2 Inches and Smaller: Not Allowed.

2. 2-1/2 Inches and Larger: 150 pound cast iron body, stainless steel shaft, nodular iron disc, EPDM resilient seat, lever handle with memory stop. Provide with extended neck where used on insulated piping. Valve shall have lugs allowing dead end service with downstream piping removed. ON valves 6 inches and larger, provide with manual gear drive having hand wheel.

D. Ball Valves: Bronze or brass body, rated for 150 psi working steam, pressure chrome-plated, brass or stainless steel ball, Teflon seats, two-piece body, conventional port, blow-out-proof stem and complying with Fed. Spec. WW-V-35. Threaded or soldered end connections. Milwaukee Series BA-100, BA-150 or approved.

E. Balancing Valves: Calibrated balance valve, with brass readout valves with integral EPT insert and check valve to minimize fluid loss during balancing. Valve shall have calibrated nameplate and memory stop. Valve shall have a preformed polyurethane insulation. Valve shall be same size as pipe installed in. Bell and Gossett “Circuit Setter” or approved.

F. Constant Flow Valves: Shall automatically maintain flow rates to plus or minus 5% of specified flow rates over an operating differential pressure of at least 14 psig (or 14 times the minimum required for valve control, whichever is greater). Valves shall be factory set for the flow rates indicated; factory settings shall be no less than 3% nor more than 7% of the flow rates indicated. Valve control mechanism shall consist of a stainless steel cartridge with a ported cup and coil/helical spring. Valve bodies shall be rated for use at not less than 150% of system designed operating pressure and no less than 250 degrees F. Valves shall have two integral temperature/pressure ports for measuring across valve. Identification tags shall be provided on all valves; tags shall be indelibly marked with flow rate, model number, zone identification; tags shall be 3” x 3” aluminum. All flow control systems shall be by the same manufacturer and shall be warranted for five (5) years to be free of all defects in materials and workmanship and to give satisfactory service in this project’s applications. Manufacturer shall submit certified independent laboratory tests verifying accuracy of performance.

G. Heat Pump Hose Connection Kits: Supply and return hose connection kits for connection of heat pump to run-out piping. Kits shall include all items as shown on the drawings and as follows:

1. Ball Valves: Shall comply with Paragraph E above.

2. Strainer: shall be Y-type configuration made of bronze with a brass cap. Maximum pressure rating of 450 psi. Strainer screen shall be stainless steel, ported with 0.055 inch diameter holes, and easily accessible for cleaning without disconnecting hoses. Strainer shall be provided with blow-down ball valve.

3. P/T Port: Brass body adaptor with test port for reading pressure and temperature.

4. Hoses: Shall be flexible, fire retardant type, minimum 18 inches long. Hoses shall be equipped with swivel connections at terminal unit. All end connections shall meet stated pressure ratings. Hose materials shall be stainless steel braided over a synthetic polymer liner. Hoses shall be rated for 230° F and a minimum working pressure of 175 psi at 230° F. Hoses shall meet or exceed the ASTM-D380-83 standard and withstand working pressures of 375 psi (1/2 inch) at 250° F.

5. Constant Flow Valves: Shall comply with Paragraph G above.

H. Pressure Relief Valves: ASME rated pressure relief valve, set for pressure indicated or as required to protect system from over-pressure. Watts Series No. 174A or equal. Relief valve sizes shall be as required to give relief capacity 150% of the protected item's heat input, but no less then ¾ inch connection sizes.

I. Solenoid Valves: Pilot operated quick opening slow close 24 volt DC normally open solenoid valve. Valve shall be 2-way, 200 PSI rated, brass construction, with relay and accessories for connection to Section 15900 control system. Valve shall be specifically designed and intended for use on hydronic heat pumps. Valve shall have adequate operating force to fully close against system pump head.

2.04 **EXPANSION TANKS**

A. Type: Pre-pressurized, ASME labeled, diaphragm expansion tanks.

B. Capacity: Tank volume shall be as indicated on the drawings, factory pressurized to the pressure indicated, and shall be rated for 125 psig maximum working

pressure and 240° F maximum temperature and shall be constructed in accordance with ASME code.

C. Data Sheet: Furnish each expansion tank with manufacturer's Data Report for Pressure Vessels, per ASME Boiler and Pressure Vessel Code.

2.05 **AIR ELIMINATOR**

A. Type: Cast iron vortex separator with pilot piston air elimination valve. Thrush No. 721.

B. Construction: Cast iron body and cover, rate for up to 150 psig pressure.

2.06 **GLYCOL FEED SYSTEM**

A. General: System shall consist of a polyethylene tank, hinged polyethylene lid, carbon steel frame NEMA 4X control panel, low level float switch, bronze gear pump with internal relief valve, pressure switch, relief valve, schedule 80 PVC plumbing and vinyl braided hose.

B. Tank and Frame: Polyethylene tank shall be industrial grade with a nominal wall thickness of ¼". Shoebox type lid shall be 1/3 the diameter hinged with 304 stainless steel piano hinge and 316 stainless steel rivets. Tank frame shall be constructed of carbon steel with bracing for plumbing and control panel. Tank frame shall have 10 gauge pump mount shelf and be coated with water based enamel paint. Tank shall be minimum capacity as scheduled on plans.

C. Pump: Pump shall be gear type, close coupled with internal pressure relief valve. Pump will be capable of minimum capacity as scheduled on the plans at 100PSI. Pump motor shall be of HP and voltage/phase as indicated on plans. 60 hertz, open drip proof type and factory wired to control panel.

D. Controls:

1. Pressure Switch: Pressure switch shall be designed for pressures to work with system pressures noted on plans, and shall be pre-wired to control panel to turn on and off unit pump based on rising and falling system pressure.

2. Control Panel: Fiber filled polycarbonate NEMA 4X control panel shall be of ample size for equipment needed and servicing of electrical components. All exterior components shall be rated NEMA 4X and installed per manufacturers' instructions. Wiring and wiring diagram shall be color-coded for easy trouble shooting. All internal wire shall be 16-gauge minimum. Controls shall include: main power switch and

indicator light, pump hand/off/auto switch and indicator light, red low-level indicator light, and all necessary devices and wiring to properly operate.

3. Dry Contact: Dry contact shall be SPST NO switch, shall be wired to indicate low tank level for Section 15900 alarm signal.

E. Pressure Relief Valve: PVC pressure relief valve shall be constructed of Schedule 80 PVC and with an elastomer backed Teflon diaphragm. Valve will incorporate a gauge with pressure range relative to system pressure settings.

F. Check Valve: Backflow check valve shall be tapered valve body design with an enlarged valve chamber to reduce valve chatter. PVC construction with stainless steel spring and raised radius valve seat for positive seal.

G. Low Level Switch: Polypropylene low level switch shall be interlocked with pump feed and low level indicator. Low level will stop all pump operations when level falls below the factory set point.

2.07 **AIR VENTS**

A. Automatic Air Vent-High Capacity: Float type, with stainless steel float and float mechanism, cast iron body, rated for 250 psig maximum operating pressure, 300° F maximum temperature and 10 cfm capacity at 100 psig water pressure. Hoffman No. 792.

B. Automatic Air Vent: Float type, with stainless steel float and float mechanism, semi-steel or cast brass body, ball check preventing re-entry or air, rated for 150 psig maximum pressure and 250° F maximum temperature. Hoffman No. 78.

C. Manual Air Vent: ¼ inch, 125 psi bronze ball valve (Milwaukee BA-100 or equal), with nipple connecting to pipe and discharge nipple and ¼ inch inside diameter black rubber flexible tubing, 24 inch long, provided.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Install hydronic heat pump water piping system as shown on the drawings, completely connected to all devices and heat pumps.

B. Piping and fitting installation shall comply with Section 15060, Pipe and Pipe Fittings.

C. Install automatic air vents installed at each high point in the system, where air may become trapped, and where system is separated from other air vents by vertical drops or rises. Provide added automatic air vents where shown on the drawings.

D. All automatic air vents shall be connected to the system through a ball valve.

E. All automatic air vents shall be provided with drain piping to the nearest funnel or floor drain. Multiple vents may be plumbed to a common drain line which then runs to the nearest funnel or floor drain. Such a drain system may not be shown on the drawings (due to its incidental nature) but is a project requirement. Such drain line shall pitch toward nearest drain at a minimum 1% slope down and shall be minimum ½ inch for serving up to 4 AAV's, ¾ inch for serving up to 12AAV's, and 1 inch where more are served.

F. Provide manual air vents where shown on the drawings.

G. Use eccentric reducers for changes in pipe sizing, keeping the top of pipes in line.

H. Install drain valves at the low points in the piping system and at the base of each system riser. Provide additional drains as required to allow for complete draining of the system. These drain valves shall take off of the bottom of any horizontal pipe that they are connected to.

I. Install flow measuring devices, balancing valves, constant flow valves per manufacturer's instructions; with the proper distances upstream and downstream to any pipe fittings.

J. Install valve types as shown on the drawings. The Contractor, at his option, may use butterfly valves on piping 2-1/2 inch and larger, and ball valves on piping 2 inch and smaller.

K. Set balancing valves in initial position as shown on the drawings. Where an initial setting has not been shown, the valves shall be installed in a wide open position.

L. Heat Pump Connections: Provide hose connection kits for supply and return connections at heat pumps. Connection size shall be same size as unit connections (or larger); provide length of flexible hoses as required to prevent hose kinks, but not less than 18 inch long.

M. Mock-Up: The Contractor is required to provide a sample piping installation for an air handling unit prior to installing and connecting other units. Such mock-up

shall be at the location that will be the final unit installation. Selected unit to be mocked-up is Contractor's choice, but selected unit shall be typical to most units, and be agreed to by the Engineer. Mock-Up shall include all coil valving, strainers, supports, bracing, vents, controls, etc. See Section 15815, 18540 and 15900 for related work.

3.02 **FLUSHING AND TESTING**

A. Scope: All hydronic heat pump water piping systems that have been worked on shall be tested. The system shall have an initial test applied after flushing and an additional test applied after system cleaning.

B. Isolation: Isolate from the piping, all hydronic heat pumps, and any other parts of the system or equipment (this includes all constant flow valves) that may be damaged by the test pressure or entrapment of debris during the flushing process. The system may be isolated into various smaller sub-systems to allow earlier testing and locating of leaks. Connect each heat pump's supply line directly to the return run-out, bypassing the heat pump and the constant flow valve. Provide temporary bypass piping as required.

C. Flushing: Prior to initial testing and chemical cleaning, the system shall be filled and flushed with clean water to remove all large debris. Flush system until water runs clear.

D. Initial Testing: After initial flushing and draining, the system shall be refilled and an hydrostatic test applied. Test pressure shall be 125 psig on new system and 75 psig on existing piping systems. System shall hold the test pressure for a minimum of two h ours with no drop in pressure. Any leaks shall be repaired and the system re-tested until system proves tight.

E. Final Testing: After system cleaning, the system shall be prepared for normal operation, with equipment connected (except parts of system or equipment that would be damaged by the test pressure) and re-tested using the same pressures and criteria as outlined in Subparagraph D, Initial Testing. All leaks shall be repaired and system re-tested until it proves tight.

F. Gauges: contractor shall insure that clear, accurate, and readable pressure gauges are used to insure accurate testing and allow for witnessing by others. Contractor shall make a written record of the gauge readings, time, date, and where connected to the system and mark this information on the site as-builts.

G. Witnessing: Contractor shall notify the Architect/Engineer in advance (minimum three (3) days notice) of when testing will take place, and such testing shall be witnesses by the Architect/Engineer.

H. Documentation: Submit dates and results of all flushing and testing.

3.03 CHEMICAL CLEANING AND TREATMENT

A. Scope: The interior surfaces of all hydronic heat pump water piping shall be flushed and chemically cleaned; this includes all new piping, all existing piping, and normally connected piping components.

B. Supervision: All work shall performed under the direct supervision of a trained Water Treatment Specialist.

C. Isolation: Isolate from the piping all hydronic heat pumps and any parts of the system or equipment that may be damaged by the cleaning chemicals, entrapment of dirt, or in any other way have their performance hindered by the cleaning process. Connect each heat pump's supply line directly to the return run-out, bypassing the heat pump and the constant flow valve. Provide temporary bypass piping as required.

D. Sequence: The system shall be flushed and pressure tested prior to cleaning. An additional pressure test shall be conducted after system cleaning (see Paragraph 3.02, Flushing and Testing).

E. Cleaning Chemical: Shall be specifically designed and intended for use in cleaning hydronic heat pump piping systems. The cleaning chemical shall be formulated to work effectively in circulating temperatures from 65° F to 165° F. The cleaning chemical shall be formulated with detergents, dispersants and alkaline emulsifiers which are capable of removing greases, oils and mill scale (HydroChem 280 – 281 or equal).

F. Application: The cleaning solution shall be added via a bypass feeder or pump until a phenolphthalein alkalinity of 500 ppm is obtained. The solution shall be circulated for approximately 12 hours. During this time, partially close and re-open all manual valves. At the end of the cleaning period, a running flush shall be started and continued until the system water runs clear, clean of chemical and is at the normal pH of fresh water.

G. Strainer Cleaning: The systems shall be drained and all strainers blow-down and thoroughly cleaned and any temporary bypass hosing or piping removed and the system connected for normal operation. The system shall then have a final pressure test applied (see Section 3.02, Flushing and Testing).

H. Biocide: After successful final testing, a broad spectrum microbicide formulation shall be added to the system (quantities as recommended by Water Treatment Specialist) to insure a biologically free environment.

I. Corrosion Inhibitor/Glycol: A corrosion inhibitor such as HydroChem 437-K shall be added to a sodium nitrate residual of 1000 ppm. Where a glycol concentration is indicated, Dow Chemical inhibited propylene glycol shall be added to the concentration indicated. Prior to final system filling with glycol, verify that water system is free from leaks and all air vents are piped to capture overflow. Fill system with Propylene glycol treated water mixture. Test mixture freeze temperature and submit test report for review. Record volume of glycol required on test report. Glycol tank to be left full of Propylene glycol treated water mixture for Owner use. See plans for glycol concentration.

J. Report: The Water Treatment Specialist shall prepare a complete report of the cleaning operation and submit five (5) copies to the Architect/Engineer and additional copies to the Mechanical Contractor for inclusion in the Operation and Maintenance Manual.

END OF SECTION

SECTION 15500

FIRE PROTECTION SPRINKLER SYSTEM

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Sprinkler System Design.

B. Piping.

C. Sprinkler Heads.

D. Valves.

E. Accessories.

F. Pre-Installation Conference.

G. Owner Instruction.

1.02 **RELATED WORK**

A. Section 15010 – Mechanical, General.

B. Section 15050 – Excavation, Trenching and Backfill for Mechanical Underground Utilities.

C. Section 15060 – Pipe and Pipe Fittings.

D. Section 15080 – Piping Specialties.

E. Section 15090 – Hanger and Supports.

F. Section 15095 – Sleeves and Seals.

G. Division 16 – Electrical.

1.03 **SUMMARY COMMENTS**

A. All new construction of academic and residence hall facilities shall be fully furnished with sprinklers.

B. For facilities that are currently unfurnished with sprinklers and are undergoing renovations, consideration must be given to providing sprinklers within impacted areas. Discussions with Pacific Lutheran University and the authority having jurisdiction (AHJ) shall dictate code compliance and scope of work.

1.04 **CODES AND STANDARDS**

A. Design shall comply with the requirements of the following codes and standards:

1. Washington State Fire Prevention and Building Code, International Building Code (IBC) and Washington State Fuel Gas Code.

2. Factory Mutual Global (FM) where applicable.

3. All applicable NFPA.

4. ANSI A-17.1, Safety Code for Elevators and Escalators.

B. In the event of an overlap or conflict between the requirements of the codes, laws and ordinances, and this standard, then negotiations involving the AHJ and Environmental Health & Safety (EH&S) shall bring resolution to the dispute.

1.05 **DEFINITIONS**

A. Authority Having Jurisdiction (AHJ): shall be defined at the inception of the project and has the potential to vary in conjunction with project location. Consult with Pacific Lutheran University to obtain appropriate AHJ.

B. EH&S – Pacific Lutheran University Environmental Health and Safety Office. EH&S provides acceptance and inspection of all fire protection and suppression systems.

C. Contractor – When referenced within Section 15300, “contractor” shall mean the firm responsible for preparation of shop drawings and installation of fire protection systems.

D. Project Engineer – The Engineer of record who represents the Design/Engineering firm. The Engineer shall seal with a Professional Engineer (P.E.) stamp all record contract drawings prior to distribution.

E. Owner – Pacific Lutheran University and/or appointed representative shall be considered the Project Manager or Construction Manager as assigned.

F. FM – Factory Mutual

G. UL – Underwriters Laboratories

1.06 **GERNERAL DESIGN REQURIEMENTS**

A. General Design Requirements:

1. All fire protection systems shall be hydraulically calculated and designed by a qualified designer or fire protection engineer.

2. All fire protection systems shall be monitored by the fire alarm system and Pacific Lutheran University Campus Safety. All buildings equipped with fire sprinkler systems shall also have an exterior local alarm (bell) initiated by the flow detection device (water motor gongs shall not be used).

3. All drains shall discharge to sanitary. Verify capability of existing drains to accept full flow discharge.

A. System Sub-Section Zones:

1. Sub-section zoning shall be provided for the following areas:

a. Elevator Machine Rooms and Shafts – Flow switches may be specified as deemed appropriate by the engineer. All installations are to be in accordance with ANSI A-17.1.

b. Transformer Rooms – (double interlock pre-action).

c. Information Technology Rooms – shall not contain wet piping. Wet sidewall heads are acceptable, although pre-action is preferred if feasible.

d. Buildings that exceed three floor levels shall be zoned per floor. This will allow phased occupancy in the event of a sprinkler system activation.

e. All other zoning is the discretion of the Engineer.

f. Zone Check flow switch assemblies are preferred over manual inspectors test and drains, if feasible. This device allows the annual inspections to be performed without the discharge of system water.

B. Existing Equipment:

1. The use of existing features should be considered.

2. All equipment or piping shall be inspected and tested for operational integrity and must be in compliance with current code prior to direction being given.

C. System Design Consideration:

1. Wet pipe systems are preferred and shall be used in the majority of applications.

2. Glycol systems shall not be designed or installed unless prior approval has been given by Pacific Lutheran University.

3. Dry pipe systems are discouraged and shall only be used for incidental areas susceptible to freezing conditions, or to meet specific requirements of special use facilities.

4. If piping is intended to be exposed, the use of screwed fittings is the preferred standard installation.

1.07 FIELD QUALITY CONTROL

A. All testing shall be in accordance with specified procedures in the listed codes and standards.

B. A representative of Pacific Lutheran University EH&S shall witness back flushing of all new installations and hydrostatic testing of new sprinkler installations. The authority having jurisdiction (AHJ) requires that a representative witness the sprinkler and standpipe hydrostatic testing of new installations that are within their jurisdiction. Advance notice and scheduling is required.

C. All fire protection systems shall be thoroughly cleaned and flushed with tri-sodium phosphate prior to final acceptance.

1.08 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirement affecting the Work of this Section.

1.09 **QUALITY ASSURANCE**

A. All materials and equipment shall be listed as approved by the Underwriters' Laboratories "List of Inspected Fire Protection Equipment and Materials", or the Factory Mutual Laboratories, "List of Inspected Fire Protection Equipment and Materials", or the Factory Mutual Laboratories, "List of Approved Equipment, Fire Protection Devices and Devices Involving Fire Hazard"; and shall be of the Manufacturer's latest design.

B. Equipment and installation to meet requirements of NFPA 13, Standard for the installation of Sprinkler Systems and all other governing codes (see Section 15010), and to exceed these codes as indicated. Various items in these specifications exceed code requirements.

1.10 **SUBMITTALS**

A. All submittals shall comply with Section 15010.

B. Submit shop drawings of entire sprinkler system for approval by the local Fire Marshal. Submit these same drawings to the Architect/Engineer; label these as "Information – Subject to Code Approval – Not For A/E Review". Submit Fire Marshal approved drawings to Owner/Architect/Engineer as the submittal for review. Shop drawings shall show head locations on reflected ceiling plans; use shop drawings from ceiling installer for ceiling layout. Where these drawings are not available, use Bid Set reflected ceiling planes. Shop drawings shall also show ductwork along with sprinkler piping; use shop drawings from sheet metal contractor or contract drawings if no sheet metal shop drawings are provided.

C. Submit product information on all products to be used.

1.11 **GENERAL REQUIREMENTS**

A. All fire sprinkler design shall be performed by a Contractor thoroughly familiar with and knowledgeable of NFPA 13, NFPA 24 and fire sprinkler system design and installation. By virtue of submitting a bid, the Contractor is acknowledging that he does in fact, have such knowledge; and all work provided will fully comply with all the requirements of these specifications. The fire sprinkler Contractor shall be qualified, as required by local authorities to design and install

all parts of the fire sprinkler contractor, of by a level U certified plumbing contractor, as issued by the State Fire Marshal's office.

B. All fire sprinkler design drawings shall be stamped by a Washington State Licensed Fire Protection Engineer or Designer (as required by Authority Having Jurisdiction).

C. System shall be Contractor-designed and approved by both the Fire Marshal and Owner/Architect/Engineer.

D. System Description: Fire sprinkler system provided for the entire building. All spaces shall be sprinklered as required by NFPA 13, and per local code requirements. Provide fire sprinkler coverage for all concealed combustible spaces, all concealed non-combustible spaces, and above and below all ceilings. This coverage exceeds code requirements, and shall be provided as noted. For coverage non-combustible areas not required by code, treat areas as if they are of combustible construction.

E. This section alone does not specify all work for the fire sprinkler system. Other sections which include fire sprinkler work are: 15010, 15015, 15050, 15080, 15090, 15095 and 15200 (as a minimum); the Contractor is responsible to review all divisions.

F. Special Design Areas: Portions of the building's fire sprinkler system where the fire sprinkler piping is to be run exposed or requires drilling through building structure require special design effort, and coordination among trades and with the Authority Having Jurisdiction (AHJ) and the design team. The Contractor shall include in his bid costs for such special coordination and design efforts. This work shall include multiple meetings with local and state code officials, various contractors, and members of the design team.

1.12 **PRE-INSTALLATION CONFERENCE**

A. General: A pre-installation conference shall be held prior to the Contractor installing any of the materials of this section. The conference shall occur after all submittals have been satisfactorily reviewed by the Architect/Engineer and returned to the Contractor, and approximately fourteen (14) days prior to the proposed system installation date and prior to the fabrication of any system piping components. The purpose of this conferences is to review the Contractors installation methods, materials, schedule, coordination with all other trades, and related construction/design issues to allow for efficient and proper construction. The Architect/Engineer and Owner will highlight various items of concern, typical problems encountered on similar projects, coordination issues, and related items.

B. Attendance: The pre-installation conference shall be attended by the General Contractor, the Contractor doing the work of this Section, other contractor trades as appropriate to the proper coordination of the work of this section, the Owner's Representatives (at their option), the Engineer, and the Architect.

C. Coordination: The Contractor shall notify the Owner/Architect of the Contractor's readiness to hold the pre-installation conference at least fourteen (14) days prior to the proposed meeting time, and mutually agreed upon meeting times arranged.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. All products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Sprinkler System Components: Reliable, Viking, Gem, Star, Central, Grinnell.

C. Valves: Grinnell, Viking, Gem, Central.

2.02 **PIPE AND PIPE FITTINGS**

A. Pipe and fitting standards shall be as specified in Section 15060, Pipe and Pipe Fittings.

B. Aboveground Piping and Fittings: Piping shall be black steel. Fittings shall be suitable for 175 psi working pressure, and shall be cast iron or malleable iron screwed, grooved or welded in accordance with NFPA 13. Piping and fittings ran outside and exposed to the outdoors shall be galvanized type. (i.e. if piping is concealed in soffit, galvanized is not required.)

C. Underground Piping and Fittings: Shall conform to local utility requirements, NFPA 24 and NFPA 13. Shall be ductile iron pipe conforming to AWWA C151, thickness class 52 minimum. Fittings shall conform to AWWA C111, with pressure rating no less than the piping connected to. Pipe and Fittings shall have cement-mortar lining conforming to AWWA C104. Pipe and fittings shall be restrained against movement in accordance with NFPA 24. Thrust restraining joints/fittings shall be UL listed for fire main use.

2.03 **VALVES**

A. 2 Inch and Smaller: Bronze gate valve, 175 psi water working pressure, threaded ends conforming to ANSI Standard B2.1, UL listed and FM approved. Stockham Figure B-133, or approved. ALTERNATE: Bronze butterfly or ball valve, UL listed for fire protection service and FM approved. Milwaukee or equal.

B. 2-1/2 Inch and Larger: Iron body OS & Y gate valve, 175 psi non-shock, cold water, flanged ends conforming to ANSI Standard for Class 125 cast iron flanges B16.1, UL listed and FM approved. Stockham Figure G-634, or approved. (Provide with tapping for corporation stop matching detector check valve where valve is used upstream of detector check.)

C. Check Valves: Iron body swing check valve, 175 psi non-shock cold water, UL listed and FM approved. Stockham Figures G-938, G-940, or approved.

D. Backflow Preventer – Double Check Valve Type: Washington State approved type, UL listed, with replaceable clapper rubbers, four corporation stops for testing, air vents on each check valve, and having galvanized iron check valve bodies and covers. Use compact type as necessary to suit space available as shown on plans.

2.04 **ALARM VALVE-WET PIPE**

A. Alarm valve shall be UL listed and FM approved for use as an alarm valve in a wet pipe fire sprinkler system, size as selected by Contractor.

B. Alarm valve shall be complete with retard chamber, system and supply pressure gauges, main drain valve, pressure alarm switch, alarm test valving, and all other accessories to provide a complete alarm valve assembly as required to function in accordance with NFPA standards.

2.05 **ALARM VALVE-DRY PIPE**

A. Alarm valve shall be UL listed and FM approved for use as an alarm valve in a dry pipe fire sprinkler system, size as selected by Contractor.

B. Alarm valve, pressure alarm switch, alarm test valving, priming connections, drain lines/drain cup, connections for water motor alarm, check and isolation valves for air line connection, air line relief valve and all other accessories to provide a complete alarm valve assembly as required to function in accordance with NFPA standards.

2.06 **ALARM BELL**

A. Water Motor Type: Water motor alarm shall sound continuous ringing alarm when driven by water from sprinkler system alarm valve. Shall be compatible with alarm valve furnished, be UL listed and FM approved.

B. Labeling: Alarm bells shall be labeled or provided with sign mounted adjacent to bell, reading “Sprinkler fire Alarm” (in 1-inch high capital letters), followed by “when bell rings, cal Fire Department or Police.” Sign shall be aluminum lithographed, with red letters on white background.

2.07 **SPRINKLER HEADS**

A. Wet Type – Finished Areas:

1. Pendant: Shall be low profile, glass bulb type, with temperature rating to suit application and factory chrome plated finish. Where installed through ceilings provide with escutcheons, two piece adjustable type, with factory chrome finish to match heads.

2. Upright: Shall be glass bulb type, with temperature rating to suit application, and factory chrome plated finish.

3. Sidewall: Shall be glass bulb or fusible solder type, with temperature rating to suit application, and factory chrome plated finish.

B. Wet Type – Unfinished Areas: Sprinkler heads in unfinished areas shall be fusible/solder type or glass-bulb type, with natural bronze or chrome plated finish, temperature rating to suit application.

C. Dry Type:

1. General: Provide where system may be exposed to freezing temperatures, finish, length and temperature rating to suit application.

2. Finished Areas: Polished chrome finish type with flush type chrome plated escutcheon where installed through ceilings, soffits, and similar elements.

3. Unfinished Areas: Natural bronze finish with flush or deep type brass finish escutcheon where installed through a floor, ceiling or similar element.

D. Sprinkler Guards: Hard-wire cage sprinkler guard, designed to protect sprinkler from mechanical damage, with chrome plated finish.

E. Sprinkler heads shall be upright, pendant or sidewall type as required to suit application.

F. See Section 15010 for definition of “Finished Areas”, and “Occupied Areas”.

2.08 **ACCESSORIES**

A. Water flow Alarm – Flow Type Indicator: Shall be UL listed, with polyethylene paddle water flow detector, cast metal body, adjustable time delay retard mechanism to allow indicator to absorb fluctuations or water flow due to pressure surges to prevent false alarms.

B. Water flow Alarm – Pressure Type: Furnished with Alarm valve, see paragraph entitled “Alarm Valves – Dry Pipe”. Switch shall indicate activation of sprinkler system.

C. Low Pressure Air Alarm Switch: single pole double throw switch, for indicating low air pressure supplied to a dry pipe system. Shall be rated for 250 psi service pressure, be enclosed in NEMA 2 housing, have a neoprene diaphragm, and be field adjustable between 20 and 225 psi.

D. Valve Switches: Switch for indicating operation of valve; type and configuration to suit valve used on. Switch shall have single pole, double throw type contacts, with cast aluminum housing and non-ferrous parts for corrosion resistance. Shall be weatherproof type where installed outdoors.

E. Sway Bracing/Restraints: Contractor fabricated of riser clamps, Schedule 40 pipe and pipe fittings, all welded construction, size and configuration to suit application.

F. Specialties: Access doors, gauges, and related piping specialties; see Section 15080.

G. Hangers/Supports: See Section 15090.

H. Sleeves/Seals: See Section 15095.

I. Air Compressor:

1. Sizing: Shall be by Contractor, in compliance with NFPA requirements.

2. Type: Air compressor shall be electric motor-driven, air cooled, single-stage, tank mounted type. Tank shall be ASME labeled. Unit shall be complete with connections for controlling unit On/Off, motor starter, disconnect, vibration isolators, relief valve, pressure gauge outlet isolation valve, outlet union, and related accessories for proper unit operation.

3. Power: Unit shall be no larger than ¾ HP, and shall be for use with 120 volt/1 PH electricity, and shall have single point power connection.

4. Noise: Compressor noise shall not exceed NC 35 in any octave band. Provide acoustic enclosure or remote piped air intake with a muffler to reduce noise as required.

J. Air Maintenance Assembly: Shall be type for use with dedicated sprinkler system air compressor. Assembly shall include air line strainer, air pressure switch for compressor control, bypass globe valve, isolation valves, unions, and all related components to properly connect the air compressor to the dry pipe system, in compliance with NFPA and local code requirements.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Installation of all equipment shall be performed by a Contractor specializing in this work and subject to Owner and Fire Marshal approval.

B. Water Supply: The fire sprinkler system shall be connected to the site water supply as indicated on the plans. All underground site work related to the fire sprinkler system shall be reviewed by the Contractor doing the Work of this Section, to verify that the installed piping conforms to acceptable professional practices and governing code. The Contractor doing the Work of this Section by virtue of connecting to this site piping is certifying that this site piping has been reviewed and is acceptable for connection to.

C. Outside water mains and connections shall comply with NFPA 24. Provide concrete thrust blocks or other approved restraining devices at all changes in pipe direction. Piping excavation and backfilling shall comply with Section 15050.

D. Flush outside fire water mains prior to connecting to inside system. Failure to flush will result in system rejection. Reference NFPA 24 for requirements; coordinate with site contractor.

E. All piping shall be run concealed in ceiling space, attic space, pipe shafts, soffits, etc. Provide all necessary drilling of beams, trusses, etc. Reference Section 15010 for cutting requirements (Structural Engineer's approval is required). Piping may only be exposed with Engineers approval and then shall be painted as directed by the Architect/Engineer. Piping shall run parallel to building structure in a neat, workmanlike manner.

F. Provide chrome plated escutcheon plates at exposed pipe penetrations of all ceilings, floors and walls.

G. Where piping is below grade, it shall not be insulated, but it shall be painted with a heavy coat of bitumastic paint.

H. Electrical, mechanical, architectural and structural plans shall be carefully examined by the Sprinkler Contractor, and his work shall be arranged to avoid interferences and to comply with all related requirements on these drawings.

I. If piping routes are not properly coordinated with other trades and structures, rerouting and possible re-sizing will be required as directed by the Architect/Engineer. The fire piping system has lowest priority of all systems routed in ceiling space.

J. Offset, crossover and otherwise route piping to install system in available space. Not all offsets necessarily shown. Pitch all branch lines, cross mains, feed mains and risers to drainage points.

K. Special care shall be taken to insure that entire sprinkler system is drainable in accordance with NFPA 13. Any work without proper slope to drain will be rejected. Where space permits, increase slope to 1 inch per 10 feet.

L. Extend main drain(s) and inspector's test connections to outside for drainage. Label valves and outlets. Each system shall have an inspector's test connection per Fire Marshal's requirements.

M. Installation of water motor alarm shall be in strict accordance with manufacturer's instructions. Adjust water flow indicator time delay as necessary to prevent false alarms due to pressure fluctuations.

N. Labeling: All drain valves, alarm bells, and risers shall be labeled to clearly indicate purpose/area served, per NFPA requirements and as specified herein. All piping shall be labeled per Section 15010. Risers shall be labeled to indicate hydraulic calculation basis.

O. Tamper Switches: Provide valve tamper switches at all isolation valves, and as required by the local Fire Marshal to indicate valves not fully open. Connection to central fire alarm system shall be by Division 16.

P. Provide alarm indicators to indicate water flow at riser for connection by Division 16 Contractor to central fire alarm system. Provide other alarm indicators as required by NFPA and by the local Fire Marshal.

Q. Heads shall be centered in ceiling panels. Where "scored" ceiling panels are used, heads shall be located to be centered in the flat portion of the tile between "scores".

R. Provide wire cage protectors for heads susceptible to damage (this includes all heads in mechanical loft areas with sprinkler heads 7 feet of less above walking surface, all gym heads, outside soffit heads below 9', and similar areas).

S. Provide shields to divert sprinkler water from equipment (i.e. electrical panels) which may be damaged (typical all areas).

T. Hangers and Supports: Shall comply with NFPA 13 and Section 15090. See also structural drawings for added limitations/requirements of supports and attachments to structure.

U. Contractor shall use caution in routing of wet pipe lines to maintain distances from outside walls and other areas which could have freezing temperatures in extreme conditions.

V. Pipe Routing: Contractor shall in no way interfere with mechanical access, and shall maintain 7' clear headroom at all locations over platforms at mechanical equipment (unless structurally prohibited). Provide separate mains to serve corridors and areas below mechanical platforms – piping that runs on platform or interferes with access will not be accepted.

W. Air Compressor: Install and connect up air compressor piping and accessories to system and provide all wiring interconnections between controller and compressor. Install compressor on vibration isolators.

X. Provide building access doors as needed to allow maintenance access to all sprinkler heads and system components. Doors shall be no smaller than 24" x 24". Note: This is in excess of NFPA 13 requirements. Reference Section 15080 for access door requirements. Coordinate with other trades for proper framing/block-out provisions to accommodate doors, and to insure no other systems block door access.

Y. Electrical/Fire Alarm: Any power or fire alarm connections required but not shown on the electrical drawings shall be furnished and installed by the Section 15500 Contractor.

3.02 SYSTEM DESIGN

A. System shall be Contractor designed in accordance with NFPA 13, and additional requirements as cited in the Contract Documents.

B. System design shall be based on hydraulic calculation using approved water flow test data on the water supply line to the fire protection system. Such test data must meet the approval of the local Fire Marshal and the Architect/Engineer. Water flow date is shown on the plans is preliminary only. Contractor is responsible to arrange for such water flow tests and pay all associated fees for such a test.

C. Submit all system calculations showing calculations and compliance with NFPA.

D. Design shall include complete system, including water main to building, and extending as far back into the local utilities systems (i.e. reservoirs) as deemed necessary by the AHJ.

3.03 TESTING

A. The systems shall be hydrostatically and operationally tested in accordance with the requirements of NFPA 13 and the local Fire Marshal. Any changes required to meet time or flow tests shall be made without additional cost to the Owner. Submit documentation of testing including dates and results of testing. Certificates of acceptance shall be submitted to the Architect/Engineer.

3.04 OPERATING AND OWNER INSTRUCTIONS

A. Typewritten, plastic covered, framed instructions shall be mounted in the buildings near each fire sprinkler riser. Instructions shall explain riser components, how to test, and how to drain.

B. The Owner or his representative shall be instructed by the Sprinkler Contractor in the operation of the system. The instruction shall be given by Contractor's personnel who are considered qualified in the opinion of the Architect/Engineer and shall be for a minimum of two (2) hours. Instruction shall include location of all valves, drains, and pipe routing, as well as proper maintenance and testing procedures.

END OF SECTION

SECTION 15760

ELECTRIC HEATERS

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Fan Forced Wall Heaters.

1.02 **RELATED WORK**

A. Section 15010 – Mechanical, General

B. Section 15900 – Controls.

C. Division 16000 – Electrical.

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products: Shall comply with Section 15010 Part 2.01 – Acceptable Manufacturers.

B. Fan Force Wall Heaters: Aztec, Berko, Qmark, Markel.

2.02 **GENERAL**

A. Size and Capacity: Shall be listed on the drawings.

B. Type and Manufacturer: As shown on the drawings.

C. Listing: All heaters shall be UL listed.

D. For installing in ceiling type as indicated on plans (reference Architectural ceiling plans).

E. Shall have minimum one (1) year warranty.

2.03 **FAN FORCED WALL HEATERS**

A. Type: Heavy duty wall mounted electric forced air heater. Markel Series noted on equipment schedule.

B. Construction: Exposed sheet metal shall be constructed of minimum 16 gauge zinc coated steel, with extruded louvered aluminum front, for surface or semi-recessed installation as shown on the drawings. Unit shall have brown baked-on enamel finish on steel, and satin bronze finished aluminum.

C. Heating Elements: Unit shall have two or three heavy-duty, totally enclosed, corrosion resistant, steel sheathed elements, mechanically bonded to common corrosion resistant fins. Minimum 2" cold end conductor pins, maximum 60 W/in. density.

D. Motor and Fan: Motor shall be shaded pole, heavy-duty, total enclosed, permanently lubricated type. Fan shall provide 245 cfm at 660 fpm, with minimum 7-3/4" blade diameter.

E. Electrical and Controls: Unit shall have automatic reset thermal cut-out. Provide with 24 volt contactor and transformer for remote pilot duty control of heater.

F. Warranty: Entire heater shall be warranted for five (5) years.

G. With automatic reset thermal overheat protector.

H. Unit shall be of tamper resistant construction with integral thermostat and fan.

I. Unit shall have brown bake finish and satin finished aluminum frame.

J. Unit shall have a power control relay to allow DDC control of heater.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Heater controls shall be installed and connected under Section 15900 – Controls.

END OF SECTION

SECTION 15815

HYDRONIC HEAT PUMPS

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Horizontal Hydronic Heat Pumps.

B. Mock-up.

C. Start-up.

D. Owner Instruction.

1.02 **RELATED WORK**

A. Section 15010 - Mechanical, General

B. Section 15060 – Pipe and Pipe Fittings

C. Section 15080 – Piping Specialties

D. Section 15090 – Hangers and Supports

E. Section 15200 - Vibration and Seismic Control

F. Section 15420 – Soil, Waste and Vent Piping System

G. Section 15745 – Hydronic Heat Pump Water Piping System

H. Section 15755 – Hydronic Heat Pump Ground Coupled Piping System

I. Section 15840 – Ductwork

J. Section 15880 - Air Filtering Equipment

K. Section 15900 – Controls

L. Section 15955 – Air and Hydronic Balancing

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **DEFINITIONS**

A. "ESP" is defined to mean external static pressure, measured external to the heat pump unit duct connection collars but including a pressure drop for the units' filters. Filter pressure drop has been estimated in one-half dirty/one-half clean condition using 0.25 inch.

1.05 **QUALITY ASSURANCE**

A. Listing: Units shall be listed by an approved testing laboratory for the use and application intended (reference Section 15010),

B. Rating and Certification: Unit performances shall be tested and rated in accordance with ARI Standard 320, and units shall be ARI certified.

1.06 **SUBMITTALS**

A. Shall comply with Section 15010.

B. Submit product and performance data on all products to be used. Provide schedule clearly indicating what model numbers are proposed for each unit.

C. Project is attempting to attain LEED Credit EA #4, Enhanced Refrigerant Management. Contractor shall submit calculations that proposed heat pumps meet or exceed requirements for this credit.

D. Submit equipment seismic anchoring features.

1.07 **GENERAL REQUIREMENTS**

A. Standardization: In interests of Owner's standardization, all heat pumps shall be the product of the same manufacturer.

B. Substituted Equipment: The drawings show design configuration based on particular manufacturer's equipment. Use of another manufacturer's equipment will require redesign of mechanical ductwork, piping, electrical, structural, unit support systems, and general building construction to accommodate the substituted equipment. Such redesign shall meet the requirements and have the approval of the Architect/Engineer prior to fabrication. If a different

manufacturer than shown on the plans is used, the Contractor shall submit complete shop drawings showing all alternate unit installation plans and details; shop drawings shall comply with Section 15010. The redesign shall be equal or superior in all respects to the Architect/Engineer's design (as judged by the Architect/Engineer), including such aspects as equipment access, ease of maintenance, duct connection locations, unit electrical requirement, noise considerations, unit performance, and similar concerns. Cost of redesign and all additional costs incurred to accommodate the substitution equipment shall be borne by the Contractor.

C. Equipment shall utilize HFC R-410A refrigerant and shall have a maximum charge meeting the requirements of USGBC LEED Credit #EA, Enhanced Refrigerant Management.

1.08 **PRE-INSTALLATION CONFERENCE**

A. General: A pre-installation conference shall be held prior to the Contractor installing any of the materials of this Section. The conference shall occur after all submittals have been satisfactorily reviewed by the Architect/Engineer and returned to the Contractor, and approximately fourteen (14) days prior to the proposed system installation date. The purpose of this conference is to review the Contractor's installation methods, materials, schedule, safety, coordination with all other trades, and related construction/design issues to allow for efficient and proper construction. The Architect/Engineer and Owner will highlight various items of concern, typical problems encountered on similar projects, coordination issues, and related items.

B. Attendance: The pre-installation conference shall be attended y the General Contractor, the Contractor doing the work of this Section, other contractor trades as appropriate to the proper coordination of the work of this Section, the Owner's Representatives (at their option), the Engineer, and the Architect.

C. Coordination: The Contractor shall notify the Architect of the Contractor's readiness to hold the pre-installation conference at least fourteen (14) days prior to the proposed meeting time, and mutually agreed upon meeting times arranged.

1.09 **REFERENCES**

A. ARI 320: Water Source Heat Pumps (ANSI/ARI 320)

B. ARI 350: Sound Rating of Indoor Air Conditioning Equipment

C. ASHRAE 52: Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter, Method of Testing.

D. USGBC LEED Green Building Rating System

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Hydronic Heat Pumps: Florida Heat Pump, Climate Master.

2.02 **GENERAL**

A. Capacity: Units shall have the minimum heating, cooling, and supply air cfm capacities as scheduled on the drawings at the conditions show. Units shall be capable of meeting or exceeding all capacities indicated.

B. Starting Limits: Unit shall be capable of starting in an ambient of 40° F with entering water at 70° F with both air and water flow rates at the ARI rating conditions.

C. Operating Limits: Units shall be capable of operating satisfactorily within the following limits:

	Cooling	Heating
Minimum Ambient Air	20° F	20° F
Maximum Ambient Air	100° F	85° F
Minimum Entering Air	50° F	50° F
Maximum Entering Air, db/wb	100/83° F	80° F
Minimum Entering Water	20° F	20° F
Maximum Entering Water	120° F	120° F

D. Electrical: Units shall have single point power connection and have an internal power distribution system providing necessary power to all components. Unit shall be for use with the power (voltage and phase) as scheduled on the drawings. Unit shall be name plated to accept time delay fuses or HACR circuit breaker for branch over-current protection of the power source.

E. Fan Drives: Shall be sized for not less than 120% of the rated motor horsepower.

F. Listing: Shall be UL listed and as specified in Section 15010 and shall also comply with this Section.

G. Seismic: Units shall be designed and constructed for operation in seismic zone 3.

H. Ground Coupled: Units shall be designed and be intended to operate as part of a ground coupled hydronic piping system, with wide variations in system water temperatures.

2.03 HORIZONTAL HYDRONIC HEAT PUMPS

A. Type: Water source heat pumps of horizontal discharge configuration.

B. Cabinet:

1. General: Shall be constructed of heavy-gauge galvanized steel, with a baked-on enamel finish. Cabinet interior shall be lined with minimum ½ inch thick, 1-1/2 lb./ft.^{3} density fiberglass duct liner. Cabinet shall have panels providing access to fan, fan motor, compressor, and control box. An insulated panel shall separate the air handling compartment from the compressor compartment.

2. Filter Bracket/Collar: Units shall be provided with a combination return air duct collar/filter bracket, suitable for holding a 2-inch thick filter and allowing return air duct connections directly to the unit. Filter bracket shall be capable of being field modified to allow for bottom or side filter removal. Units shall be factory shipped with side filter access.

3. Drain Pan: Units shall have integral condensate drain pan, constructed of galvanized steel, with drain connection extending through unit cabinet.

4. Configuration: Unit shall be provided from the factory configured as shown on the drawings in either straight-discharge or side-discharge.

5. Knockouts/Utility Connections: Cabinet shall have separate holes and knockouts for entrance of line voltage and low voltage control wiring. Supply and return water connections shall be copper FPT fittings and shall protrude through the cabinet.

C. Acoustic Package: Provide units with additional sound attenuating material factory applied to compressor, cabinet interior and fan scroll to further dampen and attenuate sound transmissions.

D. Supports: Units shall be supplied with heavy metal brackets, and accessories to be hung from building structure. See Section 15205 for vibration isolation.

E. Compressors: Shall be hermetic type with external vibration isolators and motor thermal overload protection. Specifically designed for heat pump duty.

F. Air/Refrigerant Coils: Shall be constructed of aluminum fins mechanically bonded to copper tubes; tubes shall be tested to 400 psig.

G. Water/Refrigerant Coils: Shall be coaxial type with an outer steel tube serving as the shell and inner finned copper tube. Coil shall be rated for 400 psig on the water side and 450 psig on the refrigerant side. Water coils shall be for use with 25% glycol solution.

H. Refrigerant Circuit Accessories:

1. Reversing Valve: Pilot operated sliding piston type, with replaceable encapsulated magnetic coil; valve shall be energized/de-energized in such a manner to minimize noise of operation.

2. Metering System: Refrigerant metering system for proper heating and cooling cycle operation.

3. Safety Controls:

a. High refrigerant pressure cut-out.

b. Low refrigerant pressure cut-out.

c. Low refrigerant pressure bypass time delay (to prevent nuisance trippings at cold start-up).

d. Anti short cycle timer (to prevent short cycling of compressor).

e. Safety cut-outs shall be reset only by interrupting and then restoring main power supply to the unit. Control system calls for cooling, heating, or fan operation shall not reset safely cut-outs.

I. Refrigerant: Unit shall be fully charged at the factory with refrigerant. Refrigerant shall be HFC R-410A and shall comply with USGBC LEED Credit EA #4, Enhanced Refrigerant Management.

J. Fan/Motor Assembly:

K. Drive Type:

ARI Standard Cooling Capacity	Drive Type
50 MBH and Less	Direct
51 MBH to 69 MBH	Direct or Belt
70 MBH and Higher	Belt

L. Direct Drive: Fan shall be forward curved centrifugal type. Fan motor shall be multi-speed permanent split capacitor type, with internal thermal overload protection. Fan arrangement shall be field convertible from straight-through to right-angle discharge (and vice-versa) without the use of additional parts.

M. Belt Drive: Fan shall be forward curved centrifugal type, with solid steel shaft having heavy duty ball bearing supports, with adjustable pitch motor sheave and fixed fan pulley. Motor shall be open type, permanently lubricated, with internal overload protection. Fan/motor assembly shall be mounted on a heavy steel assembly, isolated from the unit; motor mounting shall be adjustable to allow proper bolt tension.

N. Duct Collar: Fan housing shall extend through the cabinet to provide a collar for duct connections.

O. Filters: Unit shall be for use with 2-inch thick, MERV 8 filters, as specified in Section 15880. Provide filters in accordance with Section 15880.

P. Electrical: Units shall be factory furnished with all necessary motor starters, transformers, relays, etc. to provide for start/stop of all powered equipment and appropriate interlocks to all safety cut-outs and connections to unit control terminal strip.

Q. Controls:

1. General: Unit shall be furnished with devices that are compatible with the Section 15900 control system. Unit shall have all necessary interconnections, relays, transformers, terminals, and wiring to properly control the unit's compressor, reversing valve, fan, as activated by the Section 15900 system. Unit's internal safety controls shall lock-out operation; reset shall occur per safety controls. All control devices shall be located in an accessible control box within the unit.

2. Condensate Overflow: Units shall have condensate overflow float switch in the drain pan to shut down compressor operation when the pan is full.

3. Refrigerant Safety Controls: See paragraph on Safety Controls.

4. Alarm Indication: Provide dry contacts for connection to Section 15900 system to indicate unit alarmed condition. Alarmed condition. Alarmed condition to include any safety cut-out and compressor malfunction.

5. Section 15900 Interface: Provide unit with necessary terminals and accessories to allow sequence of operation as specified in Section 15900, and to be compatible with the control system furnished. Unit shall (as a minimum), allow for Section 15900 control of fan compressor, heating and cooling operation.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. General: Install units in locations shown on plans and in accordance with manufacturer's instructions.

B. Piping: Provide condensate, hydronic loop supply, and hydronic loop return piping connected to unit. See Section 15420 for condensate waste piping and Section 15745 for hydronic loop piping system. No hydronic loop piping connections shall be made to the heat pumps until these lines are thoroughly flushed and cleaned per Section 15745.

C. Unit Protection: Units shall be protected during construction to prevent mud, dirt, paint overspray, plaster materials, and similar debris from depositing on the unit.

D. Horizontal Units:

E. Pitch units towards condensate drain outlet to facilitate condensate drainage.

F. Support units with hangers, rods, and manufacturer furnished clips and vibration isolators.

G. Mock-Up: The Contractor shall provide two (2) sample heat pump installation prior to installing and connecting other units. Such mock-ups shall be at the heat pump's final installation location. Selected unit to be mocked up is of the Contractor's choice, but selected unit shall be typical to most units, and shall be agreed to by the Engineer. Mock-up shall include all supports, bracing, duct connections, motorized dampers, actuators, control connections, etc. See Section 15745, 15840, and 15900 for related work.

3.02 **START-UP**

A. Initial Checks: Prior to operating units, checks shall be made to insure that adequate voltage, water flow, duct connections, electrical connections, control connections, crankcase heaters (where applicable), and other items as listed by the manufacturer are properly provided/connected and operating to insure safe and proper unit operation.

B. Testing and Adjustment: Operate unit in various modes of operation to test for proper operation, including fan rotation, proper damper travel (where applicable), proper cooling/heating, correct interface to other controls (time clock, fans, etc.), purging of air from coils, etc. Make necessary adjustment per manufacturer's directions. See Section 15955.

C. Final Check: When the testing and adjustment is complete, a final check of each unit shall be done by the manufacturer's authorized service repetitive, or direct employee, to verify proper unit operation. Any defective items shall be repaired or replaced by the Contractor until proper operation is confirmed by the manufacturer's authorized service representative.

D. Written Report: When the final check has been completed, a written report from the manufacturer's authorized service representative shall be provided. The report shall list all units checked, items checked, check results, any items which may impair proper unit operation, and the name and phone number of the actual individual(s) doing the check. The report shall include a statement whether or not all units are operating as specified.

3.03 **OWNER INSTRUCTION**

A. After all testing and adjustments have been satisfactorily completed, the heat pump owner shall be provided with operator instructions (including start-up, shut-down, emergency, maintenance, and repair instructions) by the manufacturer's authorized service representative.

B. Time Period: Instruction period shall be for a minimum of three (3) hours for each unique heat pump type. See Section 15010 and Division 1 for additional requirements.

C. Instruction and notification shall comply with Section 15010.

END OF SECTION

SECTION 15820

FANS

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Inline Cabinet Fans.

B. Ceiling Cabinet Fan.

C. Rooftop Low Profile Fan.

1.02 **RELATED WORK**

A. Section 15010 – Mechanical, General

B. Section 15090 – Hangers and Supports

C. Section 15840 – Ductwork

D. Section 15060 – Duct Accessories

E. Section 15900 – Controls

F. Section 15955 – Air Balancing

G. Section 15995 – Commissioning of Mechanical Systems

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **QUALITY ASSURANCE**

A. Fans shall bear the AMCA certified seal unless indicated otherwise.

1.05 **SUBMITTALS**

A. Submittals shall comply with Section 15010.

B. Submit fan curves showing SP vs. CFM and BHP vs. CFM with system operating point clearly marked.

C. Submit sound power level data showing sound power levels in decibels referenced to 10 watts for each of the eight octave bands (not required for fans under 1500 CFM). Submit sound power levels in zones for fans under 1500 CFM (or decibel values if available).

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Fans: Greenheck, Penn, Cook.

2.02 **GENERAL**

A. Guards: All belt drives shall be equipped with belt guards, or enclosed within fan casing. Guards shall be factory fabricated and furnished with equipment, and comply with OSHA regulations. Exposed openings into fan housings shall be protected with substantial metal screens or gratings.

B. Drives: Shall be sized for not less than 150% of the rated motor horsepower.

C. Adjustable Sheaves: All belt drive fans shall have adjustable sheaves. Sheave shall be selected so that they are their midpoint at design conditions.

D. Motors: Shall be UL listed and as specified in Section 15010. Motors shall have adjustable supports for adjusting belt tension. Provide explosion proof motors in accordance with NEC Class 1 group D standards where indicated on the drawings.

E. Capacity: Fan capacity shall not be less than the values listed in the Fan Schedule on the drawings.

F. Outlets and Inlets: Equipment shall be furnished with attachment angles and/or flanges as required for attaching ductwork flexible connections as shown on the drawings.

G. Fan Types: The type of each fan is indicated on the Fan Schedule, under the "Type" column, and corresponds to the types specified herein.

H. Fan Performance Ratings: Shall be based on laboratory tests conducted in accordance with AMCA Test Codes.

I. Fan Arrangement and Drive: Shall be as shown on the drawings.

J. Finish: All fans shall have factory applied enamel finish (manufacturer's standard color) over a rust inhibiting primer base coat (except not required on rooftop fans).

K. Backdraft Dampers: Provide all exhaust fans with backdraft dampers, constructed of aluminum or galvanized steel, having felt of neoprene lined edges. Backdraft dampers shall be gravity type unless indicated to be motorized type.

L. Weatherproof: Where installed exposed to weather, fans shall have weatherproof enclosure, preventing any wind driven water entry into unit or drive assembly.

M. Disconnects specified with fans are in addition to any Division 16 specified disconnects.

2.03 **INLINE CABINET FANS**

A. Type: In-line, centrifugal cabinet fan.

B. Housing: Shall be constructed of galvanized steel, with inlet and outlet duct connection collars, spring-loaded discharge backdraft damper, adjustable mounting brackets for wall or ceiling mounting, and minimum ½" – 1-1/2 lb/cubic foot density fiberglass duct liner insulation. Fan shall have access panel allowing access to fan motor and scroll without disturbing fan housing, ductwork or wiring.

C. Fan Wheel(s): Unit shall have forward curved centrifugal type fan wheel(s). Wheel(s) shall be statically and dynamically balanced. Provide twin fan wheels when indicated on the Fan Schedule or where required to provide capacity indicated.

D. Drive: Fan shall be direct drive, with drive assembly mounted on vibration isolators.

E. Speed Controls: Solid state speed controller allowing speed reduction down to 50% of maximum.

2.04 CEILING CABINET FANS

A. Type: In-line, centrifugal cabinet fan with grille, for mounting above ceiling.

B. Housing: Shall be constructed of galvanized steel, with discharge backdraft damper, and ½" – 1-1/2 lb/cubic foot density fiberglass duct liner insulation. Fan shall have either access top or horizontal discharge (as required). Housing shall have adjustable mounting brackets to match ceiling thickness.

C. Grille: Shall be of aluminum construction, with white-baked-on enamel finish.

D. Fan Wheel(s): Shall be forward curved, centrifugal type.

E. Drive: Fan shall be direct drive, with drive assembly mounted on vibration isolators.

F. Speed Controls: Solid state speed controller allowing speed reduction.

2.05 ROOF TOP LOW PROFILE FANS

A. Type: Low profile centrifugal fan for roof top curb mounting, with backward inclined fan wheel and louvered penthouse hood. Greenheck Model LDP and LBP, or approved.

B. Housing: Shall consist of louvered penthouse type hood constructed of minimum 0.040 inch thick aluminum with mitered and welded corners. Hood shall have aluminum hinged removable cover, allowing access to complete drive assembly and wheel. Curb cap shall be of aluminum construction, with pre-punched mounting holes (minimum two each side). Lower wind band shall be of aluminum construction and shall be welded to curb cap and support unit drive assembly. Inlet cone shall have deep venture shape and match fan wheel inlet. Provide with bird screen on outlet. All fasteners shall be corrosion resistant type. Conduit chase shall be provided through the curb cap for routing electrical conduit/wiring into the power compartment.

C. Fan Wheel: Shall be aluminum, backward inclined, non-overloading centrifugal type; dynamically and statically balanced. Wheel shall overlap inlet venturi to allow maximum performance.

D. Drive Assembly: Entire drive assembly shall be mounted on rubber vibration isolators. Belt drive units shall have motor and drive located out of the airstream. Drive shafts shall be constructed of ground and polished steel, with permanently lubricated sealed ball bearings. Fan shall be direct or belt drive as indicated on the Fan Schedule.

E. Motor: Shall be permanently lubricated, sealed ball bearing type. Shall comply with Section 15010.

F. Disconnect Switch: Factory mounted in motor compartment and wired to motor.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Install fans at locations as shown on the drawings and as best actual construction conditions allow. Allow proper fan access.

B. Install fans in accordance with Manufacturer's recommendations and instructions.

C. Fans with solid state speed controllers shall have the speed controller mounted on the fan housing unless another location is indicated on the drawings (controller is for use by balancer).

D. Provide flexible connections in ductwork connections to all fans; except that internally spring isolated fans do not require a flexible connection.

E. Install all fans with vibration isolators so that no sound or vibration is transmitted to the structure. See Section 15205 for vibration isolation specifications. If fans have internal spring isolators then no additional isolation is necessary.

F. Sheave Changes: Provide sheaves and sheave changes are required by balancer to achieve proper system airflows. Assume one sheave change for each belt driven fan.

3.02 **START-UP**

A. Check fans for correct rotation tighten belts to proper tension, adjust fan rpm to value shown on drawings, and lubricate bearings per manufacturer's recommendations.

B. Complete manufacturer's start-up sheet for each fan. Submit completed copy of start-up sheet indicating that all tasks have been satisfactorily completed.

END OF SECTION

SECTION 15830

Air Conditioning and Refrigeration System

PART 1 – GENERAL

1.01 **RELATED DOCUMENTS**

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. The provisions of Section 15830, Common Work Results for HVAC apply to work specified in this section.

1.02 **SUMMARY**

A. This Section includes: Air handling units.

1.03 **SUBMITTALS**

A. Submit the following:

1. Shop Drawings showing details of construction, dimensions, arrangement of components, and isolation.

2. Product data showing performance data.

3. Operating and maintenance data.

4. Specified testing requirements.

PART 2 – PRODUCTS

2.01 **CUSTOM ROOFTOP AIR HANDLING UNITS**

A. Acceptable Manufacturers:

1. York Custom (Pace), Haakon, Huntair.

2. Other Manufacturers: Submit Substitution Request.

B. Description: Variable volume, single zone, draw-through custom fabricated roof mounted air handling units consisting of return plenum, return fan section with motor and drive, mixing section, pre-filter and final filter sections, electric heating and Dx heating/cooling coil sections, access sections, supply fan with motor and drive, sound attenuator section, discharge plenum sections, and interior lighting all contained in an insulated steel casing mounted in a common steel base. Provide exterior lighting on unit and integral wall switch near entrance to screened enclosure. Arrange components as specified and as indicated on drawings.

C. Unit Casing:

1. Casing of 16 gauge steel reinforced and braced for operation to 10-inches WG shall limit deflection to 0.25-inch on 120-inch unsupported spans when subjected to 125% of the designed system static pressure, not to exceed 10- inches WG. Caulk and seal all seams to make unit water and air tight.

2. The leakage rate of the casing shall not exceed 0.5% of unit airflow at 1.25 times the rated static pressure unless units require factory shipping splits or installation or unit airflow is less than 5000 CFM. The leakage rate for units with shipping splits and airflow under 5000 CFM shall be 1%.

3. Outdoor units shall have double double-sloped roof with a longitudinal peak and a minimum pinch of ¼" per foot. Roof snow-loads capacity shall be at least 50 lb/ft^2. Roof panel shall overhang unit perimeter by two inches.

4. Support unit on continuous structural steel C-channel supports around the perimeter of the unit with intermediate angle and channel framework to limit deflection to 0.25-inch on 240-inch unsupported spans. Units less than or equal to 20 ft in length shall have a minimum 4-inch channel, and units greater than 20 ft in length shall have a minimum 6-inch channel.

5. Provide safely grating at all floor openings, with top of grating even with floor.

6. Floor to be 3/16-inch checker plate continuously welded. Provide 1-1/2-inch collar around perimeter of unit to ensure the unit is internally water tight.

7. Provide bellmouth duct fittings at unit supply discharge connection. Bellmouths to have minimum radius/duct diameter of 0.20.

8. Insulation of entire cabinet (walls, roof, base, corners, doors) shall be 2-inch thick minimum, R-8 minimum. Insulation shall be 3 lbs/cubic ft. faced rigid fiberglass insulation or polyurethane foam , with internal liner of 22 gauge perforated metal throughout.

9. Provide access doors for inspection of fan and motor, coils, filters, dampers, attenuators, and other components. Access doors of double wall construction same gauge and insulation as the casing. Provide continuous piano hinge fastened to door frame. Door frame of 16 gauge steel continuously welded. Provide continuous perimeter of closed cell neoprene gasket to form an air tight seal. Provide heavy duty door handles which can be operated on both sides of door. Provide suitable means for latching door in both the open and closed positions. Provide wired glass window for inspection of fan and motor and on access downstream of cooling oil. Doors shall be not less than 24" wide at fan access sections and not less than 18-inches wide at other access locations.

10. Unit shall be manufacturers' standard factory finish. Entire unit exterior including all doors, louvers, hoods, and other miscellaneous items shall be finished to match.

D. Fans:

1. Fan type and capacity as indicated on the drawings.

2. Minimum Fan Efficiency 65%.

3. Factory install fan inlet airflow measuring stations where indicated.

4. Statically and dynamically balanced in its own bearings with a maximum full amplitude shaft deflection at bearings not to exceed 0.001-inch at 1200 RPM.

5. Provide spherical roller bearings, 80,000 hour L-10 life per AFBMA Standards.

E. Motor and Drive:

1. Integrally mounted 1800 or 1200 rpm motor, with pre-lubricated sealed ball bearings.

2. V-belt drive sized for 150% of motor horsepower, with cast iron fixed sheaves.

3. Multiple belt drives.

4. Sheaves statically and dynamically balanced.

F. Vibration Isolators:

1. Provide as an integral part of each unit as indicated. See Section 23 05 48.

2. Coordinated weights and location of support points with the vibration isolation equipment supplier.

3. Provide vibration isolator restraints.

G. Cooling Coils:

1. Provide stainless steel support rack so that coils can individually be removed without disturbing other coils.

2. Provide stainless steel drain pan for each level of cooling coils.

3. Drain pan shall be double sloped, in direction of air flow and toward drain connection.

H. Electric Heating Coils:

1. See schedule for capacities.

2. Integral with unit including magnetic contactor and automatic controls. Provide contractors/controls to allow building automation system to stage coil on in 5Kw increments by low voltage signal.

3. Furnish transformer for a single point electrical connection.

I. Filters: Provide suitable access doors, slide rack, and sealant strips for filters specified.

J. Flexible Connections:

1. Constructed in accordance with UL 181, Class I air duct with flanged connections.
2. Flexible, neoprene-coated glass fabric not lighter than 30 oz/sq. yd.
3. "Ventglas" by Vent-Fabrics, Inc.

K. Dampers:

1. Provide multi-blade dampers as indicated and specified elsewhere.
2. Provide minimum outside air damper so that damper is closed with motor shaft retracted and at minimum flow position with motor fully extended.
3. Arrange return air and minimum outside air dampers to discharge against each other for maximum mixing in the mixing box prior to the coil.

L. Sound Attenuators:

1. Provide sound attenuators as specified in Section 23 33 19 Duct Silencers.
2. Each silencer pod shall consist of radiused noses and tails and perforated metal panels stiffened for flatness.
3. Acoustic media shall be compressed and supported to minimize dusting and erosion. Mineral wool is not acceptable. Insulation shall ne encapsulated with Tedlar.
4. The performance and size shall be as per schedule.
5. Silencer pods shall be full height and full width of the plenum.
6. Stacked duct type silencers are not acceptable.

M. Sound Requirements:

1. The manufacturer shall furnish sound power levels at the supply air connection, return air connection, outside air opening, relief air openings and casing radiation for each air handling unit.
2. Sound power level (re: 10^{-12} watts) when producing scheduled airflow (CFM) at static pressure shall not exceed following in any octave band:

Sound Power Levels (db)									
Unit	Open	Band	1	2	3	4	5	6	7	8
		Freq	63	125	250	500	1000	2000	4000	8000
RTU – 1A	SA DISCH		80	78	67	60	60	60	60	60
RTU – 1A	OA		77	73	64	61	60	60	60	60
RTU – 1A	EA		78	77	77	77	80	74	68	62
RTU – 1A	RA INLET		73	72	68	67	70	64	60	60
RTU – 1A	RADIATED		71	70	64	60	60	60	60	60
RTU – 2A	SA DISCH		87	81	72	66	60	60	61	60
RTU – 2A	OA		84	77	69	67	64	62	60	60
RTU – 2A	EA		83	81	82	81	82	78	72	66
RTU – 2A	RA INLET		79	76	73	71	72	68	62	60
RTU – 2A	RADIATED		77	73	68	63	60	60	60	60

3. Sound performance shall be based on modeled data using manufacturer's software.

4. Sound performance shall be based on actual tested performance. An officer of the manufacturing company shall certify test results and forward copies of certified test results to the consultant.

N. Air Flow Testing:

1. The unit manufacturer shall factory test each unit to ensure it meets the specified air flow requirements.

2. The test shall be carried out in accordance with the guidelines set forth in the SMACNA HVAC AIR TEST MANUAL.

3. An officer of the manufacturing company shall certify test results and forward copies of certified test results to the consultant.

O. Air Leakage Testing:

1. The unit manufacturer shall factory pressure test each air handling unit to ensure the leakage rate of the casing does not exceed the specified airflow. The leakage test shall be performed with all factory mounted components installed.

2. The test shall be conducted in accordance with SMACNA duct construction manual. A calibrated orifice shall be used to measure leakage airflow.

3. An officer of the manufacturing company shall certify test results and forward copies of the certified test results to the consultant.
4. "Double duct" or "side by side" units shall have each duct or side tested independently.

5. Positive pressure plenums shall be tested positively and negative pressure plenums shall be tested negatively.

P. Deflection Testing:

1. The unit manufacturer shall factory test each unit to ensure it meets the specified deflection requirements.

2. Deflection shall be measured at the midpoint of the cabinet height and midpoint of the width in the largest unsupported casing section.

3. The consultant shall witness the sound test on the units. The manufacturer shall provide transportation for the consultant and owner to the factory.

4. An officer of the manufacturing company shall certify test results and forward copies of certified test results to the consultant.

Q. Lights and Convenience Receptacles:

1. Provide factory-mounted lighting fixtures so that each section of the unit is illuminated. Lights shall be marine type with protective metal cage and glass seals. Provide compact fluorescent lamp.

2. Each section shall have a separate switch mounted on the unit with an indicator light.

3. Install duplex receptacles on inside wall of each fan section, and on the outside of the unit on the two longest sides.

R. Controls Enclosure:

1. Provide separate, external, weatherproof NEMA rated enclosure for field mounted control components. Coordinate with work of Section 23 09 00, Instrumentation and Controls for HVAC.

S. Electrical:

1. Provide single point 460V power connection on exterior of unit to serve all electrical loads. Factory install and wire all VFDs, starters, disconnects, circuit breakers, staged electric heating coils contactors (controlled by building automation system), fuses, lighting and convenience outlets (and other 460V equipment). Provide transformers and separate circuit breakers for all 120V circuits.

2. Mount VFDs, starters and other electrical equipment in service vestibule, or external weatherproof NEMA rated enclosure(s).

3. Provide separate, 120V circuit for controls, wired to control enclosure. Coordinate with Section 23 09 00, Instrumentation and Controls for HVAC.

4. Provide junction boxes and wiring at splits for field connections between splits for units shipped in sections.

5. Provide flexible conduit connections to all motors.

6. All electrical work shall be in accordance with NEC and Division 16 of this specification.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Roof Mounted Air Handling Unit:

1. Install with air filters in place before operating unit.

2. Mount on curb as indicated on drawings. Account for roof slope to provide level mounting service for equipment.

3. Pipe drain pan to roof drain with 3-inch minimum trap seal.

B. Flexible Connections:

1. Provide flexible connections between fans and the connected ducts or plenums.

2. Install with 1-inch space between the fan and connecting duct with fabric snug but not stretched tightly.

3. Provide accurate alignment between fan and duct.

4. Secure in place with flanged connections. Do not crimp into the duct construction. Ends of the screws shall not project into the duct more than 1/8-inch.

END OF SECTION

SECTION 15832

DECENTRALIZED UNITARY HVAC EQUIPMENT

PART 1 – GENERAL

1.01 **RELATED DOCUMENTS**

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. The provisions of Section 23 05 00, Common Work Results for HVAC apply to work specified in this Section.

1.02 **SUMMARY**

A. This Section includes:.

1. Variable Refrigerant Flow System.

1.03 **SUBMITTALS**

A. Submit the following:

1. Shop drawings showing details of construction, dimensions, arrangement of components, isolation, filters, etc.

2. Product data showing performance data, standard items and accessories, operating weight.

3. Operating and maintenance data.

PART 2 – PRODUCTS

2.01 **VARIABLE REFRIGERANT FLOW SYSTEM**

A. Acceptable Manufacturers:

1. Mitsubishi (City Multi), Dakin (VRV).

B. Indoor Unit – Wall Mounted:

1. Description: The unit shall be a wall-mounted ductless fan-coil unit. Furnish complete unit including cabinet, wall mounting kit and accessories, refrigerant line set, electronic expansion valve, fan and motor assembly, cooling coil, condensate drain pan and filter. Unit as scheduled on drawing, factory-tested and assembled, factory wired, refrigerant-to-air heat exchanger, fan/motor assembly, compressor, controls and safety devices, control circuit transformer, shipped in one piece with ARI certification and UL listing.

2. Cabinet: 18 gauge steel, removable panels for access to components. Provide drain connection.

3. Fan and Motor: The evaporator fan shall be an assembly with one or two line-flow fan(s) direct driven by a single motor. The fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The fan shall consist of two (2) speeds, High and Low.

4. Coil/Piping: The indoor coil shall be direct expansion type for nonferrous construction with smooth plate fins on copper tubing. A condensate pan shall be located under the coil. Both refrigerant lines shall be insulated.

5. Filter: Return air shall be filtered by a removable, washable filter.

6. Electrical: Furnish all starters, contactors and disconnects. Arrange for single point electrical connection.

7. Condensate Pump: Provide condensate pump when required; pipe drain to floor drain.

8. Provide control module, router, intranet hub, and related software (and license) to interface system through BACnet into the building automation system. Provide digital wall mounted thermostats.

C. Outdoor Unit:

1. Description:

   a. Provide air cooled air conditioner (outdoor unit) designed for outdoor installation with factory supplied supports, properly assembled and tested at the factory.

b. Unit shall be completely weatherproofed and include compressor, condenser coils, condensing fans, motor, refrigerant reservoir, charging valve, all controls and a holding charge of refrigerant.

c. Provide guards on condenser fans and coil guard. Unit shall have a power coated finish.

d. Unit shall be completely factory assembled, piped, wired and tested.

e. Both refrigerant lines shall be insulated between the outside and inside units.

f. Unit shall have a sound rating no higher than 63 dB(A).

g. The units shall be modular in design and allow for side-by-side installation with minimum spacing.

2. Cabinet: The casing(s) shall be fabricated of galvanized steel, bonderized and finished with baked enamel.

3. Condenser Fans and Motors: Direct driven variable speed propeller type fans with permanently lubricated motors. All fans shall be provided with a raised guard to prevent contact with moving parts. The outdoor unit shall have vertical discharge airflow.

4. Refrigerant Circuits: Units shall hold a charge of R410A refrigerant. Unit shall include back seating service valve and gauge ports in liquid and suction lines. Provided refrigerant filter-dryer. The refrigeration circuit of the condensing unit shall consist of a scroll compressor, motors, fans, condenser coil, electric expansion valve, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut-off valves, oil separators, service ports, liquid receivers and accumulators.

5. Coil: The outdoor coil shall be of nonferrous construction with lanced or corrugated plat fins on copper tubing.

6. Compressors: Furnish inverter driven scroll hermetic sealed compressor isolation and sound muffling. Units shall have overload and inherent winding thermostat protection to prevent burn out. Provided crankcase heater. Multiple compressors shall be manifolded for single joint connection on liquid and suction lines. The capacity shall be completely variable down to 16% of rated capacity.

7. Controls: Provide high and low pressure cutouts, contractors and internal overload protection on all motors. Provide low ambient operation to 0˚F outside to maintain condensing temperature on part load operation. Provide short cycle timer.

D. Branch Circuit Controller:

1. General: The unit shall have a galvanized steel finish. The BC Controller shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors. Unit shall operate so that different zones served by each controller can be in heating and cooling mode simultaneously.

2. Cabinet:

a. The casing shall be fabricated of galvanized steel.

b. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.

c. The unit shall contain tube-in-tube heat exchangers.

E. Refrigerant Valves:

1. The unit shall be furnished with multiple two position refrigerant valves.

2. Each circuit shall have a two-position liquid line valve and a two-position suction line valve.

3. When connecting a 54,000 BTU-h or larger indoor unit section, two branch circuits shall be joined together at the branch controller to deliver an appropriate amount of refrigerant. The two refrigerant valves shall operate simultaneously.

4. Linear electronic expansion valves shall be used to control the variable refrigerant flow.

5. Integral Drain Pan: An integral condensate pan and drain shall be provided.

6. Controls: The control circuit between the indoor units and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

PART 3 – EXECUTION

3.01 **VARIABLE REFRIERANT FLOW SYSTEM**

A. Installation:

1. Install in location shown on the Drawings. Level unit and secure to structure.

2. Make piping connections and unit installation per manufacturer's recommendations and installation guides.

3. Size and run refrigerant piping between fan coil unit and air-cooled condensing unit per manufacturer's recommendations. Provide double suction and/or discharge risers if recommended by the manufacturer.

4. Insulate all refrigerant piping.

5. Pipe condensate pan to floor drain per manufacturers installation guide.

B. Start-up:

1. General: Comply with manufacturer's instructions.

2. Install filters before operating unit.

3. Ensure proper refrigerant and air flow before operating unit compressor.

C. Provide interconnecting power, controllers, intranet hub, router, thermostat and control wiring between all components to point of connection to building control system.

D. Testing and Adjusting/Performance Test: Except where initial unit operation clearly shows the performance meets or exceeds the requirements, test to show compliance. The manufacturer's representative in the presence of the Engineer shall perform tests.

E. Controller shall be set up to provide remote control via campus intranet (facilities office) and through local building control system. All necessary point mapping (from VFRS to BAS) related to accomplish this task shall be performed in the contract.

END OF SECTION

SECTION 15835

CONVECTION HEATING AND COOLING UNITS

PART 1 – GENERAL

1.01 **RELATED DOCUMENTS**

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 **SUMMARY**

A. This section includes:

1. Cooling coils.

1.03 **SUBMITTALS**

A. Submit the following:

1. Catalog data showing dimensions and performance.

2. Computer calculations for coil performance.

PART 2 – PRODUCTS

2.01 **COOLING COILS, DIRECT EXPANSION**

A. Acceptable Manufacturers:

1. Pace, Carrier, Trane, McQuay, Dunham-Bush, Colmac, Thermal Corporation, York, Heatcraft.

2. Other Manufacturers: Submit Substitution Request.

B. Description:

1. Coils of nonferrous extended surface construction with continuous 16 gauge stainless steel casing for installation in air supply unit.

2. Primary surface of seamless copper tubing brazed into nonferrous headers.

3. Fins shall be nonferrous, mechanically bonded to tubes, with fin spacing of ten fins per inch maximum.

4. Coils tested at 300 psi hydrostatic pressure.

5. Distributors: Pressure type, brass construction with copper distributing tubes.

6. Liquid and suction connections on same side.

7. 0.008-inch minimum fin thickness; 0.017-inch minimum tube wall thickness.

8. Capacity certified in accordance with ARI Standard 410-72. Face velocity not to exceed 350 fpm at specified air flow.

9. Match operating points with respective condensing unit.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Cooling Coils: Installed in air handling units as standard with manufacturer or in ductwork as shown.

B. Heating and Reheat Coils: Installed in air supply units as standard with manufacturer or in ductwork as shown.

C. Damaged Coils: Make every effort to prevent damage to both built-up coils and coils of packaged equipment. Comb damaged coil fins to be straight.

END OF SECTION

SECTION 15840

DUCTWORK

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Environmental Ductwork Systems

B. Flexible Duct

C. Acoustical Duct Lining

D. Preparation of Duct for Service

E. Duct Pressure Testing

1.02 **RELATED WORK**

A. Section 15090 – Hangers and Supports

B. Section 15095 – Sleeves and Seals

C. Section 15250 – Insulation

D. Section 15815 – Hydronic Heat Pumps

E. Section 15820 – Fans

F. Section 15860 – Duct Accessories

G. Section 15870 - Air Outlets and Inlets

H. Section 15880 – Air Filtering Equipment

I. Section 15955 – Air Balancing

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **DEFINITIONS**

A. Duct Sizes: All duct dimensions shown are inside clear dimensions. Where inside duct lining is specified or indicated, duct dimensions are to the inside face of lining.

1.05 **QUALITY ASSURANCE**

A. All work and materials shall comply with HVAC-DCS, NAIMA-DLS, ASHRAE-F, IBC, IMC, NFPA 90A, NFPA-90B, and code. The most restrictive criteria governs.

B. Leakage Criteria: Duct system shall be constructed and sealed so that leakage does not exceed the following.

1. All Systems – Supply Duct: From fan to connection to air outlet 5%.

2. All Systems – Return Duct: 5%

3. All Systems – Exhaust Duct: 5%

C. The Contractor performing the Work of this Section shall have his fabricating facilities and main company office located within 100 miles of the project site.

1.06 **SUBMITTALS**

A. Submittals shall comply with Section 15010.

B. Submit shop drawings for all HVAC ductwork; drawings shall comply with Section 15010, and e at ¼" = 1'-0", double line and shall show duct layout, fittings, and accessories.

C. Submit product data and MSDS sheets for all adhesives and sealants indicating their VOC limits.

1.07 **DUCT PRESSURE CLASS**

A. Constant Volume Systems: Ductwork shall be constructed to the pressure class corresponding to the static pressure indicated for the fan which serves the ductwork, or to 1 inch pressure class standards (plus or minus as appropriate), whichever is higher; unless noted otherwise.

1.08 **REFERENCES**

A. ADC-FLEX: Air Diffusion Council Flexible Duct Performance and Installation Standards.

B. ASHRAE-F: ASHRAE Handbook of Fundamentals, 2001 Edition.

C. ASTM A 653: Steel Sheet, Zinc Coated (Galvanized) for Zinc-Iron Alloy-Coated (Galvannealed) by the Hot Dip Process.

D. ASTM A 924: General Requirements for Steel Sheet Metallic-Coated by the Hot-Dip Process.

E. IMC: International Mechanical Code.

F. NAIMA-DLS: North American Insulation Manufacturers Association Fibrous Duct Liner Standards, 1st Edition.

G. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems.

H. NFPA 90B: Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

I. SMACNA-DCS: SMACNA HVAC Duct Construction Standards, 3rd Edition.

J. UL 181: Underwriter Laboratories Factory-Made Air Ducts and Air Connectors.

K. South Coast Air Quality Management District (SCAQMD), Rule #1168, 2005.

1.09 **PRE-INSTALLATION CONFERENCE**

A. General: A pre-installation conference shall be held prior to the Contractor installing any of the materials of this Section. The conference shall occur after all submittals have been satisfactorily reviewed by the Architect/Engineer and returned to the Contractor, and approximately fourteen (14) days prior to the proposed system installation date and prior to the fabrication of any system piping components. The purpose of this conference is to review the Contractors installation methods, materials, schedule, safety, coordination with all other trades, and related construction/design issues to allow for efficient and proper construction. The Architect/Engineer and Owner will highlight various items of concern, typical problems encountered on similar projects, coordination issues, and related items.

B. Attendance: The pre-installation conference shall be attended by the General Contractor, the Contractor doing the Work of this Section, other contractor trades as appropriate to the proper coordination of the Work of this Section, the Owner's Representatives (at their option), the Engineer, and the Architect.

C. Coordination: The Contractor shall notify the Architect of the Contractor's readiness to hold the pre-installation conference at least fourteen (14) days prior to the proposed meeting time, and mutually agreed upon meeting time arranged.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, and Acceptable Manufacturers.

B. Sheet Metal: All domestic manufacturers.

C. Spin-in Fittings: Sheet Metal Connectors Inc. United McGill, Royal Metal Products, Airflow Products Inc.

D. Duct Sealant and Tape: Durkee-Atwood, Hardcast, Duro-Dyne, Benjamin Foster, Grace Construction Products, United McGill.

E. Flexible Duct: Flexible Technology Inc., JP Lamborn Co.; Hart & Cooley.

F. Acoustical Duct Lining: Johns-Manville.

2.02 **GENERAL MATERIALS**

A. Ducts: Construct of galvanized sheet steel, suitable for lock forming without flaking or cracking, conforming to ASTM A653 and A924, having a zinc coating of 0.60 ounces total per square foot for both sides of a sheet, corresponding to coating G60. Except that ducts located outdoors shall have a zinc coating of 0.90 ounces total per square foot, corresponding to coating designation G90.

B. Fasteners: Use rivets and bolts throughout; sheet metal screws are only acceptable on ductwork constructed to 2-inch pressure class standard or less.

C. Spin-in Fittings: Factory fabricated of galvanized steel with die-formed mounting groove and damper with raised damper quadrant where ducts are to be insulated. Collar length for flexible duct attachment shall be at least 2" long.

Provide 45 degree scoop when the spin-in fitting is installed in a duct which has a width of 12 inches or more.

D. Duct Sealant: Shall be fire resistant with a flame spread rating of 25 or less, and a smoke developed rating of 50 or less. Sealant shall also be water resistant and compatible with mating materials and types of joints or connections being sealed, specifically made for sealing ducts. Exterior duct sealant shall be specifically intended for outdoor use as a duct sealant, shall be ultraviolet ray and ozone resistant where exposed to natural sunlight. Sealant shall not exceed VOC limits set forth by South Coast Air Quality Management District (SCAQMD), Rule #1168, 2005.

E. Duct Tape: Shall be fire resistant with a flame spread rating of 25 or less, and a smoke developed rating of 50 or less. Tape used shall be specifically compounded for maximum adhesion to galvanized steel, and shall be compatible with the duct sealant used.

2.03 **DUCT FABRICATION**

A. Duct Gauge and Reinforcement: Shall be as shown in SMACNA-DCS according to the pressure classification of the system and the duct dimensions.

B. Joints and Seams: Construct in accordance with SMACNA-DCS, code requirements, and these specifications (more stringent governs). Ducts shall be constructed and sealed so that the leakage criteria is not exceeded. Round ducts shall be the spiral same type; except that branch ducts to individual air inlets/outlets less than 16" diameter may be of other types as allowed by SMACNA-DCS. Coordinate joint spacing with duct reinforcement requirements so that transverse joints having the required stiffness may be incorporated in the reinforcement spacing schedule. Round duct transverse joints shall be made with beaded sleeve joints or flanged connections in accordance with SMACNA-DCS; except that branch ducts to individual air inlets/outlets less than 16" diameter may use other joining methods as a allowed by SMACNA-DCS.

C. Elbows and Tees: Shall be long-radius type with a center-line radius not less than 1-1/2 times the width or diameter of the duct. Where space does not permit the use of long-radius elbows, short-radius or square elbows with turning vanes may be used. Elbows in round duct systems shall be stamped type, welded segmented type, or standing seam segmented type.

D. Transitions: Increase duct sizes gradually. Transitions for diverging air flow shall be made with each side pitched out not more than 22.5 degrees. Transitions for converging air flow shall be made with each side pitched in not more than 30

degrees. Except that eccentric transitions for round to flat oval may have up to a 45 degree pitch.

E. Branch Connections: Shall comply with SMACNA-DCS, and as required herein.

1. Rectangular-to-Rectangular: Rectangular take-off with 45 degree angle on "inside" of take-off, minimum 4" length. Reference SMACNA-DCS Figure 4-6. Close corner openings.

2. Rectangular-to-Round:

a. Serving Individual Air Inlet/Outlet: Spin-in type connector (unless a different fitting type is specifically noted).

b. Serving Branch Duct: Rectangular to round transition, with maximum degree pitch as specified for transitions. Rectangular end size shall have free area no less than round end. Rectangular connection to rectangular main shall be made as specified for "Rectangular-to-Rectangular" connections.

3. Round-to-Round: In accordance with SMACNA-DCS and recognized professional practices.

4. Other Connections: In accordance with SMACNA-DCS and recognized professional practices.

F. Ductmate Systems:

1. Rectangular Duct: Transverse duct joints may be made with Ductmate System, or approved equal. System shall consist of companion flanges of 20 gauge galvanized steel with an integral polymer mastic seal; corner pieces of 12 gauge G90 galvanized steel; 20 gauge G90 galvanized cleats; closed cell, high density gasket type; and galvanized carriage bolts with hex nuts. The flanges shall be securely fastened to the duct walls using self-drilling screws, rivets or spot welding. Fastener spacing shall be as recommended by the manufacturer for the size of duct and the pressure class. The raw duct ends shall be properly seated in the integral mastic seal. A continuous strip of gasket tape, size ¼" x ¾", shall be installed between the mating flanges of the companion angles at each transverse joint; and the joint shall be made up using 3/8 inch diameter x 1 inch long plated bolts and nuts. Galvanized drive-on or snap-on cleats shall be used at spacings as recommended by the manufacturer.

2. Round Duct: Transverse duct joints may be made with Ductmate "Spiralmate" system, or approved equal. System shall consist of galvanized steel round connector flanges (fitting inside each duct section to be joined) and an exterior galvanized steel closure ring with tightening bolt to form an airtight duct connection and join flanges together. Duct connector flanges shall have non-hardening integral mastic to seal between flanges and duct, and a neoprene gasket to seal flange faces.

G. Lined Ductwork:

1. Rectangular Ducts: Contractor Fabricated ductwork with duct lining. Duct fabrication and liner installation shall comply with NAIMA-DLS. Lining material shall comply with paragraph titled "Duct Lining" in this specification section.

2. Round and Oval Ducts: Shall consists of acoustic insulation in between a perforated interior duct liner and solid exterior duct. Acoustic insulation shall be 1 inch thick, except where noted to be greater. Duct sections shall connect by mechanical means to maintain positive concentricity of liner with duct. All fittings and transitions shall have perforated inner liner (except where noted otherwise). Lining material shall comply with paragraph titled "Duct Lining" in this specification section. United McGill "Acousti-k27" (or approved).

2.04 **FLEXIBLE DUCT**

A. Type: Factory insulated fully lined flexible duct.

B. Construction: Two polyester film internal liners encapsulating a zinc coated steel wire helix to form an air-tight core, with surrounding fiberglass insulation and outer polyethylene (or metalized/fiberglass scrim) vapor barrier.

C. Thermal Characteristics: Certified Thermal resistance "R" of 4.2 Hr-SF-Deg F/Btu in accordance with ADC-FLEX.

D. Working Pressure: As required to suit maximum pressure to be encountered on system, but not less than 4" w.g. positive, 0.5" w.g. negative.

E. Length: Shall not exceed 8 feet where used on duct systems with a pressure class rating of 2 inches and less; maximum 5 feet length on higher pressure class systems.

F. Code Compliance: Shall comply with all applicable codes, NFPA 90A, NFPA 90B, and shall be UL listed and labeled as a Class 1 connector per UL 181.

2.05 **DUCT LINING**

A. Material: Flexible, inorganic glass fiber material, bonded with thermosetting resin, maximum thermal conductivity of 0.26 Btu-inch/hr-sq. ft.-degree F at 75° F, coated to prevent erosion, conforming to NAIMA-DLS and exceeding that standard as specified herein. Surface shall be coated with an acrylic coating having anti-microbial agents and factory applied edge coating Johns-Manville "Permacote Linacoustic" (or approved).

B. Thickness: Lining shall be 1-inch thick except where noted otherwise.

C. Adhesives and Fasteners: Shall conform to NAIMA-DLS, and as suitable for the duct liner material and ductwork.

PART 3 – EXECUTION

3.01 **DUCTWORK INSTALLATION**

A. General: Install all ductwork and plenums in sizes and location as shown on the drawings, complete with all accessories and connections to provide complete and operable duct systems.

B. Field Measurements: Prior to fabricating any duct materials, the Contractor shall field measure all areas where ducts will be installed to verify room available and all offsets and fittings required.

C. Workmanship: All work shall comply with code, SMACNA-DCS, and other applicable standards. Ducts shall be installed level (unless noted otherwise) and in neat lines with the building construction using best professional practices.

D. Exposed Ducts: All ducts are to be installed concealed unless indicated otherwise. Ducts that are exposed shall be carefully fabricated, stores, and installed for best appearance. All dents, dings, scratches and other damage shall be repaired for a high quality finished look; all dirt, debris, labels, stickers, lettering, and marks removed; and the duct completely cleaned. Any sealant shall be cleaned to form a straight and even seam adjacent to joints, have no overlap onto duct areas not needing sealant, and have all excess sealant removed.

E. Flexible Duct: May only be used where specifically shown on the plans. Attach flexible duct to sheet metal in accordance with manufacturer's instructions, using sheet metal screws or draw bands to secure the duct; in addition, coat the

inside of flexible duct at connection with duct sealant. Install flexible duct with a centerline turning radius not less than one duct diameter. Where this turning radius cannot be maintained with the flexible duct, sheet metal elbows shall be used or (at air inlets/outlets) provide a plenum at the air inlet/outlet to allow for a straight side connection.

F. Spin-in Fittings: May be used for branch ducts to individual outlets only. Apply a bead of duct sealant to all spin-in fittings where fitting seals against sheet metal duct.

G. Sealing: Seal all joints as required to meet duct leakage criteria, and as a minimum as follows:

1. Ducts with pressure Class 3" and greater: Seal Class A.

2. Ducts with pressure Class 2": Seal Class B.

3. Ducts with pressure Class 1" and less: Seal Class C.

H. Ductmate: All "Ductmate" and similar systems shall be installed in strict accordance with manufacturer's instructions.

I. Exterior Ductwork: Exterior ductwork shall be sealed to prevent any entry of water. Sealant shall be applied to all seams and joints prior to assembly in order to provide a layer of sealant which is continuous through the joint or seam. Additional sealant shall then be applied to the exterior of the joint of seam to ensure a weathertight closure. Any leakage or damage from water leakage into duct or building shall be repaired at no additional cost to the Owner.

J. Coordination: The Contractor shall fully coordinate the work of all trades to avoid interferences and conflicts. Due to the extremely tight spaces in portions of the building, the Contractor shall coordinate duct reinforcement spacing and supports with other trades as necessary to avoid interferences. In addition, the Contractor shall select duct gauge and reinforcement types to avoid interferences. Changes required due to lack of coordination between trades, improper spacing or selection of hangers, or improper duct gauge and reinforcement selection, shall be done at no additional cost to the Owner.

K. Provide temporary sheet metal caps or heavy visqueen covers over all open portions of ductwork to prevent debris, dirt, and dust from entering the ductwork. Such covers shall be installed at the end of each work shift, and shall remain in place until all work activities or events that may cause duct contamination will no longer occur.

L. Alternative Duct Sizes: The Contractor, at his option, may use duct sizes other than those shown on the drawings, provided that: the Architect/Engineer give prior approval, and the pressure drop per lineal foot of the proposed duct does not exceed that for the duct shown.

M. Round Duct: The Contractor, at his option, may use round duct in lieu of rectangular or flat oval shown on the drawings provided that: the Architect/Engineer gives prior approval, and the pressure drop per lineal foot of the proposed duct does not exceed that for the duct shown. Shop drawing submittals are required for any contractor proposed changes from the contract drawings.

3.02 ACOUSTICAL DUCT LINING INSTALLATION

A. Install acoustical duct lining in ducts to extent shown on drawings, covering all interior surfaces. Round ducts shall use factory fabricated double-wall ducts as specified.

B. Installation shall comply with NAIMA-DLS and these specifications.

C. The duct liner shall be applied with a 100% coverage of adhesive.

D. Horizontal Duct Runs: Tops of ducts over 12” wide and sides of duct over 16” high shall have liner additionally secured with mechanical fasteners.

E. Vertical Duct Runs: Any side of duct over 12” in size shall have liner additionally secured with mechanical fasteners.

F. Mechanical Fasteners shall be installed flush with the liner surface, and shall be spaced in accordance NAIMA-DLS.

G. All joints, exposed edges and any damaged areas of the liner, shall be heavily coated with fire resistant adhesive/mastic.

H. The liner shall be cut to assure tightly butted joints.

I. Install metal nosings on the leading edges of the liner in ducts where the velocity exceeds 4000 feet per minute.

3.03 PREPARATION FOR SERVICE

A. All ducts shall be wiped or blown clean of all dust and debris prior to the installation of grilles or diffusers. Duct cleaning shall comply with Section 01354

"Construction Indoor Air Quality Management." Notify the Engineer to allow for an inspection prior to installing grilles or diffusers.

B. Where ducts have been contaminated by dirt or debris during the construction process, the affected duct systems shall be cleaned by an independent firm specializing in the vacuum cleaning of ductwork. All costs associated with such cleaning shall be the responsibility of the Contractor.

3.04 **DUCT PRESSURE TESTING**

A. Tested Systems: Supply air systems and return air systems shall be tested.

B. Test Method:

1. Cap all outlets temporarily to isolate the portion of the system being tested.

2. Use portable blower with volume adjustment and a calibrated orifice for determining cfm of air being added to ductwork. Maintain duct system rated pressure in duct; examine each section at this pressure, and seal all observable leaks so that leakage during final testing will be at or below maximum permissible leakage.

3. Maximum Permissible Leakage: See "Quality Assurance" paragraph, Part 1 of this specification section.

4. Final test of each section shall be witnessed by the Architect/Engineer or Owner's representative. Give Architect/Engineer at least seven (7) days prior notice before such test.

5. Test Data: Record data of test results of final test only, including sketch or diagram of tested section, computation of total system cfm, allowable leakage and actual leakage found during test. Submit two (2) copies to Architect/Engineer.

C. Low Pressure System Testing: Air balancers readings will be used to determine percent leakage of ductwork. Where leakage exceeds allowable by 25% or less, sealing shall be provided at all potential leak spots. Where leakage exceeds allowable by more than 25%, the system shall be re-sealed and the Sheet metal Contractor shall pay the Balancer to re-measure and determine the new leakage rate.

END OF SECTION

SECTION 15860

DUCT ACCESSORIES

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Manual Dampers

B. Backdraft Dampers

C. Turning Vanes

D. Flexible Connections

E. Duct Access Doors

F. Building Access Doors

1.02 **RELATED WORK**

A. Section 15815 – Hydronic Heat Pumps

B. Section 15820 – Fans

C. Section 15840 – Ductwork

D. Section 15870 – Air Inlets and Outlets

E. Section 15865 – Air Terminal Units

F. Section 15880 – Air Filtering Equipment

G. Section 15955 – Air Hydronic Balancing

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **QUALITY ASSURANCE**

A. Construction and installation of all duct accessories shall comply with SMACNA HVAC Duct Construction Standards, 1st Edition.

1.05 **SUBMITTALS**

A. Submittals shall comply with Section 15010.

B. Submit product information on all items to be used. Submit cfm vx. Pressure drop curve for backdraft dampers.

C. Submit dynamic insertion loss data for all sound attenuators.

1.06 **REFERENCES**

A. SMACNA HVAC Duct Construction Standards

B. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems

C. UL 555S: Leakage Rated Dampers for use in Smoke Control Systems

D. UL 555: Fire Dampers and Ceiling Dampers

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Manual Damper Hardware: Duro-Dyne, Young Regulator Co., Ventfabrics Inc., Krueger, Titus, Anemostat.

C. Backdraft Dampers: American Warming and Ventilating, Ruskin, Greenheck.

D. Flexible Connections: Ventfabrics, Duro-Dyne.

E. Duct Access Doors: National Controlled Air, VentFabrics, United-McGill, Air Balance, Kees, Ruskin, Vent Products.

F. Building Access Doors: JR Smith, Zurn, Josam, Acudor, Elmdoor, Kees, JL Industries.

2.02 MANUAL DAMPERS

A. Dampers shall be fabricated of galvanized steel, two (2) gauges heavier than duct in which installed.

B. Maximum blade width is 12 inches; fabricate multi-blade dampers with opposed blade pattern for ducts larger than 12" x 48".

C. Damper regulator sets shall have quadrant dial regulator with locking nut, square end bearing one side, and spring round end bearing other side (small sizes) or open and square bearing (larger sizes), axis of blade the long dimension. Regular sets shall be Duro-Dyne Model numbers as follows:

Max. Blade Dimension	Duro-Dyne Regulator Set	Shaft Size
10" and less	KS-145, 145L	¼"
11" to 14"	KSR-195, 195L	3/8"
15" to 23"	SRS-388, SB-138, KP105	3/8"
24" and larger	SRS-128, SB-112, KP105	½"

A. Multiple blade dampers shall have individual quadrants for each blade or one quadrant with interconnected blades.

B. Flush-mounted concealed type damper quadrants shall have primer paint finish, and shall be VentFabrics No. 666 or Young Regulator Co. No. 301.

C. Extractor Fittings: Krueger Model No. EX-88, with worm gear mechanism for adjustment through face of grille.

2.03 BACKDRAFT DAMPERS

A. Shall be metal blade type with gasketed edge seals. Blades shall be made of 24 gauge aluminum. Frames shall be constructed of 0.063-75 extruded aluminum.

B. Seals shall be felt or neoprene material; no noise or blade "chattering" will be accepted.

C. Bearings shall be self-lubricated nylon.

D. Unit shall have adjustable counter-weights to allow adjustment of unit operation.

2.04 **TURNING VANES**

A. Turning vanes may be either contractor or factory fabricated.

B. Vanes and runners shall be fabricated of minimum 24 gauge galvanized.

C. Turning vanes shall comply with SMACNA HVAC Duct Construction Standards. For duct widths less than 19 inches, vanes may be single wall construction; for widths greater than 19 inches, vanes shall be double wall “airfoil” type.

D. Turning vanes shall be equally spaced, parallel to each other, and securely attached to runners.

E. For elbows where the inlet and outlet dimensions are not the same, modify vane shape or angle to provide optimum turning.

2.05 **FLEXIBLE CONNECTIONS**

A. Material shall be a flexible glass fiber fabric with an inorganic elastomeric coating.

B. Material shall be flame retardant and comply with requirements of NFPA-90A.

2.06 **DUCT ACCESS DOORS**

A. Access doors shall be of double wall construction, made with minimum 24 gauge galvanized steel, tight fitting, with sealing gasket, and cam locks (or may be hinged type with latches).

B. Access doors shall be of sufficient size so that items concealed in duct can be serviced and inspected, and shall be adequately sized to allow complete removal of the item being served (where removal cannot be made without disturbing fixed ductwork).

C. Doors shall be minimum 14” x 14”. Where duct size will not accommodate this size door, the doors shall be made as large as practicable.

D. Doors larger than 14” x 14” shall have a minimum of four (4) cam locks (or where hinged type is used, have a minimum of two (2) latches).

E. Doors in insulated ducts shall be insulated type, with minimum 1 inch thick fiberglass insulation.

F. Round ducts shall use either lined rectangular tap off with insulated rectangular access door or curved insulated access door (for insulated duct); or curved type uninsulated access door (for uninsulated duct).

2.07 **BUILDING ACCESS DOORS**

A. Hinged lockable steel access door, for mounting on face of wall, with 16 gauge frame and 18 gauge door, concealed hinge, cam and cylinder lock, and adjustable anchor straps. Provide of 18-8 stainless steel construction with No. 4 finish where used in restrooms, locker rooms, kitchens, and similar "wet" areas. Provide of steel construction with prime coated finish in other areas. Size shall be 12" x 12" (unless indicated otherwise) but shall be large enough to allow necessary access to item being served and sized to allow removal of the item (where access door is the only means of removal without disturbing fixed construction).

B. Fire Rating: Door shall maintain fire rating of element installed in; reference drawings for required rating.

C. Access doors shall all be keyed alike. Provide two (2) keys for each door.

PART 3 – EXECUTION

3.01 **MANUAL DAMPERS**

A. Dampers shall be fabricated and installed in accordance with SMACNA requirements for volume dampers.

B. Install dampers at locations shown on the drawings, and at all other locations as required by the Balancer to allow for the balancing of the system.

C. Locate dampers at a point where the duct is accessible wherever possible.

D. Provide flush-mounted concealed type damper quadrants for ducts concealed in walls or non-removable ceiling and where a remote damper operator has been indicated.

E. Set and lock all dampers in the full open position prior to balancing.

3.02 **BACKDRAFT DAMPERS**

A. Install in accordance with manufacturer's instructions.

B. Provide access doors to backdraft dampers, except that where damper is installed immediately behind a ceiling or wall grille, and is accessible by removing this grille; an access door is not required.

C. Adjust dampers' counterweights to give proper opening and closure. Perform initial setting prior to balancing and then final setting when balancer is present. Notify Engineer when setting is occurring to allow witness of adjustments by Engineer.

3.03 **TURNING VANES**

A. Install turning vanes in all square duct turns, and at locations shown on the drawings.

B. Securely attach turning vane runners to ductwork.

3.04 **FLEXIBLE CONNECTIONS**

A. Provide flexible connections at all duct connections to fans, where ducts of dissimilar metals are connected, and where shown on the drawings.

B. For round ducts, the flexible material shall be secured by zinc-coated, iron clinch type draw bands.

C. For rectangular ducts, the flexible material shall be locked to metal collars which shall be connected to the duct using normal duct seam construction methods.

D. Install flexible connections with sufficient slack to permit 2 inches of horizontal or vertical movement of ducts or equipment at flexible connection point without stretching the flexible material.

E. Where installed exposed to outside weather, provide a galvanized "hat" channel protecting top and vertical stretches of flexible connector from sunlight and weather.

3.05 **DUCT ACCESS DOORS**

A. Provide duct access doors at all automatic control dampers, fire/smoke dampers, duct control devices, filters, and any other components in the duct system that require service or inspection.

B. Access doors shall be of sufficient size and so located so that the concealed items may be serviced and inspected or completely removed and replaced.

3.06 **BUILDING ACCESS DOORS**

A. Provide access doors in walls, floors, ceilings, etc. where needed to provide access to duct access doors, damper actuators, dampers, coils, fans, HVAC equipment and similar items.

B. Consult architectural drawings and coordinate location and installation of access doors with trades which are affected by the installation.

END OF SECTION

SECTION 15865

DUCT SILENCER

PART 1 – GENERAL

1.01 **SECTION INCLUDES**

A. Duct Silencers

1.02 **STANDARDS**

A. Silencers shall be tested in strict accordance with the latest revision of ASTM E477 (Standard Method of Testing Duct Liner Materials and Pre-fabricated Silencers for Acoustical and Airflow Performance) with air flowing through the silencers, both with and against airflow. A negative face velocity implies sound transmission in the opposite direction to airflow. ASTM E477 shall have been performed in a laboratory that is NVLAP-accredited to conduct the test.

1.03 **SUBMITTALS**

A. Submit under provisions of Division 15.

B. Shop Drawings: Indicate assembly, materials, thickness, dimensional data, pressure losses, acoustical performance, layout, and connection details.

C. Product Data: Test results shall be submitted to the Architect and approved by the acoustical consultant to qualify for bidding. Submittals shall name the testing laboratory, date of test, dimensions of the silencer being tested, and model number. The following data shall be presented: dynamic insertion loss at each of the eight octave bans in dB, the face velocity, the static pressure drop in inches of water gauge, and the self-generated sound power level in dB (re 1 pW) in each octave band.

1.04 **PROJECT RECORD DOCUMENTS**

A. Submit under provisions of Division 15.

B. Record actual locations of duct silencers.

1.05 **QUALIFICATIONS**

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum ten (10) years documented experience.

PART 2 – PRODUCTS

2.01 **DUCT SILENCERS**

A. Acceptable manufacturers are:

1. Industrial Acoustics Company

2. Dynasonics

3. Vibro-Acoustics

B. The duct silencer dimensions shall match the dimensions of the connecting duct work.

C. The acoustical and aerodynamic performance of all duct silencers shall conform to the values in the following schedule. Where conflicts occur between this schedule and information contained in the drawings, the information in the schedule takes precedence.

Minimum Dynamic Insertion Loss in dB
Octave Band Center Frequency in Hz

Location	Type	FPM	PD iwg	63	125	250	500	1K	2K	4K	8K
HP 102 Return	IAC 3’ LFL	750	0.05	4	8	14	19	19	13	11	10
HP 109 Supply	IAC 5’ LFM	450	0.05	9	14	25	30	29	17	16	13
HP 109 Return	IAC 5’ LFL	450	0.05	7	11	18	26	26	15	13	12
HP 110 Supply	IAC 5’ LFM	450	0.05	9	14	25	30	29	17	16	13
HP 110 Return	IAC 7’ LFM	450	0.05	12	17	31	42	39	22	18	15
HP 111 Supply	IAC 5’ LFM	450	0.05	9	14	25	30	29	17	16	13
HP 111	IAC 7’ LFM	450	0.05	12	17	31	42	39	22	18	15

Return											
HP 112 Supply	IAC 7’ LFM	500	0.05	12	17	31	42	39	22	18	15
HP 112 Return	IAC 3’ LFM	450	0.05	5	8	16	21	18	13	12	11
HP 112 Return	IAC 3’ LFL	450	0.01	4	8	14	19	19	13	11	10

Maximum Self-Generated Noise Sound Power Levels in dB re 1 picowatt
Octave Band Center Frequency in Hz

Location	Type	FPM	PD	63	125	250	500	1K	2K	4K	8K
HP 102 Return	IAC 3’ LFL	750	0.01	32	24	32	25	34	39	24	20
HP 109 Supply	IAC 5’ LFM	450	0.05	47	34	38	35	40	37	27	20
HP 109 Return	IAC 5’ LFL	450	0.05	32	24	32	25	34	39	24	20
HP 110 Supply	IAC 5’ LFM	450	0.05	47	34	38	35	40	37	27	20
HP 110 Return	IAC 7’ LFM	450	0.05	42	40	43	45	47	46	37	27
HP 111 Supply	IAC 5’ LFM	450	0.05	47	34	38	35	40	37	27	20
HP 111 Return	IAC 7’ LFM	450	0.05	42	40	43	45	47	46	37	27
HP 112 Supply	IAC 7’ LFM	500	0.05	47	34	38	35	40	37	27	20
HP 112 Return	IAC 3’ LFM	450	0.05	42	40	43	45	47	46	37	27
HP 112 Return	IAC 3’ LFL	450	0.01	32	24	32	25	34	39	24	20

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Provide duct silencers where indicated on drawings and install in accordance with manufacturer’s instructions.

END OF SECTION

SECTION 15870

AIR OUTLETS AND INLETS

PART 1 – GENERAL

WORK INCLUDED

A. Supply Outlets

B. Exhaust Inlets

C. Return Inlets

D. Wall Caps

RELATED WORK

A. Section 15820 – Fans

B. Section 15840 – Ductwork

C. Section 15860 – Duct Accessories

SUSTAINABLE BUILDING REQUIREMENTS

See Section 01011 for sustainable building requirements affecting the Work of this Section.

REFERENCES

A. SMACNA HVAC Duct Construction Standards, 1st Edition.

SUBMITTALS

A. Shall comply with Section 15010

B. Submit product information on all items.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Diffusers, Grilles, and Registers: Kees, Titus, Price

C. Wall Caps: Greenheck, Penn

2.02 **GENERAL REQUIREMENTS**

A. Air outlets shall be of the size, type, and with number of throws as shown on the drawings; and shall match the appearance and performance of the manufacturers' models specified and scheduled on the drawings.

B. Air outlet application shall be based on a noise level of NC 20 maximum for studios, and NC 30 for all other areas.

C. Furnish all necessary screws, clips, duct collars, and transitions required to allow for the air outlet installation and connection to ductwork.

D. Finish: Factory enamel finish, color as selected by Architect/Engineer, (or anodized aluminum finish where noted).

E. Frame Style: Provide air outlets and inlets with frame style to match ceiling or wall construction installed in. Where supply air outlets or inlets are installed in T-bar ceiling systems, they shall be factory installed in 2' x 2' or 2' x 4' metal panel to match ceiling layout. Where installed against gypsum board surface, brick or similar hard surface or, where exposed, provide with 1-1/4" wide outer border. Where space does not permit installing 2' x 2' metal panel, provide outlets or inlets 1-1/4" wide outer border. Where air outlets are installed adjacent to surface mounted light fixtures, outlets shall have 4 inch deep drop frames. (See reflected ceiling plan and/or electrical lighting plan for ceiling type and allowable space).

F. Ceiling transfer grilles (TG) shall be same as CEG's unless specifically shown otherwise; wall transfer grilles (WTG or TG) shall be4 same as WRG unless specifically shown otherwise.

2.03 **SUPPLY AIR OUTLETS**

A. Ceiling Diffuser (CD, CDR): Aluminum construction, louver face, square neck, with air straightening grid in neck.

B. Wall Supply Grill (WSG): Shall be of steel construction, double deflection type, with horizontal face bars and vertical rear bars. Unit shall have outer frame

borders 1-1/4" wide, gasket to prevent air leakage and minimize smudging. Deflecting bars shall be rigid extruded aluminum of semi-air-foil design, on ¾" centers. Vertical and horizontal bars shall be adjustable.

C. Wall Supply Register (WSR): Same as WSG, but with an opposed blade damper operable through the face of the grille.

2.04 **RETURN AIR INLETS**

A. Ceiling Return Grille (CRG): Steel construction, perforated face, style to match ceiling diffusers.

B. Ceiling Return Register (CRR): Same as CRG but with opposed blade damper.

C. Wall Return Grille (WRG): Shall be of steel construction, with 35 degree angular horizontal face bars. Unit shall have outer frame border, ¼" wide, gasketed to prevent air leakage and minimize smudging. Deflecting bars shall be rigid extruded aluminum of semi-air-foil design, on ¾" centers.

D. Wall Return Register (WRR): Same as WRG but with an opposed blade damper.

2.05 **EXHAUST AIR INLETS**

A. Ceiling Exhaust Grille (CEG): Same as CRG.

B. Ceiling Exhaust Register (CER): Same as CEG but with opposed blade damper operable from face of register.

C. Wall Exhaust Grille (WEG): Same as WRG.

D. Wall Exhaust Grille – A (WEG-A): Same as WRG-A.

2.06 **WALL CAPS**

A. Constructed of extruded aluminum, "brick vent" type, with bird screen. 16" wide x 8" high, Penn Model No. B100 or approved.

2.07 **ROOF VENTS**

A. Type: Penthouse louvered type. Greenheck Model WIH, WRH, or approved.

B. Construction: Roof vents shall be constructed of galvanized steel, or aluminum and shall be designed for mounting on factory fabricated roof curbs. Roof vents shall have ½ inch mesh wire bird screen.

C. Size: Roof vents shall be of throat size and maximum pressure drop as shown on the drawings.

D. Roof Curb: Shall be constructed of minimum 18 gauge galvanized steel or 0.064 inch thick aluminum, of all-welded construction, with top wooden nailer (as required by roof/flashing type) held in place by metal wrap-around, and internally insulated with minimum ½ inch thick rigid fiberglass. Size of curb shall match roof vent and/or extended base used with. Provide curb type (i.e., with built-in cant and step height to allow for roof insulation) as required to match roof type. Green heck Model GPR, GPS, GPF, or approved equal.

E. Dampers: Dampers shall be gravity counter-balanced type. Size shall match roof vent throat size. Shall be as specified in Section 15860.

2.08 **MISCELLANEOUS**

A. Screen: ½ inch mesh, constructed of either 0.051 inch aluminum wire or 19 gauge galvanized steel wire.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Install air outlets in locations shown on the drawings and so as to conform with architectural features and lighting arrangements.

B. Paint ductwork, duct liner, turning vanes, liner attachments, air grids, and all visible items (includes fastening pins for duct lining) which are behind air inlets and outlets (including louvers) flat black.

C. All outlets/inlets and curbs exposed to the weather shall be adequately flashed and installed in a manner to assure complete weatherproofness. Sealing and caulking of all outlets and inlets exposed to the weather shall conform to Division 7 and Section 15010.

D. Provide screened openings (SO) on all duct openings where indicated and where openings do not have grilles or registers.

E. Coordinate with the Division 9 Contractor for any necessary painting of air inlets/outlets/louvers/etc. prior to installation.

F. Where louvers require blanking off of unused area, use minimum 22 gauge sheet metal, painted flat black on louver side, and insulated on building side with 1" duct liner or similar equal rigid or fiberglass insulation. Tape off all raw edges of liner.

END OF SECTION

SECTION 15880

AIR FILTERING EQUIPMENT

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Air Filters

B. Temporary Air Inlet Filters

C. Filter Gauges

1.02 **RELATED WORK**

A. Section 15815 – Hydronic Heat Pumps.

B. Section 15840 – Ductwork.

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **SUBMITTALS**

A. Submittal shall comply with Section 15010.

B. Submit product information on all products to be used.

C. Submit independent test lab data for all AHU final filters, showing air filter performance as tested per ASHRAE 52.2.

1.05 **REFERENCES**

A. ASHRAE Standard 52.2 Method of Testing General. Ventilation Air-Cleaning Devices For Removal Efficiency By Particle Size.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. Products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Filters: Camfil-Farr, Air Guard.

C. Filter Gauges: Dwyer.

2.02 **MERV 8 FILTERS**

A. Type: Filters shall be medium efficiency, pleated panel type, disposable filters; Camfil-Farr or approved.

B. Efficiency: Filter media shall have an average efficiency of MERV 8.

C. Resistance: Initial resistance of a 24” x 24” x 4’ filter handling 2000 cfm shall not exceed 0.15” w.g.

D. Size: Filters shall be 2” deep (unless indicated otherwise), with number and sizes as required to match size requirements as indicated on drawings.

2.03 **TEMPORARY AIR INLET FILTERS**

A. Type: Glass fiber of synthetic material blanket type filter media.

B. Capacity: Shall have an average arrestance no less than 64%; dust holding capacity of 172 grams.

C. Size: Minimum 1” thick, cut to size as required to cover inlets.

D. Temporary filters shall comply with Section 01354 “Construction Indoor Air Quality Management”.

2.04 **AIR FILTER GAUGE**

A. An air filter gauge for measuring the resistance to air flow through the filters. The gauge shall be diaphragm actuated, shall have 3-7.8” diameter white dial with black figures and graduations, shall have pointer zero adjustment and shall be furnished complete with two static pressure tips, fittings for ¼” metal tubingand means for mounting the gauge.

B. MERV 8 Filters: Gauge shall be Dwyer No. 2001-AF reading to 1" water in 0.02" division.

PART 3 – EXECUTION

3.01 **INSTALLATION**

A. Temporary Filters: Contractor shall provide temporary sealing of all duct systems during the construction period to prevent the entry to dirt, dust and debris into the duct systems. See Section 15010.

B. Systems that are operated during the construction period shall have temporary filters installed over all inlets and filters installed in the air handling equipment. Filters installed in equipment shall be same type as final filters required for the units. Temporary air inlet type filters shall be taped over all inlets to completely filter all air drawn into the systems, and shall be laid in front of equipment filters as well. All duct systems carrying return or exhaust or relief air prior to dust generating work being complete, shall be vacuum cleaned by a professional duct cleaning contractor.

C. Filter must be in place and sealed properly before using fans.

D. Provide three (3) complete sets of all filters in addition to any that the Contractor requires for the work (reference Section 15010 and 15960). Store as directed by Owner. One (1) set shall be placed in units at time of that Owner takes building occupancy. Other two (2) sets are for the future Owner use. All sets shall be clean and new, unused.

E. Provide air filter gauge at each filter bank on all units serving studios and equipment rooms, and at an additional one unit per floor (to serve as a typical measurement for all units). Confirm units with Engineer. Connect sensing tips to gauge with copper or aluminum tubing. Locate gauge in easily read position, provide brightly colored tape marker to indicate clean filter pressure drop and change-out pressure drop (use clean pressure drop plus 0.25" unless instructed otherwise).

END OF SECTION

SECTION 15900

CONTROLS

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Control System Design.

B. Complete Automatic Control System for Building Heating, Ventilation, Air Conditions, Exhaust, and Domestic Water Systems.

C. Control Devices, Components, Wiring, and Software.

D. Pre-Installation Conference.

E. Testing and Adjustment.

F. Operator Training.

1.02 **RELATED WORK**

A. Section 15010 – Mechanical, General

B. Section 15140 – Pumps

C. Section 15450 - Plumbing Fixtures.

D. Section 15745 - Hydronic Heat Pump Water Piping System.

E. Section 15755 – Hydronic Heat Pump Ground Coupled Water Piping System

F. Section 15815 – Hydronic Heat Pumps

G. Section 15820 - Fans

H. Section 15830 – Air Conditioning and Refrigeration System

I. Section 15955 – Air and Hydronic Balancing

J. Section 15995 – Commissioning

K. Division 16 – Electrical

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **QUALITY ASSURANCE**

A. All materials and equipment shall be listed as approved by the Underwriters' Laboratories "List of Inspected Fire Protection Equipment and Materials", or the Factory Mutual Laboratories, "List of Inspected Fire Protection Equipment and Materials", or the Factory Mutual Laboratories, "List of Approved Equipment, Fire Protection Devices and Devices Involving Fire Hazard"; and shall be of the Manufacturer's latest design.

B. Equipment and installation to meet requirements of NFPA 13, Standard for the installation of Sprinkler Systems and all other governing codes (see Section 15010), and to exceed these codes as indicated. Various items in these specifications exceed code requirements.

1.05 **SUBMITTALS**

A. All submittals shall comply with Section 15010.

B. Submit shop drawings of entire sprinkler system for approval by the local Fire Marshal. Submit these same drawings to the Architect/Engineer; label these as "Information – Subject to Code Approval – Not for A/E Review". Submit Fire Marshal approved drawings to Owner/Architect/Engineer as the submittal for review. Shop drawings shall show head locations on reflected ceiling plans; use shop drawings from ceiling installer for ceiling layout. Where these drawings are not available, use Bid Set reflected ceiling planes. Shop drawings shall also show ductwork along with sprinkler piping; use shop drawings from sheet metal contractor or contract drawings if no sheet metal shop drawings are provided.

C. Submit product information on all products to be used.

1.06 **GENERAL REQUIREMENTS**

A. All fire sprinkler design shall be performed by a Contractor thoroughly familiar with and knowledgeable of NFPA 13, NFPA 24 and fire sprinkler system design and installation. By virtue of submitting a bid, the Contractor is acknowledging that he does in fact, have such knowledge; and all work provided will fully

comply with all the requirements of these specifications. The fire sprinkler Contractor shall be qualified, as required by local authorities to design and install all parts of the fire sprinkler contractor, of by a level U certified plumbing contractor, as issued by the State Fire Marshal's office.

B. All fire sprinkler design drawings shall be stamped by a Washington State Licensed Fire Protection Engineer or Designer (as required by Authority Having Jurisdiction).

C. System shall be Contractor-designed and approved by both the Fire Marshal and Owner/Architect/Engineer.

D. System Description: Fire sprinkler system provided for the entire building. All spaces shall sprinklered as required by NFPA 13, and per local code requirements. Provide fire sprinkler coverage for all concealed combustible spaces, all concealed non-combustible spaces, and above and below all ceilings. This coverage exceeds code requirements, and shall be provided as noted. For coverage non-combustible areas not required by code, treat areas as if they are of combustible construction.

E. This section alone does not specify all work for the fire sprinkler system. Other sections which include fire sprinkler work are: 15010, 15015, 15050, 15080, 15090, 15095 and 15200 (as a minimum); the Contractor is responsible to review all divisions.

F. Special Design Areas: Portions of the building's fire sprinkler system where the fire sprinkler piping is to be run exposed or requires drilling through building structure require special design effort, and coordination among trades and with the Authority Having Jurisdiction (AHJ) and the design team. The Contractor shall include in his bid costs for such special coordination and design efforts. This work shall include multiple meetings with local and state code officials, various contractors, and members of the design team.

1.07 **PRE-INSTALLATION CONFERENCE**

A. General: A pre-installation conference shall be held prior to the Contractor installing any of the materials of this Section. The conference shall occur after all submittals have been satisfactorily reviewed by the Architect/Engineer and returned to the Contractor, and approximately fourteen (14) days prior to the proposed system installation date and prior to the fabrication of any system piping components. The purpose of this conference is to review the Contractors installation methods, materials, schedule, coordination with all other trades, and related construction/design issues to allow for efficient and proper construction. The Architect/Engineer and Owner will highlight various items of concern, typical

problems encountered on similar projects, coordination issues, and related items.

B. Attendance: The pre-installation conference shall be attended by the General Contractor, the Contractor doing the work of this Section, other contractor trades as appropriate to the proper coordination of the work of this section, the Owner's Representatives (at their option), the Engineer, and the Architect.

C. Coordination: The Contractor shall notify the Owner/Architect of the Contractor's readiness to hold the pre-installation conference at least fourteen (14) days prior to the proposed meeting time, and mutually agreed upon the meeting times arranged.

PART 2 – PRODUCTS

2.01 **ACCEPTABLE MANUFACTURERS**

A. All products shall comply with Section 15010, Paragraph 2.01, Acceptable Manufacturers.

B. Sprinkler System Components: Reliable, Viking, Gem, Star, Central, Grinnell.

C. Valves: Grinnell, Viking, Gem, Central.

2.02 **PIPE AND PIPE FITTINGS**

A. Pipe and fitting standards shall be specified in Section 15060, Pipe and Pipe Fittings.

B. Aboveground Piping and Fittings: Piping shall be black steel. Fittings shall be suitable for 175 psi working pressure, and shall be cast iron or malleable iron screwed, grooved or welded in accordance with NFPA 13. Piping and fittings ran outside and exposed to the outdoors shall be galvanized type. (i.e. if piping is concealed in soffit, galvanized is not required.)

C. Underground Piping and Fittings: Shall conform to local utility requirements, NFPA 24 and NFPA 13. Shall be ductile iron pipe conforming to AWWA C151, thickness class 52 minimum. Fittings shall conform to AWWA C111, with pressure rating no less than the piping connected to. Pipe and Fittings shall have cement-mortar lining conforming to AWWA C104. Pipe and Fittings shall be restrained against movement in accordance with NFPA 24. Thrust restraining joints/fittings shall be UL listed for fire main use.

2.03 **VALVES**

A. 2 Inch and Smaller: Bronze gate valve, 175 psi water working pressure, threaded ends conforming to ANSI Standard B2.1, UL listed and FM approved. Stockham Figure B-133, or approved. ALTERNATE: Bronze butterfly or ball valve, UL listed for fire protection service and FM approved. Milwaukee or equal.

B. Terminal Unit Controllers (TUC's): Shall provide control of air handling units, fans, air terminal units, and similar type units; controllers shall be microprocessor based and shall contain a non-volatile resident program to allow for proper sequencing of controlled equipment. The Terminal Unit Controller (TUC) shall interface to the building control system via multi-drop (or serially connected) communications network. An individual controller shall be provided for each air handling unit (as a minimum). Each terminal control unit shall be accessible for purposes of control and monitoring from a central or remote operator's terminal as specified herein. TUC shall be enclosed in a NEMA 1 (or better) enclosure where located in any place other than ceiling plenum.

C. Central Operator Station (COS):

1. General: Shall consist of keyboard, software, modem, printers, monitor, microprocessor, and interface devices for communication to stand-alone control units and to system. Operator station shall provide full interface to entire system for monitoring, equipment control, database management, system performance analysis and management reports. The operator station shall communicate with the system controllers and with other operator stations.

2. Over Furnished: Central Operator Station (COS): Shall be furnished by Owner and installed by Contractor. Six (6) months prior to installation, the Contractor shall submit to the Owner a list of specific requirements for COS to interface with building control system.

D. Controllers/System Features: Stand-alone control units, terminal unit controllers, slave panels, accessories, and central operator's station shall all be combined to form a complete system providing the sequences of operation/functions specified and having the following basic features:

1. The Control System shall monitor and control all functions relating to building environmental control and mechanical systems as specified. The point monitoring and controlling functions to be performed by the System shall include but not limited to the following capabilities:

a. Binary inputs (contact closures).

b. Analog (electrical) inputs.

c. Binary output (start/stop).

d. Analog outputs (varying voltage signals).

e. PWM (pulse width modulation) with feedback position indication.

2. The system SCU's and TUC's shall directly control all valves, fans, heat pumps, dampers, duct coils, and similar devices. All control software shall be implemented in the SCU's and TUC's. See sequence of operation for minimum points of monitoring and control.

3. Zone-by-zone control of space temperature, usage scheduling, equipment failure reporting, and override timers for off-hours usage. (A zone is the area served by an individual piece of HVAC equipment).

4. Zone temperatures to be set by operator from the operator terminal (except where indicated otherwise).

5. Access to system shall be by priority password security system to prevent unauthorized use. Minimum of three (3) levels, each assignable to dedicated function keys. Invalid passwords shall lock data base access after three attempts. Password shall not be needed for access to monitoring programs.

6. Equipment monitoring and alarm function including information for diagnosing equipment problems.

7. Auto-restart on building power failure. System shall have programmed sequence to prevent excessive electrical demand due to all equipment starting at the same time. Provide staggered start times for all equipment to prevent more than 25 hp of electrical load from starting at the same time. Provide 5 minute delay between loads.

8. Time Clock Bypass Operation: Bypass switches shall send signal to control system indicating requirement for override operation. The operator shall program the time of override operation at the keyboard from 1 to 15 hours. Override tie remaining to show at COS, and operator shall be able to alter override time or turn area back to automatic.

9. All “Monitoring Data” indicated as information to be provided to COS shall be based on direct measurement at the point of interest (unless indicated otherwise).

10. Equipment run time totalization and start/stop totalization of all mechanical equipment connected to system; totalization information, at will, with no required auxiliary equipment.

11. Operator shall have complete capability to modify displays, menus and menu format headings, data base information, at will, with no required auxiliary equipment.

12. Operator may select individual security level assignments for each operation and menu selection available, according to his/her specific operation responsibilities.

13. All set points shall be operator adjustable (via common English language commands); all reset schedules shall be operator changeable (via common English language commands); all devices which indicate on/off status to the COS shall have their on/off status manually and automatically controlled from the COS.

14. Peak Demand Recording: The demand peak in KW and its date and time of occurrence shall be recorded. These values shall be observable by the operator. Provide a KW-hour trend log. Provide demand reading program that matches method and time base used by local utility company to bill for demand so that control system demand readings match the utility readings.

15. Power Recording: Current annual, monthly and daily total building electrical power usage shall be recorded. Provide a KW trend log.

16. Clock/Standby Power: Real-time clock shall be self-contained and accurately controlled by a quartz crystal. The clock shall be set via the keyboard and may be viewed on the display. A battery standby power supply shall be used to maintain clock operation when primary power fails. When primary power returns, the system shall automatically reboot to the appropriate schedules and require no action from maintenance personnel to re-initialize.

17. Failure: Upon failure of any SCU or TUC, system shall display off line occurrence for each individual affected point at COS. Provide communication verification to each SCU for each I/O channel. In event of

COS failure at operator's terminal, SCU and TUC shall operate in stand-alone mode, operating equipment at last command's or default values.

18. Disk System:

    a. System shall be able to store data base on standard digital disk or load a data base from the disk. This shall be accomplished locally at the COS. Operator to be able to program system to automatically dump data base to disk storage system at end of each day for the purpose of updating all point data information and logs.

    b. The disk system shall be activated to load or store data to the CPU on system initialization or as permanent changes as recorded. Disk system shall not be utilized for routine system operation. Hard disk shall be used only for data storage.

19. Alarm Program shall be capable of:

    a. Monitoring each analog input point and providing operator assignable high and low alarm limits.

    b. Monitoring each analog input alarm and each digital input and providing the following assignable alarm responses:

        1) Provide digital output.

        2) Display point English-language description on reserve area of screen.

        3) Print out alarm description and operator-created alarm message.

        4) Require acknowledgment by operator and print occurrence if directed by Owner.

        5) Store previous 100 alarms, with description, time of occurrence, time of acknowledgment, and time of return to normal. Provide for review of alarm history on display and printer.

        6) 100 programmable alarm messages, up to 256 characters each.

c. Provide capability for 100 maintenance alarms of at least 256 characters. These alarms shall occur in the event of equipment failure as detected by system, upon the arrival of a predetermined calendar date upon the passage of a specified equipment run time or upon passage of a specified number of equipment start/stops. Train the Owner in the development of these alarms and fully develop and program the first 25.

d. Logical Alarm: Provide alarm for each heat pump unit, if unit calls for heating (or cooling) but SA temperature does not vary appropriately from MA temp (indicating coil/valve/fan failure). Provide similar alarms for fans and water heaters.

20. Logs:

a. Trend Log: Provide 30 trend logs. For each trend log, operator may assign up to 5 points and an interval sampling rate of 1 to 256 minutes. Store time segments. Provide for review of data on display and printer. Each trend log can be assigned individual start/stop times/dates at the terminal in advance. System shall automatically begin entry into each log as scheduled. Each point in the log shall have 360 entries, all data stored for future retrieval. Trends shall be formatted for ease of reading. Submit proposed format of printed trend logs to Design Consultant for approval.

b. Current Alarm Log: Display all points currently in alarm.

c. Alarm History: Log last 100 alarms as to time of occurrence, time of acknowledgment and time of return to normal. Maintenance alarms shall be separate from operational type alarms.

21. Scheduling:

a. Time Schedules: The Control System shall provide time clock functions with at least 100 times schedules. Each schedule to be 8-day type, six (6) entries per day. All entries to be in 12 hour AM/PM format. The complete schedule shall be displayed at one time at the COS for easy editing. Each time program shall provide ON/OFF, HIGH/LOW SPEED or DUTY CYCLE commands, or Analog Control Values as desired.

b. Holiday Schedules: A minimum of twenty-four (24) holiday time schedules shall be available and shall be assigned to any number of available points.

c. Holiday schedule will display entire year and shall also allow for an interval holiday time, program showing holiday START date to END date (example: December 24 to January 2).

d. Schedules shall provide control of all mechanical equipment as indicated in the sequence of operation.

22. Duty Cycling and Demand Listing: Provide a duty cycling and demand limiting program. System shall support at least 100 loads and three demand meters.

23. Warm-up Operation: Control System shall have warm-up mode on heating to pre-warm building prior to occupancy. Time of beginning warm-up cycle shall be determined by optimum start/stop program. Outside air dampers and exhaust fans shall be off during warm-up mode.

24. Optimum Start/Stop: Control System shall have optimum start/stop program to reduce run time of HVAC equipment. Optimum start/stop program shall consider building mass, building temperatures, outdoor air temperatures, and other system factors in determining time of system start-up or shut-down. Program shall record previous warm-up times versus actual warm-up times and shall adjust the program algorithm so that the program calculated warm-up time corresponds to actual.

25. System Displays: Central Operator Station (COS) shall display system operation data. Display shall be menu driven from keyboard keys and from mouse. System shall use English language and acronyms selected to allow operators to use the system without extensive training or without programming backgrounds. Software shall use command strings in a request-response sequence in which the machine prompts the operator for all required information; operator response required shall be the appropriate parameter input data. Software shall contain edit functions and escape modes to eliminate continuous logic loops requiring system reboot to escape. Coordinate with Owners staff to develop all operational data to satisfaction of Owner.

a. Alarm conditions as listed for each equipment under (See paragraph 2.3).

b. Unit Run Times:

1) Annual run time

2) Total life run time

3) Number of starts/stops

4) Run time shall be reset by operator (provide operation confirmation that change is desired before making change).

j. Unit and zone time clock schedules.

1) Status of each zone; provide information required to be sent to COS for each heat pump or other zone.

2) Annual Time clock schedules.

3) Operation Alarms

4) Load Status

5) Time and date of last update of listed information.

6) Record of annual daily OA temperatures.

7) Record of annual daily building temperatures. (selectable from any zone or combination of zones.)

8) Trend logs.

9) Run times of all equipment.

10) All analog signals transmitted to the CPU shall be available for display. Provide organized format and menu for ease of operator display of this information.

26. System Graphics: This work is in addition to system displays listed elsewhere, and consists of color schematics, plans, and diagrams to aid in visual presentation of system data. Shall include:

a. Building plans showing locations of mechanical equipment and areas served, showing each room (zone) and temperature.

b. Summary status of mechanical equipment.

c. Schematic of system with appropriate temperatures, flow, damper positions, % of capacity, power consumption, etc. interposed on schematic. Provide schematic for each Air Handling Unit, boiler and chiller system, domestic HW, and other systems where extensive measurements are made.

d. Graphics shall include all system set points and shall allow user to adjust these points.

2.01 TEMPERATURE SENSORS

A. Room Temperature Sensors: Shall be solid state electronic type with digital display employing a resistance type output, factory calibrated to within one-half degree F., shall have RJ-11jack to allow interconnection of field computer into system, and integral momentary push button (not required for corridor or restroom sensors) for placing room's system into occupied mode when pressed. Where sensor allows reading of internal control variables at a digital display, the RJ-11 interface is not required. Each sensor (except those used in corridors and restrooms) shall have occupant set point adjustment. Provide with tamper-proof cover. Where guards are indicated to be provided, and in corridors, gym, restrooms and commons, provide stainless steel flat plate sensors.

B. Duct Temperature Sensor: Shall be solid state electronic type, employing a resistance type output. The sensor shall include a utility box and gasket to prevent air leakage and vibration noise. For all mixed air and preheat air applications, install averaging duct sensors installed so as to sense a representative sample of the medium being controlled.

C. Duct Freeze Protection Sensor: Low temperature control thermostat, electric type automatic reset, non-averaging 20 feet long (or 6 feet long for ducts with largest dimension of 24" or less) sensing elements that switch whenever any 6-inch section or more of any portion senses a temperature as low as the thermostat set point. Provide two (2) contacts, one hard-wired to stop fan and one for input to automation system.

D. Outside Air Temperature Sensor: Shall be an RTD or electronic solid state device mounted in the outdoors where air flow occurs. The temperature range shall be -20 to 180 degrees. Provide a sun shield and weatherproof assembly for mounting to ½ inch rigid conduit.

E. Liquid Immersion Temperature Sensor: Shall be solid state electronic type, employing a resistance type output. The temperature range shall be 32 to 212

degrees F. Provide brass thermowells and install sensor probe with heat conductive grease. Prove and sensor head shall be removable without breaking fluid seal. Install sensors in top of pipe for horizontal runs and at a positive slope on vertical runs to prevent condensation from flowing to sensor head.

2.02 **CONTROL DAMPERS**

A. Type: Similar and equal to Ruskin Model CD-36. Dampers shall be parallel blade or opposed blade type, as selected by contractor t o best suit application.

B. Leakage: Shall not exceed 5.8 cfm per square feet at 1-inch w.g. pressure differential across closed damper (for 24-inch damper width).

C. Blades: Single blade type, not exceeding 6 inches in width. Fabricated from 16 gauge galvanized steel, with neoprene, extruded vinyl or butyl rubber edge seals and flexible metal jamb seals; linkage interconnecting all blades and actuator axle.

D. Bearings: Nylon, molded synthetic or oil-impregnated sintered metal bearings.

E. Frame: Constructed of galvanized steel hat channel, minimum 16 gauge.

2.03 **ACTUATORS**

A. Actuators shall be heavy-duty reversible type, driving motor and gear train type. Unit shall have a sealed case. All actuators shall be proportional type. Actuators shall have a built-in electro-mechanical system to provide for positive repeatability of position, regardless of changes in output load. Actuators shall have a build tin switch for reversing the direction of the actuator. Spring return actuators shall have a manual positioning crank non-spring return actuators shall have a manual gear release handle. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the rated torque and shall have a 2-year manufacturer’s warranty.

B. Units shall be complete with all linkages, brackets, and hardware required for mounting and to allow for the proper control of the regulated damper or valve.

C. Actuator shall spring return upon power interruption. Actuator shall “fail safe” in open or closed position as dictated by freeze, fire or temperature protection requirements.

2.04 **ACCESSORIES**

A. Wiring and Conduit: Shall comply with Division 16 specifications. Wiring that performs code required life safety shutdown of equipment or fire alarm interface shall comply with NFPA and local codes for fire alarm system wiring.

B. Control Cabinet: Wall mounted, NEMA Type 1 construction, UL listed per 504 as a complete assembly, minimum 14 gauge sheet metal, hinged front door with latch. Size as required to house controls. Controls/devices shall be logically assembled in cabinet, with all devices and cabinet labeled.

C. Relays: Shall be rated for the application enclosed in a dust-proof enclosure. Relays shall be rated for a minimum life of one million (1,000,000) operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays should be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage. Relays shall have visual indication of on/off status.

D. Miscellaneous Sensors/Transmitters/Switches/Transformers: Shall be manufacturer's standard, designed for application in commercial building HVAC control systems, compatible with other components so as to provide sequence of operation specified.

E. Interval Timer: Four (4) hour (unless specified longer) spring operated interval timer with wall plate indicating timer setting, and control knob. Timers shall not have a permanent HOLD position.

F. Control Panel Lights: Allen-Bradley Bulletin 800H, push-to-test type, or approved.

G. Thermowells: Bronze or brass with NPT threads, sized to match device used with. All wells to be installed by Mechanical Contractor.

H. Flow Switch: Brass constructed paddle flow type switch for installation in pipe tee, with SPDT switch, adjustable sensitivity, and multiple paddles.

I. Remote Smoke Damper Indicator: Red LED type indicator, mounted on single-gang plate, BRK RA400 or equal.

J. CO2 Sensor: Non dispersive infrared (NDIR) type CO2 sensor, measurement range from 0-2000ppm, plus/minus 5% accuracy, plus/minus 20 ppm repeatability, and less than one minute response time. Unit shall provide mA DC signal for interface with building controls. Provide with minimum two (2) year warranty.

2.05 **SWITCHES**

A. Air Flow Switches: General Purpose utilizing differential air pressure, SPDT snap-acting contacts, adjustable 0.1 in. W.C. to 2.0 in. (minimum), neoprene diaphragm, all aluminum construction.

B. Damper End Switches: Shall be momentary type limit switches for monitoring the motion of the damper at a prescribed arc of rotation. The switch shall be hermetically sealed mercury contacts that operate by way of a trip lever. The switch shall be mounted on the exterior of the duct so that the trip lever is aligned with the damper vane. Mechanical adjustments in the switch case shall permit the proper lever action for tripping the mercury switch contacts. The switch shall have a SPDT contact arrangement that exceeds the load requirements for both voltage and current.

C. Bypass Switch: Shall be momentary contact type push button. Install in standard wall box with stainless steel cover.

D. Wall On/Off Switch: Standard wall box type switch, single pole, with illuminated switch for when controlled item is on. Provide with stainless steel wall plate, labeled as to function. Leviton or approved.

E. Water Flow Switches: General purpose liquid flow switch, SPDT snap-acting contacts, adjustable, neoprene diaphragm, in a dust-tight enclosure, rated 150 psig and 250 degrees F.

2.06 **PRESSURE SENSOR/TRANSMITTERS**

A. Air Differential Pressure Sensor: Electronic transducer, incorporating linear variable differential transformer type sensing element with two-wire 0-10 Vdc transmitter. Accuracy shall be +/- 2% of full scale. Submit chosen spans for review.

B. Liquid Differential Pressure Sensor: Single pole, single throw switch, bellows type, with adjustable range, suitable for application intended.

C. Air Velocity Transmitter: Shall be duct mounted instrument that measures the difference between total pressure and static pressure to get velocity pressure. Measurement shall be by a pitot tube located in the moving air stream or by a duct mounted air flow measuring station. Air velocity devices on inlet of air terminal units shall be furnished with units. The transmitter shall be an industrial quality device that produces a linear output directly proportional to

the input utilizing an integral square root extractor. The air velocity span shall be a segment of the range between 200 and 5000 feet per minute.

2.07 **VARIABLE FREQUENCY DRIVE**

A. Type: Adjustable frequency and voltage variable speed controller, pulse width modulated type

B. Controller: Shall be housed in a NEMA 1 (or better) enclosure, and shall provide 6 to 60 Hz adjustable torque output. Standard Features:

1. Start-stop speed selection

2. Manual speed potentiometer

3. Input fuses

4. Insensitive to incoming power phase sequence

5. Adjustable volts/Hertz

6. Output frequency stabilized to + 0.5% set speed for +10% to -5% change in line voltage of 15 degrees C change in ambient temperature.

7. Three-phase output voltage regulated to + 1% of rated voltage with +10% to -5% variations in plant power.

8. Standard off-the-shelf, NEMA B and synchronous motors (3600, 1800, 1200 rpm) usable without derating controller.

9. Automatic shutoff under output short circuit conditions or when load current exceeds 150% of maximum output amps (RMS).

10. Input fuses.

11. Line transient protection to prevent power line transients from harming the controller.

12. Relay contact to provide external signal for alarm and run condition.

13. Monitor lamps (or LCD display) indicating power on (green), zero speed, enabled, unit failure (with type indicated).

14. Hand-Off-Auto switch.

15. Auto restart after power outage.

16. Isolated Process control Follower – accepts 0 to 5 mA, 1 to 5 mA, 4 to 20 mA, 10 to 50 mA, 0 to 10 V D0C or 25 to 250 V D-C signal.

17. Input Disconnect (meeting NEC requirements for unit power disconnect).

18. Output Contactor – for positive motor disconnect.

19. Output Overloads Hand reset solid state overload relay with phase loss protection.

20. Ammeter – ampere scale depending upon drive rating.

21. Voltmeter – 0 to 500 volt (460 volt drives); 0 to 750 volts (575 volt drives).

22. Frequency Meter – 0 to 120 Hz scale.

23. Manual Bypass – To switch the motor to or from the controller to the line.

C. AFD shall be for use with specified equipment. Unit shall accept appropriate control signal and provide for variable speed operation of unit served.

D. System shall be fully compatible with motors furnished, and shall be free of audible noise exceeding an NC of 45 in any octave band.

2.08 **ZONE DAMPERS**

A. Type: High quality control dampers, for use with field installed damper actuator.

B. Construction: Galvanized steel construction, with blade seals, steel axles, and stainless steel bearings pressed in damper frame. Ruskin CDR82 or approved.

2.09 **WATER CONTROL VALVES**

A. Valves shall be fully proportioning, with modulating plugs for equal percentage of liner flow characteristics. Ball or butterfly type valves are not acceptable. The valves shall be sized by the control manufacturer and be provided with actuators of sufficient power for the duty intended. Valve body and actuator selection shall be sufficient to handle system pressure and shall close against the differential pressures liable to be encountered in the system.

B. ½ Inch Through 1 Inch: Valves shall be constructed with a cast-brass body and screwed ends. Trim shall consist of a removable cage providing valve plug guiding throughout the entire travel range. A stainless steel stem shall be provided.

C. 1-1/4 Inch Through 2 Inch: Valves shall be constructed with a cast-brass body and screwed ends. For special duty, valves may be selected by the control manufacturer to have either bronze or cast iron bodies with screwed or flanged ends.

D. 2-1/2 Inch and Above: Valves shall be constructed with a cast iron body and have flanged connections.

E. Valves shall be selected for a maximum 3.0 psi pressure drip at design flow unless indicated otherwise on the drawings.

F. Unless otherwise noted, heating valves shall be normally open; cooling valves shall be normally closed.

G. All valves 1-1/2 inch and larger shall have field manual positioning capability to allow manual positioning of valve in absence of control power.

H. Heat Pump Solenoid Valves: See Section 15945.

PART 3 – EXECTUTION

3.01 **INSTALLATION**

A. General: Provide all computer software and hardware, operator input/output devices, sensors, relays, switches, dampers, actuators, conduit, tubing, wiring, motor starters and all other devices required to provide a complete integrated Direct Digital Control (DDC) system with the sequence of operation and basic system features as specified. All control loops shall utilize proportional-integral control action. It is the Contractors responsibility to coordinate with other trades for the installation of control devices in the systems installed by others.

B. System Type: Control system shall be DDC type throughout.

C. Thermostats: Room thermostats shall be mounted 4’-6’ above finished floor. Thermostats shall connect to the HVAC unit serving the space the thermostat is located in, unless indicated otherwise. Not all thermostats are shown on the

drawings and those shown are preliminary only. Contractor shall indicate all final thermostat locations on submittal drawings. Contractor is responsible to coordinate locations to avoid chalkboards, tackboards, casework, and other interferences.

D. Power: It shall be the responsibility of this Contractor to provide power for all damper motors, time clocks, and other control devices requiring power. Power for controls shall be obtained from circuits dedicated for Division 15900 use, coordinate with Division 16 for circuits to use.

E. Electrical: Provide all electrical wiring and devices in accordance with applicable National, State and local codes and Division 16 requirements. All wiring shall be installed in conduit and in accordance with electrical section of these specifications. Low voltage wiring within the ceiling plenum spaces may be open plenum rated cable. Install all conduit and wiring parallel to building lines, in neat bundles, supported at not less than 5 foot intervals with screwed down bridal devices. All controllers shall be mounted to structure.

F. Component Labeling: All control components, except regular room thermostats, shall be equipped with name plates to identify each control component. Components in finished rooms shall be labeled as to generic item controlled for better user understanding: other devices shall be labeled with the same designation which appears on the Control Diagrams. Contractor shall submit list of proposed labeling prior to installing. Reference Section 15010.

G. Programming: Provide complete system totally programmed to provide all specified sequences, monitoring data, communications and features.

H. Central Services Connection: Network this site to existing district central services workstation. All work provided shall be accessible locally and at the district central services computer. Alterton controls shall connect using existing district software.

I. Power Metering: Coordinate with utility company and pay all associated fees for utility to provide meter having a pulse output proportional to energy usage and being compatible with control system.

J. Interlocks: Where required, may be accomplished by COS (Central Operating Station) rather than field hard wired relays or other devices, except for: fire alarm shut-down of equipment.

K. Thermostat Setpoints: Thermostat Setpoints (all adjustable) shall be as follows unless indicated otherwise:

Occupied Heating	70° F
Unoccupied Heating	55° F
Occupied Cooling	75° F
Unoccupied Cooling	95° F

L. Room thermostat set point adjustment shall be limited as to range of adjustment allowed (by physical restriction of by system software). Range shall initially be plus/minus 3 degrees F and shall be adjustable (with special tool or system password).

M. Time Clock Bypass Switch: Provide integral with each room sensor. Provide additional ones as indicated on the plans and where the room sensor is not accessible. Bypass switch shall serve unit that supplies space in which bypass switch is located. Activation of bypass switch shall put unit(s) bypassed into the occupied mode as well as all equipment interlocked with the bypassed units. Bypass shall initially be for two hours.

N. OA Temperature: Provide at least two OA sensors for this project, with display at the COS; use average of two for control purposes. Provide logic to allow disuse of "Bad" OA sensor and indicate alarm.

O. TUC Location: To simplify controls and mechanical service and trouble-shooting, the TUC shall be mounted directly on or immediately adjacent to each air handling unit. Provided a dedicated TUC (i.e. unit controller) for each air handling unit.

P. Motor Starters: Shall be by Division 16; except for loads ½ hp and less which shall be by Section 15900.

Q. Device Duct Installation: All control devices installed in ductwork shall be positively anchored and attached to the ductwork by mechanical means (fasteners, straps, unistrut, etc.).

R. COS: Provide one in the Building verify location with Architect. Provide interface to Owner's existing COS (Alerton system) at Owner's maintenance office. All necessary phone outlets are by the Owner. Where the systems provided under this Section are other than Alerton, the Contractor shall provide an additional COS (equal to that specified herein) for installation at the Owner's maintenance office. Provide modems, programming and accessories for communication between the building COS and the Owner's existing central COS.

S. Service Loop: Provide minimum of 6" extra wiring at all wiring terminations for ease of future maintenance/servicing. Such extra wiring shall be neatly coiled/bundled to allow for uncoiling when the connected equipment is serviced.

T. Provide point-to-point checkout of complete control system to verity wiring continuity, proper terminations, signal integrity, and point addressing. See Section 01810 for additional work related to Commissioning.

U. Mock-up: Provide control dampers, actuators, control valves, and related wiring/devices to allow for air handling unit mock-up (see Section 15720, 15810, 15860).

V. VFD's: Provide VFD's on equipment as noted on plans (see schedule), and as required by the specified sequence.

W. Miscellaneous Control Wiring: Provide all necessary control wiring between units furnished by others for proper operation. This includes AC units, chillers, boilers, kitchen hoods, etc.

3.02 MONITORING DATA

A. General: The following information shall be provided at each Central Operator's Station. Provide all necessary controls/devices and software to provide the data indicated.

B. Exhaust and Return Fans (500 cfm and Larger):

1. Fan on/off status (by CT's).

2. Fan failure alarm; (i.e. not "proven" on when commanded on).

C. Heat Pump units:

1. Zone temperature.

2. Zone temperature set point.

3. Unit commanded mode (heating/cooling).

4. Supply air temperature off unit.

5. Mixed air temperature at unit.

6. Percent commanded heating or cooling.

7. Override status.

8. Outside air and return damper positions (% commanded open).

9. Fan On/Off (by differential pressure device).

10. Fan commanded position (on/off).

11. Alarm/trouble conditions, SHALL INCLUDE AS A MINIMUM: Freezestat alarm; fan not "proven" on when should be on; heat failure alarm – SA temp not warmer than MA and unit is in heating; cooling failure alarm – SA no cooler than MA and unit is in cooling; "false" cooling or heating call – i.e. unit calls for heating when OA temperature is above 70°, unit calls for cooling and OA temperature is below 30°.

D. Miscellaneous:

1. Outside Air Temperature (two locations).

2. IDF Room Temperature.

3. Fire Alarm Status.

4. "Motion" status for all motion sensors.

5. Elevator machine room temperature.

6. Building electrical KW, KHW (at main panel).

E. Electric Heaters:

1. Space temperature.

2. Space set point.

3. Commanded Mode.

F. Ground Coupled Loop:

1. Overall loop temperature (supply and return).

2. Each branch loop temperature (supply and return); alternate bid item.

G. Hydronic Heat Pump Loop:

1. Main return temperature.

2. Main supply temperature before mixing valve.

3. Main supply temperature after mixing valve.

4. 3-way valve commanded position.

H. Circulating Pumps:

1. On/Off status (by differential pressure device or flow switch).

2. Failure Alarm (i.e. not “proven” on when commanded on).

3. Variable Frequency Drive (VFD) commanded position (as applicable).

I. Zone Dampers (motorized)

1. Space temperature.

2. Space set point.

3. Commanded damper position.

3.03 **START-UP AND OWNER INSTRUCTION**

A. As each part of the systems become operational, this Contractor shall calibrate all sensing and readout devices and shall test and observe the operation of each and every air moving and/or heating unit and shall adjust all controls so that the items function according to the intent of the specifications.

B. Report/Statement: After making all necessary system testing and adjusting, the Contractor shall submit a report to the Engineer indicating all testing/adjustment work done and comment on how system is operating. Such report shall be signed by an officer of the company and by the individual directly responsible for supervision of the installation of the control system. When the Contractor feels that the system is complete and ready for review by the Engineer, Contractor shall submit a written statement (signed by same individuals as for report) stating that the system is in compliance with the project requirements and ready for review. Provide such report/statements for each phase of the project, as each area is completed.

C. Instruction: Upon completion of the work, the Control Contractor shall instruct operating personnel in the operation of the system. Control Contractor shall provide a minimum of two sessions of eight hours each of on-site training in the

operation of the control system for the school maintenance personnel and other school employees (as deemed necessary by the school administration). Coordinate with Owner and Engineer for scheduling of sessions.

D. Start-Up Trend Logs: The Control Contractor shall submit to and review with the Engineer daily for a period of four weeks after substantial completion a hard copy log of the following:

1. Five (5) selected room temperature values at 15 minute intervals.

2. Outside air temperature values at 15 minute intervals.

3. Calculated optimum start times for these five areas.

4. Calculated optimum stop times for these five areas.

E. Acceptance Trend Logs: Two months after Owner acceptance of the building, the ECMS Contractor shall submit to and review with the Engineer a single tabulated 30-day hard copy printout of the systems historical data containing the following information:

1. Date

2. Daily KWH totalization

3. Daily peak KW

4. Time of Daily KW peak

5. Hour by hour zone temperature

6. Hour by hour OA temperature

F. Documentation: Contractor shall provide a blueprint documentation of the software application program for each controller. Documentation provided shall include block software flow chart showing the interconnection between each of the control algorithms and sequences for systems utilizing program listings. A program listing shall be printed onto the same blueprint, along with the program flow chart, and description of the sequence operation. This blueprint shall be stored and maintained in each stand-alone digital controller panel. System acceptance shall not be completed until this documentation is provided and located in each panel.

G. Commissioning: See Section 15995 for additional control work and where the presence of the Control Contractor is required during commissioning.

PART 4 – SEQUENCE OF OPERATION

4.01 **GENERAL**

A. General: Provide complete system with sequences of operation as specified herein.

B. Time Control: Control system shall provide central time clock control (i.e. occupied/unoccupied/warm-up modes switching) for all items.

C. Warm-up Control: Control system central optimum-start controls shall provide warm-up switching for all items indicated as having a warm-up cycle.

D. Time Schedules: Provide independent occupied/unoccupied mode schedules and optimum start (i.e., warm-up) cycles for each air handling unit and all fans indicated as having "time clock" control (see Fan Schedule).

E. Adjustability: All setpoints and differentials shall be adjustable. All DDC systems shall use proportional-integral control action.

F. Various thermostats are not shown on the drawings but are required per the sequence of operation specified. Coordinate with Engineer for location of all such thermostats prior to installing. Indicate proposed locations on submittals.

G. Average Thermostats: Where average thermostats are indicated on plans combine and average temperature requirements from each sensor and use average requirements to control unit. Provide means (at COS, in single screen command) the ability to select between using of either thermostat.

4.02 **HYDRONIC HEAT PUMPS**

A. General:

1. Coordinate with Section 15815 for providing proper interface devices to allow for proper unit operation and the control functions specified.

2. Provide proportional and integral type control so that space temperature overshoot is minimized.

3. Operate heat pump hydronic valve allowing water flow to unit prior to activation of unit compressor. See Section 15745 for hydronic valve. Close valve when compressor is no longer operating, after a 30 second delay.

B. Occupied Mode: Fan shall run continuously.

1. Heating: Outdoor air damper shall be in minimum outside air position. Heat pump shall cycle in heating mode as required to satisfy space thermostat.

2. Cooling: Use of outside air (i.e., economizer) shall be the first stage of cooling. Economizer shall be allowed to operate when OA temperature is less than the RA temperature. Economizer outdoor air and return air dampers shall modulate to maintain mixed air temperature set point, with a low limit of 54° F (adjustable). Where units are equipped with relief dampers interlock with OA/RA dampers such that relief dampers open when OA dampers open. Delay opening of relief damper until OA damper is 15% or more open, then provide custom signal to drive relief damper open parallel with OA damper so that both dampers arrive at 100% open at the same time. Compressor cooling shall be the second stage of cooling and shall be integrated with economizer operation.

C. Unoccupied Mode: Unit shall cycle on and off as required to maintain setback temperatures. Outdoor air dampers shall be fully closed, return dampers fully open, relief dampers fully closed. Fan shall cycle with unit cycling.

D. Warm-up Mode: Unit shall run as in the unoccupied mode (outdoor air dampers fully closed) until the space temperature has warmed up to the occupied mode heating set point, then unit shall operate as specified for the occupied mode.

E. Mode Control: Units' mode of operation shall be determined by central DDC time clock and time clock bypass switch; warm-up mode shall be initiated by central optimum start controls.

F. Water Flow Interlock: Units shall be interlocked with flow for circulating pumps that serve units, such that the heat pumps are locked out if there is no flow.

G. High/Low Temperature Interlock: Units shall be interlocked with system loop temperatures such that if temperature is greater than 100 degrees F (adjustable) or less than 25 degrees F (adjustable), units are locked out.

H. Occupancy Sensors: Each unit shall be interlocked with the lighting occupancy sensors located in the spaces served (see Division 16 for occupancy sensors). When in the occupied mode, and all areas served by the unit have no occupancy (as sensed by the occupancy sensors), the unit's OA dampers shall close until occupancy is detected. Unit shall maintain OA damper open for five (5) minutes prior to changing position.

I. TOC HP Units: See "TOC AC Unit switchover" paragraph for switch over to AC units. When HP units are serving the TOC room, operate two units serving area in unison, equally loaded.

J. HP-114A and HP-115 OA Dampers: Interlock with HP-114A and HP-115 OA dampers with EF-106 so that when EF-106 is turned on HP-114A and HP-115 modulate their OA dampers to 100% outside air.

K. Emergency Damper Shutdown: Upon activation from COS, close all heat pump OA dampers. All RA dampers to go full open.

4.03 **EXHAUST AND TRANSFER FANS**

A. General: Fans shall operate from either manual switches or from DDC (or both). See "Control" column on Fan Schedule for which of the following categories a fan belongs to.

B. Wall Switch: Fan shall be controlled by wall mounted on/off wall switch (as indicated).

C. Interval Timer: Fan shall be controlled by wall mounted interval timer to be on when timer is activated and off otherwise.

D. Time Clock Control: Fan shall run from DDC time clock control schedule.

E. Thermostat: Fans shall run when temperature rises above set point, and shall be off once space temperature falls 2° F or more below set point.

4.04 **PUMPS**

A. Domestic HW Recirculation Pumps: Pump shall be enabled to operate by time clock schedule. When enabled, pump shall be controlled in conjunction with a sensor in the hot water recirculation line. When HWC falls to 5 degrees F below set point, the pump shall run; when temperature returns to set point, pump shall be off. Set point and differential shall be adjustable. Initial set point shall be a 5 degree less than domestic hot water setting for system used on.

B. Heat Pump S/R Loop Pumps (CP-1A, 1B):

1. General: One pump is a standby the other pump is the primary pump. When any unit calls for heating or cooling, primary pump shall run.

2. Primary/Standby Sequence: Provide operator selection of which pump is primary and which is standby. Provide pressure switch and time delay relay to allow automatic transfer to standby pump in case of primary pump failure; de-energize primary pump when transfer occurs. Provide manual reset means at COS and at mechanical room panel to restore normal pump operation after standby operation. Provide alarm indication upon pump failure. Provide alarm light and reset button at mechanical room panel. Provide "alternator" sequence to allow for automatic alternating of pumps (if selected at COS).

3. VFD Operation: VFD shall modulate pump speed to maintain system differential pressure set point. Building differential pressure setpoints shall be established by the balancer and Engineer.

4.05 **ZONE DAMPERS**

A. Occupied Mode: Unit shall be controlled by its space sensor to vary air volume supplied to zone satisfy space conditions. As the zone temperature rises, the air volume to the zone shall increase (cooling SA) to maintain the zone set point. As the zone temperature falls, the air volume to the zone shall decrease to maintain the zone set point. The above description is for the AHU in cooling. A changeover sensor shall be provide so that unit operation shall reverse if the AHU is in heating. Changeover shall occur whenever the SA temperature is 3 degrees F different than room temperature.

B. Warm-up Mode: Same as for occupied mode.

C. Unoccupied Mode: Damper shall be full open.

4.06 **MISCELLANEOUS CONTROLS**

A. Fire Alarm System Shutdown:

1. Provide necessary conduit, wiring and accessories to shutdown each unit upon activation of that unit's smoke detectors (Smoke detectors are by Division 16). Connections shall be hardwired, independent of any control system logic, so that failure of control system or loss of control system will in no way prevent the fire alarm shutdown of the system. In addition to shutting down the unit with the alarmed smoke detector, all

equipment interlocked or served by that unit shall be off. Other units shall also shut-off as required to avoid building pressure differentials and similar undesirable effects. Upon reset of alarmed device, system shall automatically return to normal, provide time delay start of equipment to prevent excess load starting at the same time.

2. In addition to the above specified hardwired fire alarm shut-down (which pertains to equipment with smoke detectors), provide the following: Shut-down all air handling equipment when the building fire alarm system goes into alarm. Zone contacts in the fire alarm system are available for this purpose. This added shut-down may be accomplished by use of control logic and is not required to be hardwired but shall be of a fail-safe nature so as to provide the necessary shut-down in case of control failure. Reset shall be same as that specified for hardwired unit smoke-detector shut-down.

B. Water Heater: Shall be controlled by integral thermostat provided with unit. Set for 120 degrees F.

C. Exterior Lighting Control: Provide separate time schedules to allow for control of exterior lighting. Connect to Division 16 provided relays for this purpose at Division 16 lighting panel. See Electrical Drawings for number of zones. Provide control of exterior lights using input from Division 16 provided photocell. System shall provide the following control options: time clock only; photocell only; and time clock and photocell in series control (i.e. time schedule must be “on” and photocell must indicate darkness for lights to be on).

D. Electric Heaters: Shall be controlled by temperature sensor. When space temperature is below heater set point this heater shall be on when temperature exceeds set point, heater should be off.

E. TOC Room AC Unit Switch Over:

1. Manual: Provide ability at COS and in TOC room for Operator to manually shut down TOC Room heat pumps and turn on back-up air conditioning units serving room.

2. Automatic – Routine: Provide automatic operation of the back-up AC units on a two-week schedule (adjustable at COS), with a run time of 8 hours (adjustable at COS).

3. Automatic – High Loop Temperature: When main hydronic return temperature exceeds 85 degrees F (adjustable at COS), deactivate HP system serving room and switch to AC units. AC unit operation shall

remain until main return system temperature drops to 85 degrees F, but shall operate for no less than twelve (12) hours (adjustable at COS).

F. Air Conditioning Units: Units shall operate off thermostat and controls furnished with unit. Connect thermostat (furnished with unit) to indoor section; provide control interconnections from indoor section to outdoor section.

G. See plans for miscellaneous dampers, sensors, and other control items.

H. Conference Room Shut Down: Provide occupancy sensor for conference room, close HP-102 OA damper when room is unoccupied. Occupancy sensor shall comply with Division 16 specifications.

I. Hydronic Loop Reset Valve: 3-way valve shall modulate as follows:

1. If majority of building units are in heating and main R temperature is higher than bore field return temperature, bypass bore field.

2. If majority of building units are in cooling and main R temperature is cooler than bore field return temperature, bypass bore field.

3. If bore field return temperature exceeds temperature range for best efficient operation of heat pumps, bypass bore field to provide a main S temperature that is within a more efficient range. Coordinate setpoints and limits with Engineer.

END OF SECTION

SECTION 15955

AIR AND HYDRONIC BALANCING

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Air Balancing

B. Hydronic Balancing

C. Report

1.02 **RELATED WORK**

A. Section 15010 – Mechanical, General.

B. Section 15140 – Pumps.

C. Section 15410 – Domestic Water Piping System.

D. Section 15745 – Hydronic Heat Pump Water Piping System.

E. Section 15755 – Hydronic Heat Pump Ground Coupled Piping System.

F. Section 15815 – Hydronic Heat Pumps.

G. Section 15820 – Fans.

H. Section 15840 – Ductwork.

I. Section 15860 – Duct Accessories.

J. Section 15870 – Air Outlets and Inlets.

K. Section 15880 – Air Treatment Equipment.

L. Section 15900 – Controls.

M. Section 15995 – Commissioning of Mechanical Systems.

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

1.04 **REFERENCES**

A. Associated Air Balance Council: National Standards for Field Measurements and Instrumentation, Volume 2, No. 12173.

B. ASHRAE: 1981 Handbook of Fundamentals.

C. American Conference of Governmental Hygienists: Industrial Ventilation, A Manual of Recommended Practice, 6th Edition.

1.05 **GENERAL REQUIREMENTS**

A. General: The air and hydronic balancing shall be done by a company which specializes in this type of work and is totally independent and separate from the company or contractor which has installed the systems to be balanced.

B. Prior to beginning balancing, submit the name of the company of Contractor proposes to have to the balancing to the Architect/Engineer for approval.

C. Engineer: The final report of this work shall be stamped by a licensed Mechanical Engineer and accompanied by a statement from this engineer that the work complies with the Associated Air Balance Council Standards and these project specifications.

D. Notify the Architect in writing of all problems or discrepancies between actual conditions and what design documents show as work proceeds.

E. The Balancer shall be directly responsible to the Owner/Engineer and shall perform this work as directed by the Owner/Engineer.

PART 2 – PRODUCTS

2.01 **GENERAL INSTRUMENTATION**

A. Balancing equipment shall comply with Associated Air Balance Council recommendations for field measurement instrumentation.

B. All measuring instruments shall be accurately calibrated and maintained in good working order. Calibration dates and certifications shall be available at Engineer's request.

C. Instruments shall be capable of:

1. Air velocity instruments, direct reading in feet per minute with 2% accuracy.

2. Static pressure instruments, direct reading in inches water gauge with 2% accuracy.

D. Tachometers, direct reading in revolutions per minute with ½% accuracy; or revolution counter accurate with two counts per 1,000.

E. Thermometers, direct reading in degrees Fahrenheit with 1/10 of a degree accuracy.

F. Pressure gauges, direct reading in feet of water or psig with ½% accuracy.

G. Water flow instruments, direct reading in feet of water or psig with ½% accuracy suitable for readout of balancing valve provided.

PART 3 – EXECUTION

3.01 **GENERAL**

A. All air and water systems shall be completely balanced and adjusted to provide the air and water flow rates indicated, and to produce an even heating and cooling effect and control response.

B. Consult and coordinate with the Section 15900 (Controls) Contractor for the adjustment of all control devices to allow for proper system operation.

C. Make final adjustments for flow rates in order to optimize each space's comfort, including such considerations as temperature, drafts, noise, pressurization, and air changes. Where variances are made from design values, state reasons in report (e.g., "too noisy", "too drafty," etc.). All such variances are subject to approval by the Architect/Engineer.

D. All measurements and adjustments shall be in accordance with the Associated Air Balance Council National Standards.

3.02 **AIR BALANCING**

A. Pre-check of System: Prior to beginning balancing, perform, as a minimum, the following:

1. Verify that clean filters have been installed, that system is free from debris, and that all inlets/outlets are not obstructed.

2. Check all fans and equipment to verify that proper start-up and system preparation has been done by the installing contractor.

3. Check all door/window and similar building opening status to insure building is ready and proper pressurization can be obtained.

4. Open all dampers to full flow position, check positions and operation of all motorized dampers to allow full system flows.

5. Review controls and sequences of operation.

B. Tolerances: All air flow rates (supply, return, and exhaust) shall be adjusted to within plus 5 percent and minus 5 percent of the values shown in the contract documents, except that relative space-to-space pressure relationships shall always be maintained (e.g., restrooms shall be negative relative to other areas, general offices shall be positive, etc.).

C. All diffusers, grilles, and registers shall be adjusted to minimize drafts and to eliminate objectionable noise.

D. Air balancing shall be done with new, clean air filters installed. Adjust air deliveries so that design quantities will be obtained when filters are half dirty. This condition shall be simulated by covering a portion of the filter area.

E. Adjust fan speeds and fan drives as required to produce design air quantities.

F. Include one sheave change per air Handling Unit and Exhaust Fan (sheave provided by mechanical contractor).

G. Measurements and adjustments of the air handling and distribution equipment shall be executed in a manner consistent with the manufacturer's recommendation.

H. At completion of balancing mark the final position of all balancing dampers and record all data.

I. Air flow measurements in main ducts shall be made with a duct traverse using a pitot tube and micromanometer. Summation of air terminal outlets and inlets is not sufficient. Quantity of duct leakage shall be indicated.

J. Duct traverses in rectangular duct shall measure the center of equal areas in the air flow stream, with centers not more than 6 inches apart. Round duct traverses shall measure at least 20 locations, with locations being the centers of equal annular area. Reference the ACGIH Industrial Ventilation Manual, Chapter 9, Testing of Ventilation Systems.

K. Balance each branch run so that there is at least one wide open run; balance branches relative to one another so that at least one branch damper is wide open.

L. Requirements for All Air Handling Systems: Data to be measured/recorded and provided in report:

1. Floor plans clearly showing and identifying all diffusers, grilles, O.A. louvers, ducts and all other items where air flow rates were measured.

2. Identify manufacturer, model number, size, and type of all air inlets/outlets.

3. Initial, trial, and final air flow measurements for all diffusers, grilles, O.A. louvers, ducts, and all other items where air flow rates were measured.

4. Design air flow rates and percentage final air flow rates are of design values.

M. The connected voltage and corresponding nameplate full load amps, and the initial and final amperages of all fan motors.

1. Initial and final RPMs of all fans.

2. Static pressures on inlet and outlet of all fans.

3. Fan initial and final CFMs.

4. Outdoor air CFMs (record minimum and maximum values).

5. Entering air temperature (db heating) across coils and fan.

6. Leaving air temperature (db heating) across coils and fan.

7. Static pressure drop across each filter and coil bank.

8. Data required for all equipment which are part of balanced systems:

   a. Equipment name and number (as used on drawings).

   b. Service.

   c. Equipment manufacturer and model numbers.

   d. Sheave and belt sizes (where applicable).

   e. Filters sizes and quantities (where applicable).

   f. Motor manufacturer and complete nameplate data.

   g. Design operating conditions.

   h. Actual operating conditions (flows, pressure drops, rpm, etc.).

N. Quantity of duct leakage shall be indicated. See Paragraph below.

3.03 **DUCT LEAK TESTING**

A. Pre-check of System: Prior to beginning balancing, perform, as a minimum, the following:

1. Verify that all strainers have been cleaned.

2. Examine fluid in system to verity treatment and cleaning.

3. Check for proper rotation and operation of all pumps.

4. Verity that expansion tanks are not air bound and properly charged and that system is full of fluid.

5. Verify that all air vents at high points in the fluid system are properly installed and are operating freely. Remove all air from the circulating system.

6. Open all valves to full flow position, including coil and heater stop valves, close any bypass valves, and open fully balancing valves.

7. Set temperature controls so that automatic valves are open to full flow.

8. Check operation of automatic bypass valves and similar flow/pressure controls.

9. Check and set operating temperature of equipment to design requirements when balancing by temperature drop.

10. Check all equipment for proper start-up and system preparation by installing contractor.

11. Review controls and sequences of operation.

B. Tolerances: All water flow rates shall be adjusted to within plus five percent and minus five percent of the values shown in the contract documents.

C. Domestic Hot Water Recirculation Balance: Provide balance on domestic hot water system to provide even flow distribution. Use only clean instruments on system or perform balance prior to installing contractors sterilizing of system.

D. Adjust control valve bypass valves so that pressure drop is the same for full flow-through bypass valve as for full flow-through control valve and controlled equipment.

E. Set all controls and valves as required to maintain design water and/or air temperatures as shown on the drawings.

F. All adjustments and measurements shall be made in strict accordance with the manufacturer's instructions.

G. Upon completion of flow readings and adjustments, mark all settings and record all data. Permanently mark balanced position of all balancing valves. Stamp indicator plate of balancing valves without memory stop.

H. Requirements for All Hydronic Systems: Data to be measured/recorded and provided in report:

1. Floor plans or schematics showing and identifying all valves, coils, pumps and other items where temperatures, pressure drops, or water flow rate were measured.

2. Identify manufacturer, model number, size and type for all balancing devices.

3. Initial, trial, and final water flow measurements (pressure drops, temperatures, and GPMs) for all items where measurements were made.

4. Design water flow rates, and percentage final water flow are of design values.

5. The connected voltage and corresponding nameplate full load amps, and the initial and final amperages of all pump motors.

6. Pump operating suction and discharge pressures and final total developed head.

7. Pump initial and final GPMs.

8. Entering and leaving fluid temperatures at coils and major equipment.

9. GPM flow of each coil and major equipment.

10. Pressure drop across each coil and major equipment.

11. Pressure drop across bypass valve.

12. Final position of all valves (percent open or setting position on valve).

13. Data required for all equipment which are part of balanced systems:

    a. Equipment name and number (as used on drawings).

    b. Service.

    c. Equipment manufacturers and model number.

    d. Equipment capacities.

    e. Motor manufacturer and complete nameplate data.

    f. Design operating conditions.

    g. Actual operating conditions (flows, pressure drops, etc.).

3.04 **BALANCING REPORT**

A. General: A balancing report shall be submitted as specified herein, documenting all balancing procedures and measurements.

B. Preliminary Report: Two (2) preliminary review copies of the balancing report shall be submitted to the Architect/Engineer when the balancing work is 90% complete (or as near 90% complete as possible due to uncompleted work of other trades). In addition to containing all the information required of the final report, the preliminary report shall contain a list of all the work required of other trades in order to allow the balancing work to be completed. The Architect/Engineer will review the preliminary report and inform the Contractor of any additional items or revisions required for the final report. Preliminary reports may be omitted where the Architect/Engineer grants approval.

C. Final Report: Shall be included in the Operation and Maintenance Manual. Submit reports to Contractor for inclusion in Manuals (or, when manuals have been already sent to Engineer, send report to Engineer who will insert report into Manual). Provide number of reports as required to match quantity of O&M Manuals, but in no case less than five (5).

D. Report Organization: The report shall be divided into logical sections consistent with the building or system layout (i.e. by floors, building wings, air handling units, or other convenient way). Tabulate data separately for each system. Describe balancing method used for each system.

E. Format: 8-1/2" x 11" size, neat, clean copies, drawings accordion folded. Report shall be typed, shall have a title page, table of contents, and divider sheets with identification tabs between sections. Information shall be placed in a three ring binder, with the front cover labeled with the name of the Job, Owner, Architect/Engineer, Balancing Contractor, and Report Date.

F. General Balancing Information Required:

1. At the beginning of the report, include a summary of problems encountered, deviations from design, remaining problems, recommendations, and comments.

2. List of instruments used in making the measurements and instrument calibration data.

3. Names of personnel performing measurements.

4. Explanation of procedures used in making measurements and balancing each system.

a. List of all correction factors used for all diffusers, grilles, valves, venture meters, and any other correction factors used.

5. Areas where difficulties were encountered in obtaining design flow rates, or where unstable operating conditions may exist.

6. Note any parts of the system where objectionable drafts or noises may be present and efforts made to eliminate same and why they may still be present.

Note where variances from design values occur; explain why.

G. Air Balancing Information: All previously cited required measurement/recorded data, any additional recorded data, and observations.

H. Hydronic Balancing Information: All previously cited required measurement/recorded data, any additional recorded data, and observations.

END OF SECTION

SECTION 15960

INDOOR AIR QUALITY ASSURANCE

PART 1 – GENERAL

1.01 **WORK INCLUDED**

A. Building Outdoor Air Flush Out

B. Documentation

1.02 **RELATED WORK**

A. Division 1 – General Requirements

B. Division 15 – Mechanical

1.03 **SUSTAINABLE BUILDING REQUIREMENTS**

See Section 01011 for sustainable building requirements affecting the Work of this Section.

PART 2 – PRODUCTS

NOT USED

PART 3 – EXECUTION

3.01 **GENERAL**

A. Coordinate with the overall project schedule to insure that the initial building flush out occurs prior to substantial completion.

B. Adjust all outdoor air dampers, return air dampers, exhaust air dampers, fans, controls, system components, and building features (doors, door openers, windows, vents, etc.) so as to allow the use of 100% outdoor air without causing harmful pressure gradients, damage due to low or high temperatures, damage due to rate of change of temperature/pressures, or other similar problems in the building. If the outdoor air temperature is such that freezing of coils or other

item is possible, adjust the outdoor air dampers to increase temperatures to prevent such problems. Coordinate such concerns and revisions with the Architect/Engineer. Heating and cooling systems shall be operable during flush out periods.

3.02 **FLUSH OUT PERIODS**

A. Initial Building Flush Out: Prior to any furniture being placed in the building, but after completion of all interior construction finishes (trim, carpeting, painting, etc.) operate the building's HVAC systems on 100% outdoor air for a period of seven (7) days to completely flush the building's air. Systems shall operate 24 hours/day, with thermostats set to maintain space temperatures between 60 and 80 degrees F. Promptly change out all system filters after this flush out period, and reset all adjusted items for normal operation.

B. Final Building Flush Out: After all furniture has been installed (unpacked and located), operate the building's HVAC systems on 100% outdoor air for an additional period of seven (7) days. Systems shall operate sixteen (16) hours/day (evening to morning hours), with thermostats set to maintain space temperatures between 60 and 80 degrees F. Adjust system for normal, specified operation for eight (8) hours (normal, daytime, occupied hours). Promptly change out all system filters after this flush out period, and reset all adjusted items for normal operation.

3.03 **DOCUMENTATION**

A. Provide written records documenting the dates and times when the flush out periods occurred, equipment that was operated, any significant system adjustments made to allow the flush out, general weather conditions and indoor conditions observed during the flush out periods. Provide a signed copy (by the individual responsible for overseeing the Project with the General Contractor) of such documentation to the Architect/Engineer, Owner, and a copy in the O&M Manual.

END OF SECTION

SECTION 15995

COMMISSIONING: MECHANICAL SYSTEMS

PART 1 – GENERAL

1.01 **SUMMARY**

A. Section Includes:

1. System specific commissioning procedures

B. Related Sections:

1. The following sections specify commissioning activities for this project:

01810 – Commissioning General Requirements

2. Selected systems in the following sections are included in the commissioning scope and these sections contain start-up, testing and/or commissioning related activities:

15010 Mechanical, General
15015 Mechanical Operation and Maintenance Manuals
15050 Excavation, Trenching and Backfill for Mechanical Underground Utilities
15060 Pipe and Pipe Fittings
15080 Piping Specialties
15090 Hangers and Supports
15140 Pumps
15200 Vibration and Seismic Control
15250 Insulation
15410 Domestic Water Piping System
15745 Hydronic Heat Pump Water Piping System
15755 Hydronic Heat Pump Ground Coupled Piping System
15760 Electric Heaters
15815 Hydronic Heat Pumps
15820 Fans
15830 Air Conditioning and Refrigeration System
15840 Ductwork
15860 Duct Accessories
15870 Air Outlets and Inlets

15880 Air Filtering Equipment
15900 Controls
15955 Air and Hydronic Balancing
15960 Indoor Air Quality Assurance

1.02 **DESCRIPTION OF WORK**

A. Work includes the completion and documentation of formal commissioning procedures by the Contractor on selected equipment and systems as outlined in the sections listed under 1.1 B. Commissioning is defined as the process of verifying and documenting that the installation and performance of selected building systems meet the specified design criteria and therefore satisfies the design intent and the Owner's operational needs. The Contractor shall be responsible for participation in the commissioning process as outlined herein, and in subsequent sectional references and attachments throughout the project documents. Commissioning procedures shall be designed and conducted under the direction of the Commissioning Authority (CA) and coordinated by the Commissioning Coordinator (CC).

B. This Section contains the system specific commissioning requirements for the systems referenced herein.

PART 2 – PRODUCTS

2.01 **DOCUMENTATION**

A. Documentation requirements for the systems to be commissioned are specified in Section 01810, Part 2 – Products.

PART 3 – EXECUTION

3.01 **EXECUTION**

A. Execution of the commissioning process for the systems to be commissioned is specified in Section 01810, Part 3 – Execution.

SCHEDULE A – Systems Readiness Checklists and Document Tracking

System Readiness Checklists (SRC) are included in this Schedule. The Contractor responsible for delivery of each of these systems shall be responsible for completion of the SRC. The SRCs included within this Schedule are Preliminary versions and are representative of what will be included in the final Commissioning Plan. The Contractor is responsible to demonstrate the proper operation of all installed systems and the final SRC's may contain additional requirements to document these demonstrations. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents.

The following Table – A identifies the SRCs that are included within this Schedule. Listed as subcategories below each system are the documents that will be required to be submitted as a part of the system start-up activities. This documentation includes installation, start-up, static tests, pressure test, cleaning, flushing, disinfecting, certifications and other miscellaneous checklists. This table shall be used as a document tracking mechanism by the CA and CC for the process of submittal, review and approval of installation and start-up documents and SRCs. The table shall be included in the start-up plan.

Table – A: System Summary and Documentation Tracking

A	B	C	D	E	F	G
System Description Documents Req'd	Responsible Contractor	Proposed Document Received	OK	Completed Document Received	OK	Notes
Domestic Hot Water Heater						
Manufacturer Start-Up Documentation						
System Readiness Checklist		CA Provided				
Domestic Hot Water Pumps						
Manufacturer Start-Up Documentation						
System Readiness Checklist		CA Provided				
Hydronic Piping Systems						
Pressure Testing						
Cleaning Plan						
Hydronic Piping Cleaning Certificate		CA Provided				
Hydronic Piping Charged with Inhibitor & Glycol		CA Provided				
Manufacturer Start-Up Documentation						
System Readiness Checklist		CA Provided				
HVAC Pumps						
Voltage and Phase Verification						
Manufacturer Start-Up Documentation						

System Readiness Checklist		CA Provided				
Glycol Feed System						
Voltage and Phase Verification						
Manufacturer Start-Up Documentation						
System Readiness Checklist		CA Provided				
Hydronic Heat Pumps (HP)						
Manufacturer Start-Up Documentation						
System Readiness Checklist		CA Provided				
Exhaust Fans						
Manufacturer Start-Up Documentation						
System Readiness Checklist		CA Provided				
Electric Heaters						
Manufacturer Start-Up Documentation						
System Readiness Checklist		CA Provided				
Ductwork Systems						
Ductwork Pressure Test						
Fire Damper Testing						
Manufacturer Start-Up Documentation						

System Readiness Checklist		CA Provided				
Temperature Control Systems						
Graphical Interface Plan						
Point Schedule						
System Wiring and Point to Point Diagrams						
Floor Plan of Control and Monitoring Equipment						
Point to Point and Sensor Calibration Verification		CA Provided				
Manufacturer Start-Up Documentation						
System Readiness Checklist		CA Provided				
Testing, Adjusting and Balancing						
TAB Agenda						
TAB Meeting Minutes						
Preliminary TAB Report						
System Readiness Checklist		CA Provided				
Building Flush Out						
Flush Out Check Sheet		CA Provided				

Key:

A. System description for each system commissioned. A System Readiness Checklist is included for each commissioned system. The subcategories include required documentation to be submitted with the SRC.

B. Contractor responsible for installation, startup, testing and submittal of documents for commissioned system. To be filled in after contract award.

C. Date the proposed documents are received by the CA from the responsible Contractor. NOTE: These documents shall include, but are not limited to, procedures and forms to include such activities as: manufacturer's installation and start-up, pressure testing, TAB, cleaning, flushing and disinfection. The SRC is provided by the CA.

D. Indicates that CA has received and approved proposed installation and start-up documentation.

E. Date the completed documents are received by the CA from the responsible Contractor.

F. Indicates that CA has received and approved completed documentation.

G. Notes on status of forms, irregularities and rework needed.

Domestic Hot Water Heaters – Electric
System Readiness Checklist (Preliminary Version)

Installation:

- ☐ Manufacturer's required maintenance clearance provided.
- ☐ Equipment and systems are labeled per project documents.
- ☐ Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.
- ☐ Associated piping, shutoff valves, control valves and insulation are complete.
- ☐ Expansion tank installed and has been checked for proper charge.
- ☐ All gauges and thermometers are installed per project documents.
- ☐ Unit disconnect within sight of unit, power available to unit, overload protection appropriate, disconnect labeled.
- ☐ External controls installed.

Start-Up:

- ☐ Commissioning Authority notified for witness of start-up.
- ☐ Internal controls and safeties verified operational.
- ☐ External controls verified operational.
- ☐ Operating parameters measured and recorded.

Readiness:

- ☐ Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.
- ☐ Damaged factory finishes have been replaced, repaired or touched up.
- ☐ Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- ☐ Area and equipment have been cleaned, construction debris removed.
- ☐ All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

NOTE: This checklist is not intended to represent all the requirements of the Project Documents within this Section. Completion of the items on this checklist does not release Contractor from the contractual obligation to complete all the work as detailed within the entire Specification Section.

Sign-Off:

Team Member	Print Name/Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Domestic Hot Water Pumps
System Readiness Checklist (Preliminary Version)

Installation:

- ☐ Manufacturer's required maintenance clearance provided.
- ☐ Equipment and systems are labeled per project documents.
- ☐ Pumps mounted per project documents.
- ☐ Associated piping, shutoff valves, control valves and insulation are complete.
- ☐ All balancing and check valves, gauges and thermometers are installed per project documents.
- ☐ Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.
- ☐ External controls installed.
- ☐ All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency.

Start-Up:

- ☐ Commissioning Authority has been notified for witness of start-up.
- ☐ Voltage and phase has been verified.
- ☐ Pumps have been properly adjusted and aligned.
- ☐ Motor operation and rotation verified
- ☐ Pumps have been lubricated.
- ☐ Pumps have been aligned.
- ☐ Internal controls and safeties verified operational.
- ☐ External controls verified operational.
- ☐ Operating parameters measured and recorded.

Readiness:

- ☐ Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.
- ☐ Damaged factory finishes have been replaced, repaired or touched up.
- ☐ Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- ☐ Area and equipment have been cleaned, construction debris removed.
- ☐ All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

NOTE: This checklist is not intended to represent all the requirements of the Project Documents within this Section. Completion of these items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire Specification Section.

Sign-Off:

Team Member	Print Name/Co.	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Hydronic Piping and Appurtenances
System Readiness Checklist (Preliminary Version)

Installation:

- ☐ Manufacturer's required maintenance clearance provided for all components.
- ☐ Equipment and systems are labeled per project documents.
- ☐ Piping installed with slope to drain.
- ☐ Hose end drain valves installed at all low points.
- ☐ Air vents with valves installed at all high points of the hot water systems.
- ☐ Automatic air vents piping installed for drainage to nearest drain.
- ☐ Unions installed on all equipment requiring disconnects for servicing.
- ☐ Dielectric unions installed on all dissimilar materials per specifications.
- ☐ Expansion joints and loops are installed as needed and per manufacturer's recommendations.
- ☐ Pressure and temperature gauges installed at all specified points.
- ☐ Pressure and temperature gauge ranges per specifications.
- ☐ P/T ports installed at locations specified.
- ☐ Relief valves installed on all pressure vessels as specified.
- ☐ Strainers installed at all specified locations including blow-off valve and cap.
- ☐ Air separators, expansion tanks and suction diffusers installed.
- ☐ Water treatment system installed per project documents.
- ☐ Heat trace installed where specified.
- ☐ Valves provided and installed per specification in regards to connection style and size.
- ☐ Valves installed for area and group isolation, maintenance isolation and service disconnects.
- ☐ Valves installed with stems oriented up.
- ☐ Control valves installed and wired to control system.
- ☐ All specified equipment, piping, valves, pump bodies, drains; unions are insulated per specification – removable insulation installed as specified.
- ☐ All valves tagged with number and function, valve index posted.
- ☐ Pipes across traffic areas provided with protection.
- ☐ Piping is shielded to prevent water leakage above electrical equipment/panels.
- ☐ Mechanical supporting devices installed at specified locations and spacing.

Start-Up:

- ☐ Commissioning Authority notified for witness of start-up (cleaning, flushing, etc.).
- ☐ Expansion tank pressures have been checked and set per engineer's guidance.
- ☐ Water pipe pressure tested and accepted. Attach reports.
- ☐ Water piping flushed and cleaned and chemically treated per specifications and accepted. Attach reports.
- ☐ Strainers cleaned per specification procedure prior to balancing.

- ☐ Water chemical treatment complete, treatment system operational, attach treatment report.
- ☐ Control valves verified operational.

Hydronic Piping and Appurtenances
System Readiness Checklist (Preliminary Version) – Continued

Readiness:

- ☐ Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.
- ☐ Damaged factory finishes have been replaced, repaired or touched up.
- ☐ Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- ☐ Area and equipment have been cleaned, construction debris removed.
- ☐ All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

NOTE: This checklist is not intended to represent all the requirements of the Project Documents within this Section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire Specification Section.

Sign-Off:

Team Member	Print Name/Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Hydronic System Test, Flush & Clean Logs

Piping System Test and Flush Log

Instructions: Listed below are systems requiring pressure testing and flushing per the Specification. The responsible contractor for each system is to date and sign when each activity is completed.

Project team to be notified 3 days prior to flushing/charging to allow for scheduling of witnessing of activities.

System	Date	Activity–Test/Flush	Executing Contractor	Contractor	Witness
		HYDRONIC SYSTEM			
Heating Water		Pressure Test			
Heating Water		System flush and cleaned per spec 15545			
		1st flush			
		AHU valves open for 1st flush			
		2nd flush with cleaning solution – 4 hour minimum			
		AHU valves open for 2nd flush			
		3rd flush – blow down strainers – 1 hour minimum			
		AHU valves open for 3rd flush			
		Prior to inhibitor charging of system blow-down all strainers, dead legs and system low points.			
Heating Water		System charged to required levels and circulated / valves open to AHU Test report attached.			

NOTE: All flushing and system charging activities to be executed with all AHU and AHU heating/cooling/control valves OPEN.

HVAC Pumps
System Readiness Checklist (Preliminary Version)

Installation:

- ☐ Manufacturer's required maintenance clearance provided.
- ☐ Equipment and systems are labeled per project documents.
- ☐ Pumps installed, leveled, grouted and plumbed.
- ☐ Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.
- ☐ Associated piping, shutoff valves, control valves and insulation are complete.
- ☐ All balancing and check valves, gauges and thermometers are installed per project documents.
- ☐ Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.
- ☐ External controls installed.
- ☐ All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency.

Start-Up:

- ☐ Commissioning Authority notified for witness of start-up.
- ☐ Voltage and phase has been verified.
- ☐ Pumps have been properly adjusted and aligned.
- ☐ Pumps have been lubricated.
- ☐ Motor operation and rotation verified.
- ☐ Internal controls and safeties verified operational.
- ☐ External controls verified operational.

Readiness:

- ☐ Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.
- ☐ Damaged factory finishes have been replaced, repaired or touched up.
- ☐ Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- ☐ Area and equipment have been cleaned, construction debris removed.
- ☐ All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

NOTE: This checklist is not intended to represent all the requirements of the Project Documents within this Section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire Specification Section.

Sign-Off:

Team Member	Print Name / Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Glycol Feed System
System Readiness Checklist (Preliminary Version)

Installation:

- ☐ Manufacturer's required maintenance clearance provided.
- ☐ Equipment is labeled per project documents.
- ☐ Pumps installed, leveled, plumbed.
- ☐ Tank properly installed.
- ☐ Pressure switch properly installed.
- ☐ Low level Alarm properly installed.
- ☐ Associated piping, shutoff valves, control valves and insulation are complete.
- ☐ All balancing and check valves, and gauges and installed per project documents.
- ☐ Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.
- ☐ External controls installed.
- ☐ All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency.

Start-Up:

- ☐ Commissioning Authority notified for witness of start-up.
- ☐ Voltage and phase has been verified.
- ☐ Pump has been lubricated.
- ☐ Motor operation verified.
- ☐ Tank is filled with glycol solution.
- ☐ Pressure switch verified operational.
- ☐ External controls verified operational.

Readiness:

- ☐ Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.
- ☐ Damaged factory finishes have been replaced, repaired or touched up.
- ☐ Area and equipment have been cleaned, construction debris removed.
- ☐ All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

NOTE: This checklist is not intended to represent all the requirements of the Project Documents within this Section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire Specification Section.

Sign-Off:

Team Member	Print Name / Company	Initial	Date

Installing Contractor:			
GC Cx Coordinator:			

Heat Pump, Water Source
System Readiness Checklist (Preliminary Version)

Installation:

- ☐ Manufacturer's required maintenance clearance provided.
- ☐ Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.
- ☐ Inspection and access doors are operable and free from obstruction.
- ☐ Condensate drain with P-trap and cleanout is installed and unobstructed.
- ☐ Associated piping, solenoid valve, shutoff valves, and insulation are complete.
- ☐ Dampers and actuators installed and verified operational.
- ☐ Temporary filters have been removed, new installed, spares provided.
- ☐ Ductwork is complete including access to all serviceable components.
- ☐ Plenum and casings have been cleaned.
- ☐ Unit has been lubricated.
- ☐ Belts and/or couplings have been properly adjusted.
- ☐ Coil fins have been combed out if necessary.
- ☐ Disconnect within sight of unit and labeled, power active, overload protection appropriate.
- ☐ External controls installed.
- ☐ Internal controls and safeties installed.
- ☐ All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency.

Start-Up:

- ☐ Commissioning Authority notified for witness of start-up.
- ☐ Voltage and phase has been verified.
- ☐ Motor operation and rotation verified.
- ☐ Belts and/or couplings have been properly adjusted.
- ☐ Unit has been lubricated.
- ☐ Heating/Cooling operation and damper operation verified.
- ☐ Internal controls and safeties verified operational.
- ☐ External controls verified operational.

Readiness:

- ☐ Manufacturer's installation and start-up procedures were followed. Attach completed checklists.
- ☐ Damaged factory finishes have been replaced, repaired or touched up.
- ☐ Equipment and systems are labeled per project documents.
- ☐ Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- ☐ All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

NOTE: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire Specification Section.

Sign-Off:

Team Member	Print Name / Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Exhaust Fans
System Readiness Checklist (Preliminary Version)

Installation:

- ☐ Manufacturer's required maintenance clearance provided.
- ☐ Equipment and systems are labeled per project documents.
- ☐ Unit mounted per project documents.
- ☐ Vibration isolation devices installed, adjusted and free to float, shipping blocks removed.
- ☐ Inspection and access doors are operable.
- ☐ Curb mounted fans are bolted to the curb and sealed per project documents.
- ☐ Back draft damper installed and verified operational.
- ☐ Speed controllers installed as needed for balancing.
- ☐ Ductwork is complete including access to all serviceable components.
- ☐ Plenum and casings have been cleaned.
- ☐ Unit disconnect within sight of unit, power available to unit, overload protection appropriate and disconnect labeled.
- ☐ External controls installed.
- ☐ All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency.

Start-Up:

- ☐ Commissioning Authority notified for witness of start-up.
- ☐ Motor operation and rotation verified.
- ☐ Unit has been lubricated.
- ☐ Belts and/or couplings have been properly adjusted.
- ☐ Internal controls and safeties verified operational.
- ☐ External controls verified operational.

Readiness:

- ☐ Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.
- ☐ Damaged factory finishes have been replaced, repaired or touched up.
- ☐ Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- ☐ Area and equipment have been cleaned, construction debris removed.
- ☐ All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

NOTE: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire Specification Section.

Sign-Off:

Team Member	Print Name / Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Electric Heaters
System Readiness Checklist (Preliminary Version)

Installation:

- ☐ Manufacturer's required maintenance clearance provided.
- ☐ Equipment labeled with equipment number.
- ☐ Inspection and access doors are operable and free from obstruction.
- ☐ Plenum and casings have been cleaned.
- ☐ Disconnect within sight of unit and labeled, power active, overload protection appropriate.
- ☐ External controls installed.
- ☐ All motors meet or exceed the specified Minimum Nominal Full-Load Efficiency.

Start-Up:

- ☐ Commissioning Authority notified for witness of start-up.
- ☐ Motor operation and rotation verified.
- ☐ Internal controls and safeties verified operational.
- ☐ External controls verified operational.

Readiness:

- ☐ Manufacturer's installation procedures were followed.
- ☐ Manufacturer's installation and start-up procedures were followed. Attach completed checklists.
- ☐ Damaged factory finishes have been replaced, repaired or touched up.
- ☐ Equipment and systems are labeled per project documents.
- ☐ Equipment not painted at factory has been painted with a finish coat of paint (no primer).
- ☐ All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

NOTE: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire Specification Section.

Sign-Off:

Team Member	Print Name / Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Temperature Control
System Readiness Checklist (Preliminary Version)

Installation:

- ☐ Manufacturer's required maintenance clearance provided for all components
- ☐ All control devices (actuators, sensors, etc.) have been provided per the Project Documents.
- ☐ Outdoor air sensor located to minimize external influences of heat or cool.
- ☐ All sensors located per contract documents.
- ☐ Control wire installed neatly in cable trays, D-rings, conduit, cable tied or plenum rated per Project Documents.
- ☐ Control wiring, panels and all system components are permanently labeled, including point address designation, system reference and descriptions.
- ☐ Front end computer and peripherals provided per project document specifications.
- ☐ Printer provided per project document specifications.
- ☐ Surge protection and battery back-up devices installed per project documents.
- ☐ External communication connected.

Start-Up:

- ☐ Commissioning Authority notified for witness of start-up.
- ☐ System graphics are complete per graphical interface plan (showing all devices controlled, all adjustable points shown, al specified components), accurate (reflects actual field/unit installation, end-to-end verification of points done) and functional.
- ☐ Point to point testing and sensor calibration is complete and checkout forms complete with copy submitted.
- ☐ Room temperature and other set points configured per Project Documents and Owner's direction.
- ☐ Operating schedules have been set up per Project Documents or Owner's direction.
- ☐ Alarms have been programmed per Project Documents and Owner's direction.
- ☐ Access Security levels have been set up per Project Documents and Owner's needs.
- ☐ Trend logs have been set up per Project Documents and/or as directed by the CA.
- ☐ Minimum OA%, from balancer, provided on graphics as permanent reference value.

Network connection is complete, the central operator terminal has been updated and remote monitoring of the system has been tested.

Temperature Control
System Readiness Checklist (Continued)

Readiness:

- ☐ Manufacturer's installation and start-up procedures were followed. Attach completed and signed copy of all manufacturers' checklists.
- ☐ Damaged factory finishes have been replaced, repaired or touched up.
- ☐ Equipment not painted at factory has been painted with finish coat of paint (no primer).
- ☐ Area and equipment have been cleaned, construction debris removed.
- ☐ All known issues have been corrected or reported to the CA and the systems are ready for the functional performance test phase of commissioning.

NOTE: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire Specification Section.

Sign-Off:

Team Member	Print Name / Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Building Automation System Point-to-Point Verification Data Sheet

Unit	Point Description	Type	BAS	FV	BAS	FV	Ref	BAS	FV	BAS	FV	BAS	FV	BAS	FV	BAS	FV	BAS	FV	BAS	FV	Note

BAS = Building Automation System
FV = Field Verify or Measure
Cal # = Discrete Calibration Point
Ref = Reference standard used to measure

Project:_____ Date:_____

By:_____ Ref:_____

Notes:_____

Testing, Adjusting, and Balancing
System Readiness Checklist (Preliminary Version)

Installation:

- ☐ HVAC related System Readiness Checks completed regarding all installation activities.

Start-Up:

- ☐ HVAC related System Readiness Checks completed regarding all start-up activities.
- ☐ Balancing agenda provided to engineer. Provide copy to CA for review.
- ☐ Pre-balance conference complete.

System Readiness:

- ☐ HVAC equipment operation verified.
- ☐ Construction filters removed, clean filters installed, damper position and operation checked prior to balancing. Air balance due with filters simulated as ½ dirty.
- ☐ Bathrooms are negative relative to other areas.
- ☐ Rooms' pressures are positive while allowing for door closure in economizer mode.
- ☐ Overall building pressure checked with outside air at 100% to assure adequate relief.
- ☐ Relief damper operation has been checked to assure dampers open and close as needed.
- ☐ Air balanced prior to water balance.
- ☐ Hydronic system and strainers has been cleaned and treated prior to balancing.
- ☐ Expansion tanks are properly pressurized and not water logged.
- ☐ Air vents installed and operational, water system balanced with no air in system.
- ☐ Noise and vibration has been checked and adjusted as necessary.
- ☐ Final damper and speed controller permanently marked for final balancing positions.
- ☐ All systems balanced to specified design criteria except as approved by mechanical engineer.
- ☐ Preliminary report has been provided on approved forms with data specified.
- ☐ List of control minimum OA damper positions in report and provided to controls contractor.
- ☐ All defects/deficiencies have been noted to CA/engineer during testing, included in report.
- ☐ All TAB procedures are complete and ready for the system balance demonstration. The TAB contractor will demonstrate proper balance by measuring and verifying a percentage of the systems as selected and witnessed by the Commissioning Authority.

NOTE: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire Specification Section.

Sign-Off:

Team Member	Print Name / Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Building Flush Period Checklist

Building Area	A	B	C	Start Date/Time	Stop Date/Time	Sign Off

A. Fans set to run 24/7
B. Dampers set at 100% for 24/7
C. _____

Comments:

NOTE: This checklist is not intended to represent all contract requirements. The contractor is responsible for completion of all work as defined in the project documents within the entire Specification Section.

Sign-Off:

Team Member	Print Name / Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

SCHEDULE B – Functional Performance Tests

Functional Performance Tests

1. The preliminary versions of the Functional Performance Test and Verification Outline sheets contained in this Schedule define the individual systems to be tested and Contractor responsibilities based on the specific method of commissioning. These preliminary Functional Performance Test and Verification Outline sheets represent information available at the time of commissioning specification development. The final versions may be somewhat different and will be included within the Commissioning Plan as presented at the initial commissioning coordination meeting.

2. The methods of functional performance test and verification are listed in Table 1 of this Schedule. The Contractor will be responsible for supporting the testing activity as indicated. This may include developing the test plan and functional performance test forms for approval by the Commissioning Authority, performing testing to be witnessed by the CA or providing support during functional performance testing conducted by the CA or their sub-Authority.

3. Contract documents state that the Contractor is responsible to demonstrate that all systems comply with contract requirements and meet the project design intent. The scope of testing outlined in the following Functional Performance Test and Verification Outline sheets in this Schedule represent the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all system comply with the design intent. If systems fail the initial tests additional testing may be required.

4. The following Test Summary Table identifies the functional tests that will be conducted on this project. This table will be used as a document tracking mechanism for the process of submittal and review of contractor provided testing documentation.

5. The contractor is responsible for submitting proposed functional test documentation to the Commissioning Authority for review and approval at least one month prior to these activities. It is the Contractor's responsibility to notify the Commissioning Authority in advance of the scheduled activity, testing or startup date. A minimum of five (5) working days advance notification is required. If the CA is not notified in advance of a scheduled start-up or testing activity, the start-up or testing shall be rescheduled and repeated to the satisfaction of the CA.

6. The “Responsible Contractor” column of the table will be completed during the Initial Commissioning Coordination Meeting by assigning an individual Contractor responsible for the activities associated with each system based on what contractor provided that system.

Table – B: Functional Test Summary Table

A	B	C	D	E	F	G
System Description	**Responsible Contractor**	**Proposed Test Forms Received**	**OK**	**Testing Complete**	**OK**	**Notes**
Domestic Hot Water						
Hydronic Piping System						
Hydronic Heat Pumps						
Exhaust Fans						
Electric Heaters						
Split System AC						
Air Distribution System						
Temperature Control System						
Balancing Air and Water						

Summary Table Key:

A. System description for each system commissioned.

B. Contractor responsible for providing testing. To be filled in after contract award.

C. Date the proposed test forms are received by the CA from the responsible Contractor (if applicable).

D. Indicates that CA has received and approved the proposed test forms.

E. Date(s) testing was performed by contractor.

F. Indicates that Commissioning Coordinator has witnessed and approved the testing and received all completed test forms.

G. Notes on status of forms, irregularities and rework needed.

Table 1 – Functional Test and Verification Methods

Test Method A – Contractor Written and Conducted with CA Oversight

The test plan and test data sheets are developed by the contractor responsible for the system and submitted to the CA for approval. These can be the system manufacturer's stock test forms if appropriate. The CA will assist contractor in development of test forms if requested to do so. After the CA has approved the test plan and data sheets, the contractor will conduct the tests per the plan, document results and submit completed test forms to the CA.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the test during contractor testing.

2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.

3. The contractor will be required to duplicate some of the testing by demonstrating a percentage of the system as selected and witnessed by the CA.

If inconsistencies are found to exceed the stated failure rate, the contractor will be asked to correct the problems and re-conduct the entire functional test and verification.

Test Method B – CA Written and Conducted, Contractor Supports

The test plan and test data sheets are developed by the CA. After the CA has received the pre-functional checklists and other start-up documentation, the CA will conduct the tests per the plan, document results and notify contractor of any issues found. The contractor will support the CA during testing, including but not limited to: scheduling, sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control system both on-site and via remote dial-up.

Test Method C – CA Written, Contractor Conducts

The test plan and test data sheets are developed by the CA. The CA will turn over the test plan and test data sheets to the contractor. After the CA has received the pre-functional checklists and start-up documentation, the contractor will conduct the tests on all or a sample portion of the systems as directed by the CA. The contractor will support the CA du4ring testing, including but not limited to: scheduling and sequencing and adequate time for CA testing, on-site support during testing, testing instruments and equipment, setting up trend logs, providing access to equipment (including lifts), providing access to control systems both on-site and via remote dial-up.

The CA will do one or a combination of the following to verify testing:

1. The CA will witness all or portions of the tests during contractor testing.

2. The CA will re-conduct the functional tests on all or portions of the systems using the same test plan and data sheets.

Domestic Hot Water Systems
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all system comply with the design intent. Table 1 in Appendix – B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	100%

Functional Tests:

1. Water Heaters and Hot Water Boilers

    A. Demonstrate and document operation of all features

    B. Simulate alarm conditions and demonstrate and document all safeties and alarm reporting

    C. Demonstrate and document temperature control

    D. Demonstrate and document building control system Interface

    E. Demonstrate and document circulation pump and aqua-stat operation

Hydronic Piping Systems
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule – B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample or Witness
C.1	CA	Contractor	N/A	100%

Functional Tests:

1. Pumps
    A. Pump performance, demonstrate at least on point on the pump curve
    B. Verify motor operation and parameters
    C. Demonstrate hand/off/auto operation
    D. Demonstrate lead/lad operation
2. Valves
    A. Demonstrate control valve operation and indication
    B. Measure and confirm water flow
3. Appurtenances
    A. Demonstrate proper expansion tank charge
    B. Demonstrate proper glycol feed system operation
    C. Demonstrate operation of chemical treatment system
    D. Demonstrate proper glycol levels at 25% of the coils by sampling water at the coils

Hydronic Heat Pumps
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Appendix – B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample Or Witness
C.1	CA	Contractor	N/A	Up to 50%

Functional Tests:

1. Unit Operation

    A. Demonstrate operation of all features and functions

    B. Simulate all alarm conditions and demonstrate all safeties and alarm reporting.

    C. Demonstrate freeze protection mode in hand and auto

    D. Demonstrate smoke detector shutdown in hand and auto

    E. Demonstrate fan HOA functions

    F. Demonstrate temperature control

    G. Demonstrate BCS Interface

Exhaust Fans
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule – B details the various methods of accomplishing functional testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample Or Witness
C.1	CA	Contractor	N/A	100%

Functional Tests:

1. Exhaust fans

    A. Demonstrate operation of all features

    B. Demonstrate on/off control and any interlocks

    C. Demonstrate building control system Interface

Split System AC Units
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule – B details the various methods of accomplishing functional testing.

Preliminary Activities

The contractor will be responsible for marking the motorized smoke control damper shaft ends with the damper blade orientation and providing access (ladders, lifts, etc.) to the motorized dampers during testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample Or Witness
C.1	CA	Contractor	N/A	100%

Functional Tests:

1. Operation of all features
2. Cooling
3. Temperature Control
4. Scheduling
5. Alarms
6. Condensate pump and/or drain

Electric Heaters
Functional Test and Verification Outline

The testing outlined below represents the minimum expected level of testing to be performed during commissioning. The contractor shall be required to conduct and document any tests as necessary to prove all systems comply with the design intent. Table 1 in Schedule – B details the various methods of accomplishing functional testing.

Preliminary Activities

The contractor will be responsible for marking the motorized smoke control damper shaft ends with the damper blade orientation and providing access (ladders, lifts, etc.) to the motorized dampers during testing.

Testing:

Test Method	Plan & Data Sheets By:	Conducted By:	Demonstration Percentage	CA Will Sample Or Witness
C.1	CA	Contractor	N/A	100%

Functional Tests:

1. Unit Operation

    A. Demonstrate operation of all features and functions

    B. Simulate alarm conditions and demonstrate all safeties and alarm reporting

    C. Demonstrate temperature control

    D. Demonstrate BCS Interface

Schedule C – Project Closeout

Contractor Project Closeout Checklists are included in this Schedule. The Contractor responsible for the delivery of each of the listed systems shall be responsible for completion of a Project Closeout Checklist for that system. The checklists included within this Schedule are preliminary versions and are only representative of what shall be included in the final Commissioning Plan. The Contractor is responsible to demonstrate compliance with all closeout requirements and the final checklists may contain additional requirements to document this compliance. In no case shall the checklists require performance criteria more stringent than specified by the Project Documents except as noted below regarding developing training plans.

Training Plans

For all Owner instruction, the Contractor shall submit a training plan for each section identified below for review and approval by the Commissioning Coordinator and the Owner. Training shall not proceed without approval of the training plan. A sample training plan is included following the sample Project Closeout Checklist. The training plan must contain the following as a minimum:

1. Attendee sign-off sheet
2. Required training hours specified in the project documents
3. Detailed list of subject to be covered and durations
4. Qualifications of training provider
5. Training schedule including duration of each training session

Table – C: Project Closeout System Summary Table

A	B	C	D	E	F	G	H	I
System Description	**Responsible Contractor**	**Proposed Agenda Received**	**OK**	**Training Performed**	**OK**	**Closeout Form Received**	**OK**	**Notes**
Domestic Water Heater and Pumps								
Hydronic Piping System, Glycol feed system and pumps								
Hydronic Heat Pumps								
Exhaust Fans								
Split System AC Units								
Electric Heaters								
Air distribution system								
Domestic Hot Water								
Temperature Control Systems								

Summary Table Key:

A. System description for each system commissioned

B. Contractor responsible for providing project closeout and training. To be filled in after contract award.

C. Date the proposed training agenda is received by the Commissioning Coordinator from the responsible Contractor

D. Indicates that Commissioning Coordinator has received and approved the proposed training agenda

E. Date the training was performed and witnessed by the Commissioning Coordinator

F. Indicates that Commissioning Coordinator has witnessed and approved the training provided

G. Date the Contractor completed Contractor Closeout Checklists are received by the Commissioning Coordinator from the responsible Contractor

H. Indicates that Commissioning Coordinator has received and approved completed Contractor Closeout Checklists

I. Notes on status of forms, irregularities and rework needed

Contractor Closeout Checklist (preliminary version)
System:_____

Instructions:

Contractor shall complete all specified items as listed on the following checklist and return the signed checklist to the Commissioning Coordinator prior to substantial completion. In addition, the Contractor may be required to demonstrate compliance with specified criteria on-site, as deemed appropriate by the Commissioning Coordinator or Commissioning Authority.

Project Closeout Checklist:

Instruction:

- ☐ Owner instruction is complete per project documents

Warranty and Spares:

- ☐ Warranty has been provided with operations and maintenance manuals
- ☐ All spares have been submitted to Owner and receipt of materials signed

Documentation:

- ☐ O&M Manuals are complete and submitted
- ☐ As-built drawings, material list, technical literature, list of recommend spare parts, system description, and sequence of operation have been updated and included in the O&M Manuals

Final Acceptance:

- ☐ Final performance testing completed and system accepted by Owner, CC and CA
- ☐ Building IAQ flush out completed and accepted by Owner, CC and CA

Please note: This checklist is not intended to represent all the requirements of the Project Documents within this Section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Sign-Off:

Team Member	Print Name/Company	Initial	Date
Installing Contractor:			
General Contractor CC:			

Operation and Maintenance Training Agenda

Equipment / System:

Date of Training: _____

Instruction:

SECTION 1

Filled out by the project owner and Commissioning Agent (CA) and the form transmitted to the responsible contractor.

SECTION 2

Company responsible for training will be indicated, the contractor is to fill in the remainder of the section.

SECTION 3

The contractor responsible for training fill in this section and return to the project Owner and CA for review and approval.

SECTION 1 – Audience and General Scope

Description	Check all that applies
Intended Audience	
Facility Manager	
Facility Engineer	
Facility Technician	
Project Manager	
Tenant	
Other	
General Objectives and scope of training	
Provide an overview of the purpose and operation of equipment, including required interactions with trainees.	
Provide technical information regarding the purpose, operation and maintenance of equipment at an intermediate level expecting that some support from outside contractors will be provided as needed.	
Provide technical information regarding the purpose, operation, troubleshooting and maintenance of equipment at a detailed level expecting that most operational and maintenance, service and repair will be conducted by trainees.	

Use blank spaces to describe additional/other objectives for the training session as needed.

SECTION 2 – Trainers/Instructors

Company	Trainer	Position/Qualifications

SECTION 3 – Agenda and Training Topics

Description	Indicate Covered Items	Duration (min.)	Trainer	Completed
General purpose of the equipment/system (design intent).				
Review of drawings and schematics.				
Review start-up, loading, operation, unloading, shut-down, occupied/unoccupied operation, seasonal change-over procedures as applicable.				
Review building automation control interface, setpoints, schedules, alarms, graphical interface as applicable.				
Review unitary (packaged) controls, programming, troubleshooting, alarms, and manual operation procedures as applicable.				
System interface with other systems – fire alarm, emergency power system, and other systems as applicable.				
Energy conservation strategies as applicable.				
Service, maintenance, preventive maintenance procedures.				
Spare parts provide and suggested.				
Special requirements to maintain warranty.				
Special procedures related to tenant interface with the system.				
Health and/or safety issues as applicable.				
Total training time:				

Use blank spaces to fill in any additional/other subjects covered.

SECTION 3 – Continued

Training Methods Description	Check all that applies
Use of O&M manuals	
Use of as-built drawings, plans and/or schematics	
Discussion/lecture	
Site demonstration of equipment operation	
Written handouts	
Manufacturer training manuals	
Video presentation	
Question and answer session	
Training session to be taped for Owner's future reference and training requirements	

Use blank spaces to fill in any additional/other methods to be used.

Training Session Attendee Roster

Equipment / Session: _____

Training Date: _____

Attendees	Organization

PART 4 – SAMPLE DOCUMENTS

4.01

Sample functional test procedures and data forms are provided in this Section to demonstrate the rigor of the process, test procedures and documentation that will be required from the Contractor. These forms and procedures will be amended, augmented and updated in the final commissioning plan based on the final project documents, addendums and submittal information. **This sample section does not contain all functional test procedures and data forms that are required to be executed by the Contractor.** Schedule – B of Part 3 provides a full list of the functional tests that will be required to be executed by the Contractor.

Ductwork Systems Sample Functional Test Procedure
Fire/Smoke Dampers

Procedures:

1. Locate, identify and number all smoke/fire dampers indicated on the drawings.

2. Verify each fire/smoke damper has been installed, access is provided, duct access doors are installed, damper is labeled and shaft is marked. Indicate observations in the provided Observations column. Reference key provided below table.

3. Verify fire/smoke dampers open and close as power is applied (as applicable). Indicate test results in the provide Test column.

Fire Damper Data Sheet

No.	Dwg. No.	Grid Location	Type	Description	I	A	D	L	M		O	C	N	Comment

Notes:
Access through grill
Access via flex duct
Direct observation through access door
Observation of set screw as reference

Key:
I = Installed
A = Access to damper motor
D = Door for access in duct
L = Label on access door
M = Marked shaft
N = Notes
O = Open when powered up
C = Closed with no power

X = Verified
- = Does not apply

Sign-Off:

Team Member	Print Name/Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Automatic Temperature Control Functional Test Samples
Hydronic Heat Pump or AC Units

Unoccupied Mode

1. Place the control system in the unoccupied mode by changing the schedule.

2. Verify that all controlled points listed are off, OSA dampers are closed.

3. Verify by physical observation (PO) that all controlled points are off and dampers are in the correct position.

HP:					
Supply fan command displayed OFF					
Supply fan status displayed OFF					
Supply fan, PO OFF					
Compressor command displayed OFF					
Compressor status displays OFF					
Reversing valve is de-energized					
OSA damper position displayed CLOSED					
OSA damper position, PO CLOSE					
Return air damper position displayed OPEN					
Return air damper position, PO OPEN					
Supply fan command displayed OFF					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	**Print Name/Company**	**Initial**	**Date**
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Unoccupied Limits

1. Place the system in the unoccupied mode and verify all HP and hydronic condenser water system are off and heating, economizer and cooling are not locked out.

2. Simulate a zone temperature below the unoccupied low limit.

3. Verify unit comes on in full recirculation, boilers and pumps start and heating system modulates to control zone temperature.

4. Verify unit stops when zone is satisfied.

5. Simulate a zone temperature above the unoccupied high limit.

6. Verify unit comes on in cooling, chilled water system starts and the system modulates to control zone temperature.

7. Verify unit stops when zone is satisfied.

AHU:					
Pre-Test:					
Unoccupied low limit					
Unoccupied high limit					
Zone temperature					
HPs Off, Pumps Off					
Test:					
Unoccupied low limit changed to					
Supply fan command displayed					
Supply fan status displayed					
Heating command displayed					
Cooling command displayed					
OSA damper position displayed					
Return air damper position displayed					
Return air damper position displayed					
Return air temperature					
Mixed air temperature					
Outside air temperature					
DAT					
System off when satisfied					

Unoccupied high limit changes to					
Supply fan command displayed					
Supply fan status displayed					
Cooling command displayed					
Heating command displayed					
OSA damper position displayed					
Return air damper position, PI					
Return air temperature					
Mixed air temperature					
Outside air temperature					
DAT					
System off when satisfied					

- ☐ Setpoints returned to original values
- ☐ Tests are complete and performance is acceptable

Sign-Off:

Team Member	Print Name/Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Unoccupied Pushbutton Override – HP

1. Place the system in the unoccupied mode and verify all HP and hydronic heating/cooling systems are off.

2. Set the override period to a minimum value.

3. Simulate a call for heating or cooling as required, test a minimum of two each for heating and cooling.

4. One at a time, press the override button for each space.

5. Verify the HP goes into the occupied mode and the condenser water system is enabled as appropriate.

6. Verify unit stops and condenser water pumps shut down at end of time period.

AHU:					
Pre-Test:					
Override run time					
Zone temperature					
Zone set point					
AHU Off, Pumps Off					
Test:					
Override run time adjusted to					
Zone temperature set point adjusted to					
Heat Test or Cool Test					
Hydronic circulation pump command ON					
Hydronic circulation pump status ON					
Supply fan command displayed ON					
Supply fan status displayed ON					
OSA damper position displayed Min					
Return air damper position displayed (100-OSA%)					
Heating/cooling command					
Outside air temperature					
Mixed air temperature					
Discharge air temperature					
System return to unoccupied at end of override period					

☐ Setpoints returned to original values.

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Thermostat Calibration and Point to Point Test

1. At each thermostat location, press override push button (or raise/lower set point).

2. Verify that BAS indicates correct zone in override.

3. Measure room air temperature and record actual and BAS indicated temperatures.

Unit No.	Override	Room Temp	BAS Temp	Unit No.	Override	Room Temp	BAS Temp

☐ Setpoints returned to original values.

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Occupied Mode Tests

1. Place the system in the occupied mode by changing the schedule.

2. Verify by physical inspection that the supply fan starts, the air dampers modulate to normal position (minimum air or higher), heating and cooling commands are energized as needed to control to current set point, and other parameters are normal.

3. Verify BAS displays the correct status for the fan coil units.

AHU:					
Space temperature					
Space temperature set point					
Supply fan command displayed					
Supply fan status displayed					
Supply fan, PI					
Heating command displayed					
Cooling command displayed					
OSA damper position displayed					
OSA damper position, PI					
Return air damper position, PI					
Return air temperature					
Mixed air temperature					
Outside air temperature					
DAT					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	**Print Name/ Company**	**Initial**	**Date**
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Zone Control – Cooling

1. Verify outside air is below economizer lockout temperature.

2. Lower the zone set point slightly below the current zone temperature.

3. Verify outside air dampers open for economizer cooling and the compressor remains off.

4. With an increased call for cooling, verify the compressor and the reversing valve is energized to control supply air set point.

5. Mixed Air Low Limit: Simulate a mixed air temperature below the mixed air low limit set point and verify mixed air low limit overrides the economizer control by closing the outside air damper. Release low limit when done.

6. Economizer Lockout 1: Simulate an OSA temperature above the return air temperature and verify OSA dampers modulate to minimum position. Release when done.

7. Economizer Lockout 2: Simulate an OSA temperature above the Economizer Lockout Set point and verify OSA dampers modulate to minimum position.

8. Raise set point to eliminate a call for closing.

9. Cooling with economizer lockout: With economizer locked out. Create a demand for cooler air. Verify the compressor and reversing valve energize immediately.

Cooling Control:

AHU:					
Pre-Test:					
Economizer minimum set point					
Zone temperature					
Zone set point					
Discharge air set point					
Discharge air temperature					
Outside air temperature					
Economizer minimum set point					
Economizer lockout set point					
Economizer damper position					
OAT					

RAT					
MAT					
DAT					
Mixed air low limit set point					
Test:					
Zone set point lowered to					
Discharge air set point reset to					
Heating command displayed					
Cooling command displayed					
OSA damper position displayed					
OSA damper position, PI					
Return air damper position displayed					
Return air damper position, PI					
Return air temperature					
Mixed air temperature					
Discharge air temperature after about 3 minutes					
Economizer is first stage of cooling					
Zone set point lowered to					
Discharge air set point reset to					
Cooling command displayed					
OSA damper position displayed					
Return air damper position displayed					
Return air temperature					
Mixed air temperature					
Discharge air temperature after about 3 minutes					
Mechanical cooling is second stage of cooling					
AHU:					
Mixed Air Low Limit					
Mixed air low limit set point changed to					
Outside air dampers close to control to MLL					
Economizer Lockout					
Dampers to minimum position on economizer lockout based on return air					
Cooling control during economizer lockout:					
Zone set point lowered to					
Cooling command displayed					
OSA damper position displayed					

Supply air temperature after about 3 minutes					
RAT					
MAT					
Mechanical Cooling is first state of cooling					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Zone Control – Heating

1. While system is still cooling, simulate a zone temperature below the zone temperature set point.

2. Verify economizer is at minimum.

3. Verify discharge air temperature set point is reset higher in response to heating demand.

4. Verify the compressor is energized and the reversing valve is off as needed to control to set point.

Heating Control:

AHU:					
Pre-Test:					
Economizer minimum set point					
Zone temperature					
Zone set point					
Discharge air set point					
Discharge air temperature					
Test:					
Set point raised to					
Discharge air set point reset to					
Economizer at minimum					
Heating command displayed					
Cooling command displayed					
OSA damper position displayed					
OSA damper position, PI					
Return air damper position displayed					
Return air damper position, PI					
Return air temperature					
Mixed air temperature					
Outside air temperature					
Discharge air temperature after about 3 minutes					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

AHU Hard Wire Shutdowns:

1. Mixed Air Low Temperature: Trip freeze stat and verify fan shuts down and dampers close.

AHU:					
Shutdown on freeze					
Reset OK					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

AHU Occupancy Sensor Test

1. Verify system is in the occupied mode.

2. Vacate all rooms and let occupancy timers time out.

3. Verify each AHU damper set goes to full recirculation (this will have to be by BAS only as the dampers are above the ceiling in each room).

4. One at a time, enter each room and verify AHU returns to normal occupancy mode with dampers at minimum or greater depending on heating/cooling demand.

AHU -						
"Unoccupied" State:						
Dampers in full recirculation						
"Occupied" State:						
Dampers at ≥ Minimum						
AHU -						
"Unoccupied" State:						
Dampers in full recirculation						
"Occupied" State:						
Dampers at ≥ Minimum						

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Exhaust Fans

BAS Controlled Exhaust Fan Test (with Fan Proof)

1. Place the control system in the unoccupied mode.

2. Verify all exhaust fans under BAS control are commanded off, display an off status and are off by physical inspection (PI).

3. Place the system in the occupied mode.

4. Verify all exhaust fans under BAS control are commanded on, display an on status and are on by physical inspection (PI).

5. Turn off the exhaust fan at the disconnect and verify fan failure alarm is generated.

6. Turn power to fan back on and verify alarm clears.

EF -	1	2	3	4	5
Unoccupied Mode:					
Exhaust fan command displayed OFF					
Exhaust fan status displayed OFF					
Exhaust fan, PI OFF					
Occupied Mode:					
Exhaust fan command displayed ON					
Exhaust fan status displayed ON					
Exhaust fan, PI ON					
Exhaust fan failure alarm received					
Exhaust fan failure alarm cleared					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

BAS Controlled Exhaust Fan Test (without Fan Proof)

1. Place the control system in the unoccupied mode.

2. Verify all exhaust fans under BAS control display an off status and are off by physical inspection (PI).

3. Place the system in the occupied mode.

4. Verify all exhaust fans under BAS control display an on status and are on by physical inspection (PI).

EF -	1	2	3	4	5	6	7	8
Unoccupied Mode:								
Exhaust fan command displayed OFF								
Exhaust fan, PI OFF								
Occupied Mode:								
Exhaust fan command displayed ON								
Exhaust fan, PI ON								

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Manual Control Exhaust Fan Test

1. Turn exhaust fan on at local switch and verify fan starts.

2. Turn exhaust fan off at local switch and verify fan stops.

EF -	1	2	3	4	5	6	7	8
Fan Starts								
Fan Stops								

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Manual Timer Control Exhaust Fan Test

1. Verify timer is at zero and exhaust fan is off.
2. Turn timer to minimum increment and record timer setting and time of day.
3. Verify fan comes on.
4. Monitor timer/fan till shut-off and record time. Verify run time matches timer.

EF -	1	2	3	4	5	6	7	8
Timer at zero, fan off								
Timer set to								
Time of day								
Fan on								
Time of day fan off								
Fan run time								

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Thermostatically Controlled Exhaust Fan Tests (BAS)

1. Lower thermostat set point to below room temperature or simulate a space temperature higher than set point. Verify that fan starts when space temperature is above set point and BAS is correct.

2. Raise thermostat set point above room temperature or simulate a space temperature lower than set point. Verify fan stops when space temperature is below set point and BAS is correct.

EF -	1	2	3	4	5
Space temperature start of test					
Set point start of test					
Set point ( ) or Simulated Space ( ) temp					
Exhaust fan command/status displayed ON					
Exhaust fan, PI ON					
Set point ( ) or Simulated Space ( ) temp					
Exhaust fan command/status displayed OFF					
Exhaust fan, PI OFF					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Thermostatically Controlled Exhaust Fan Tests (Line Voltage)

1. Lower thermostat set point to below room temperature or simulate a space temperature higher than set point. Verify fan starts when space temperature is above set point.

2. Raise thermostat set point above room temperature or simulate a space temperature lower than set point. Verify fan stops when space temperature is below set point.

EF -	1	2	3	4	5
Space temperature start of test					
Set point start of test					
Set point ( ) or Simulated Space ( ) temp					
Exhaust fan command/status displayed ON					
Exhaust fan, PI ON					
Set point ( ) or Simulated Space ( ) temp					
Exhaust fan command/status displayed OFF					
Exhaust fan, PI OFF					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Pumps

Unoccupied Mode:

1. Place the control system in the unoccupied mode.
2. Verify all pumps under BAS control display an OFF command and status.
3. Verify all pumps under BAS control are off by direct observation.

Unit No.	Command OFF	Status OFF	Unit OFF
P-1			
P-2			
P-3			
P-4			
P-5			

Occupied Mode:

1. Place the control system in the occupied mode.

2. Verify all pumps under BAS control display an ON command and status.

3. Verify all pumps under BAS control are off by direct observation.

Unit No.	Command OFF	Status OFF	Unit OFF
P-1			
P-2			
P-3			
P-4			
P-5			

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Condenser water temperature control

1. Record the condenser water temperature control parameters.

2. Simulate an outside air temperature through various ranges of reset.

3. Verify hot water loop set point resets per schedule.

OAT	HWS SP

OAT	Expected SP	Actual SP

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Pump Lead/Lag and Failure/Alarm

1. Conduct test with lead pump running.
2. Record lead and lag pump status.
3. At the lead pump motor control center, turn the switch from Auto to Off.
4. Verify lag pump starts.
5. Turn lead pump back on, this should just require switching the MCC to Auto but also may require software reset.
6. Repeat test by disconnecting power to pump.
7. Trip the lead/lag sequence and verify the lag pump becomes the lead.
8. Repeat 1-5 for the new lead pump.

	HOA	AC Fail HOA	AC Fail		
Lead Pump	P-1	P-1		P-2	P-2
Lead Status					
Lag Pump	P-2	P-2		P-1	P-1
Lag Status					
Lag Start on Lead Fail?					

Pump Failure Alarm Reported?					
Lead/Lag Switched?					

☐ Tests are complete and performance is acceptable.

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

Hydronic loop pressure control

1. Verify pumping system is operational.

2. Record initial pressure setpoints and system readings. As option, also set up trend log for pressure, set point and VFD feedback.

3. Raise system pressure set point and allow system to stabilize.

4. Verify variable speed pumping system controls to new set point.

5. Lower system pressure set point below original set point and verify variable speed pumping system controls to new set point.

6. Repeat for all pumps.

Lead Pump:	**P-1**	**P-2**
Start of test:		
Differential pressure set point		
Differential pressure displayed by BAS		
VFD speed BAS command		
VFD speed BAS feed back		
VFD speed displayed at VFD		
Pump discharge pressure		
Pump suction pressure		
Test:		
Differential pressure set point changed to		

Differential pressure displayed by BAS		
VFD speed BAS command		
VFD speed BAS feed back		
VFD speed displayed at VFD		
Pump discharge pressure		
Pump suction pressure		
System controls		
Differential pressure set point changed to		
Differential pressure displayed by BAS		
VFD speed BAS command		
VFD speed BAS feed back		
VFD speed displayed at VFD		
Pump discharge pressure		
Pump suction pressure		
System controls		
Differential pressure set point returned to original value		
Tests are complete and performance is acceptable		

Sign-Off:

Team Member	Print Name/ Company	Initial	Date
Installing Contractor:			
GC Cx Coordinator:			

Comments:

END OF SECTION