

## DIVISION FIFTEEN

## MECHANICAL

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## SECTION 15010

### GENERAL PROVISIONS

#### PART I - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract Requirements and Division 1 -General Requirements for the Construction of this project shall apply to this division and all sections herein.
- B. Where items under the Bidding and Contract Requirements, and Division 1 - General Requirements are repeated in this section, it is intended to call particular attention to or qualify the items. It is not intended that any other parts under the Bidding and Contract Requirements of Division 1 - General Requirements shall be assumed to be omitted if not repeated herein.

##### 1.02 SCOPE

- A. The work included under this Division shall include a complete mechanical system as shown on the drawings and as specified herein. Any apparatus, appliance, material or work not shown on the drawings but mentioned in the specifications, or vice versa, or any incidental accessories necessary to make the work complete in all respects and ready for operation, even if not particularly specified, shall be furnished, delivered and installed by the contractor without additional expense to the Owner.
- B. The contractor shall note that all items of equipment are specified in the singular; however, the contractor shall provide and install the number of items of equipment as indicated on the drawings and as required for a complete system.
- C. It is the intention of the specifications and drawings to call for finished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean, "provide and install complete and ready for use."
- D. Minor details not usually shown or specified but necessary for proper installation and operations shall be included in the contractor's estimate, the same as if herein specified or shown.
- E. This contractor shall be responsible for participation and coordination with the Commissioning process as specified in section 01660.

##### 1.03 APPLICABLE SPECIFICATIONS, CODES, STANDARDS AND PERMITS

- A. All equipment, materials and installation shall conform to the requirements of national, state and local codes, laws, ordinances, rules and regulations. All utility connections shall conform to the requirements of the local utilities.

- B. Unless otherwise specified herein or shown on the contract drawings, the work and materials shall conform to the applicable requirements of the following codes, standards and regulations:
1. VUSBC            Virginia Uniform Statewide Building Code
  2. BOCA            Building Officials & Code Administrators International, Inc.
  3. ICC              International Code Council
  4. AMCA            Air Movement and Control Association International, Inc
  5. ARI              Air Conditioning & Refrigeration Institute
  6. ASHRAE        American Society of Heating, Refrigerating and Air Conditioning Engineers
  7. ASME            American Society of Mechanical Engineers
  8. ASTM            American Society of Testing Materials
  9. NEC              National Electrical Code
  10. NFPA            National Fire Protection Association
  11. OSHA            Occupational Safety and Health Association
  12. SMACNA        Sheet Metal and Air Conditioning Contractors National Association
  13. UL              Underwriters Laboratories, Inc.
  14. ANSI            American National Standards Institute
  15. AWS             American Welding Society
  16. NEMA            National Electrical Manufacturer's Association
  17. CISPI           Cast Iron Soil Pipe Institute
  18. IRI              Industrial Risk Insurers
  19. CAA             Clean Air Act Amendment of 1990 (Title VI, Section 608)
  20. CTI             Cooling Tower Institute
- C. Contractor shall give all necessary notices, obtain all permits and pay all

Government taxes, fees and other costs, including costs for water, sewer, and gas connections or extensions including meters, in connection with his work, file all necessary plans, prepare all documents and obtain required certificates of inspection for work and deliver same to Owner before request for acceptance and final payment for work.

- D. The contractor shall be responsible for purchasing equipment and appliances that bear the label of an agency, as approved by the Department of Public Works and Environmental Services (DPWES), Fairfax County. It shall be the responsibility of the contractor to pay for any label testing of equipment or appliances that are installed without the label of a DPWES approved agency.

#### 1.04 SHOP DRAWINGS

- A. The contractor shall submit eight (8) copies of the shop drawings to the Architect for review with ample time for checking prior to delivery of any of this equipment or material to the job site. The project's and the contractor's names shall be on each submittal.
- B. Shop drawings shall be submitted on all major pieces of equipment and material. Each item of equipment proposed shall be a standard catalog product of an established manufacturer. The shop drawing shall give complete information on the proposed equipment such as: capacity, size, construction, material, dimensions, arrangement, operating clearances, performance characteristics, weight and rating authority. Each item of the shop drawing shall be properly labeled, indicating the intended service of the material.
- C. The contractor shall, before submitting the shop drawings of the equipment to the Architect, check each item of the shop drawings to verify the proper equipment. Items to check shall include but not be limited to:
  - 1) Will equipment physically fit into space;
  - 2) proper equipment for the job; electrical characteristics;
  - 3) voltage matches that of electric service; proper arrangements for connections;
  - 4) meets code requirements.
- D. The shop drawings shall be neatly bound and submitted to the Architect with a letter of transmittal, which shall list each item, submitted with the manufacturer's name.
- E. Review of the shop drawings shall not be considered as a guarantee of measurements or building conditions. Where drawings have been reviewed, said review does not mean that drawings have been checked in detail; said review does not in any way relieve the contractor from his responsibility or the necessity of furnishing material or performing work as required by the contract drawings.

### 1.05 EQUIPMENT DEVIATIONS

- A. Where the contractor proposes to use an item of equipment other than the prototype equipment (a specified manufacturer's equipment used as the basis of design) or that detailed on the drawings which requires any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical, electrical or architectural layout, all such redesign and all new drawings and detailing required therefore shall be prepared by the contractor at his own expense and be approved by the Owner and Engineer.
- B. Where such deviation from the prototype equipment requires a different quantity and arrangement of materials and equipment, the contractor shall furnish and install any such ductwork, piping, structural supports, insulation, controllers, motors, starters, electrical wiring and conduit and any other additional equipment required by the system at no additional cost to the Owner.

### 1.06 QUALIFICATIONS FOR BIDDERS

- A. The contractor shall examine drawings and specifications relating to work of all trades and become fully informed as to the extent and character of work required and its relation to all other work in the project prior to submission of bid or prior to start of any construction covered by these specifications and drawings.
- B. Before submitting bid the contractor shall visit the site and examine all adjoining existing building, equipment and space conditions on which his work is in any way dependent, for the best workmanship and operation according to the intent of the specifications and drawings. Contractor shall verify dimensions and fully inform himself as to the nature and scope of the proposed work and also the conditions under which it is to be conducted. He shall report to the Owner any conditions that in his estimation might preclude him from installing his equipment and work in the manner intended and noted on the drawings and in this specification. Failure to take the above precaution will in no way relieve the contractor from his obligations to provide the material and work as indicated and as specified without additional cost to the Owner or extension of completion time.

### 1.07 TEMPORARY FACILITIES

- A. Are specified under Temporary Facilities, the General Conditions, Supplementary General Conditions, and Division I. General requirements are hereby made a part of this section as fully as if repeated herein.

### 1.08 DRAWINGS

- A. The drawings are diagrammatic, indicating general arrangement of work, and should not be scaled to establish location of work. The drawings show the size of piping and ductwork branches, risers and equipment, and must be followed.

Where a change of location or method of running becomes necessary due to obstructions or other construction difficulties, such changes shall be made after securing approval of the Owner in writing and at no increase in amount of contract.

- B. Decisions regarding any and all substitutions and options permitted by the specifications shall be submitted for approval to the Owner. Approval will only be recognized when in writing.
- C. In finished spaces all piping and ductwork shall be concealed or run behind furring unless shown otherwise. Where concealing is not possible piping and ductwork may be exposed after obtaining the Owner's approval.
- D. All horizontal piping and ductwork not run below slab on grade shall be run as close as possible to underside of floor and parallel to building lines. Maintain maximum headroom in all areas.
- E. All vertical piping and ductwork shall be run as close to walls and partitions as practicable.
- F. Coordination of all other trades prior to erecting any piping or ductwork is required to avoid conflict between various components of the building.

#### 1.09 COOPERATION WITH OTHER TRADES

- A. The contractor shall give full cooperation to other trades and shall furnish in writing, with copies to the Owner, any information necessary to permit the work of all trades to be installed satisfactorily with the least possible interference or delay.
- B. Where the work of the contractor will be installed in close proximity to work of other trades, or where there is evidence that work will interfere with work of other trades, he shall assist in working out space conditions to make a satisfactory adjustment. This contractor shall prepare composite working drawings at a scale not less than 1/4" = 1'-0" clearly showing how his work is to be installed in relation to the work of the other trades. If the contractor installs his work before coordinating with other trades or as to cause any interference with work of other trades he shall make necessary changes to his work to correct the condition without additional cost to the Owner.
- C. The contractor shall furnish to other trades as required all necessary templates, patterns, setting plans and shop details for the proper installation of the work and for the purpose of coordinating adjacent work.
- D. Structural support elements as shown on the drawings must be in place prior to the installation of piping or the setting of rooftop equipment. The contractor shall not install any piping or rooftop equipment until such elements are in place.

### 1.10 ELECTRICAL WIRING

- A. The contractor shall, regardless of voltage, furnish and install all temperature control wiring, all interlock wiring, and equipment control wiring for the equipment that the contractor furnishes unless otherwise noted. Division 16 will furnish and install power wiring to the mechanical equipment and make electrical connections unless otherwise noted on the drawings.
- B. All electrical wiring furnished under the mechanical contract shall conform with Division 16.

### 1.11 FOUNDATIONS AND SUPPORTS

- A. Contractor shall provide all necessary foundations, supports, pads and bases required for mechanical equipment and any other equipment furnished under this contract, unless covered under the architectural or structural work.
- B. For buried concrete or cast iron sewer piping installed in filled cuts over four (4) feet in depth the contractor shall provide brick or approved equal supports or piers under piping and fittings with piers or supports extending to a depth to provide sufficient firm and adequate support to overcome the possibility of any deflection in the piping system.
- C. For pumps, compressors and other rotating machinery and all equipment where foundations are indicated, furnish and install concrete pads 4" in height (unless otherwise noted) extending not less than 4" beyond equipment base in all directions. Equipment installed in areas other than slab on grade shall be installed with the appropriate vibration assembly.
- D. Construction of foundations, supports, pads, bases and piers where mounted on the floor, shall be of the same materials and same quality of finish as the adjacent and surrounding flooring material.

### 1.12 SCAFFOLDING, RIGGING AND HOISTING

- A. Unless otherwise specified, contractor shall furnish all scaffolding, rigging, hoisting, shoring and services necessary for erection and delivery into the premises for any equipment and apparatus furnished and shall remove same from premises when no longer required.

### 1.13 EXCAVATION AND BACKFILL

- A. The contractor shall be responsible for excavation, backfill, tamping, shoring, bracing, pumping, street cuts, repairing of finished surface and all protection for safety of persons and property as required for installing a complete mechanical/plumbing system. All excavation and backfill shall conform to the



architectural section of the specifications.

- B. It shall be the responsibility of the contractor to check the indicated elevations of utilities entering and leaving the building. If such elevations require excavations lower than the footing levels, the Owner shall be notified of such conditions and redesign shall be made before excavations are commenced. It is also the responsibility of the contractor to make the excavations at the minimum required depths in order not to undercut the footings.
- C. The trench shall be excavated below the installation level of the bottom of the pipe. The trench shall be filled with sand or fine gravel so entire length of barrel of piping rests on solid bed of sand or fine gravel. The backfill shall be filled in layers of 6" max depth and such layers shall be compacted after each placement.
- D. Excavation shall be made in a manner to provide a uniform bearing for pipes. The pipe elevation shall be determined by the contractor to meet the plumbing codes. Where rock is encountered, excavate 3" below pipe grade and back fill with sand to the installation level of the pipe. The pipe, including the joints, shall not rest on rock at any point.
- E. After required test and inspections, backfill the ditch and tamp. The first foot above the pipe shall be hand backfilled with rock free clean earth. The backfill in the ditches on the exterior and interior of the building shall be tamped to 95% of the standard Proctor maximum dry density (ASTM D-698). The contractor shall be responsible for any of his ditch walls that cave in.

#### 1.14 CUTTING AND PATCHING

- A. On new work the contractor shall furnish sketches showing the locations and sizes of all openings and chases, and furnish and locate all sleeves and inserts required for the installation of the mechanical work before the walls, floors and roof are built. The contractor shall be responsible for the cost of cutting and patching where any mechanical items were not installed or where incorrectly sized or located. The contractor shall do all drilling required for the installation of his hangers.
- B. On alterations and additions to existing projects, the contractor shall be responsible for the cost of all cutting and patching unless otherwise noted.
- C. No structural members shall be cut without the approval of the Owner, and all such cutting shall be done in a manner directed by him. All patching shall be performed to match the existing surface in shape, texture and color.

#### 1.15 ACCESSIBILITY

- A. The contractor shall locate equipment, which must be serviced, operated or maintained in fully accessible position. Equipment shall include but not be

limited to: valves, traps, or low limit devices, damper operators, motors, controllers, drain points, fusible links of fire dampers, fire dampers, filters, etc. If required for better accessibility, furnish access doors for this purpose. Minor deviations from drawings may be made to allow for better accessibility, and any change shall be approved. Motor starters shall be installed not more than 6'-0" above finished floor unless otherwise approved by the Owner.

- B. All filters furnished with air handling equipment shall be readily removable from sides or bottom of cabinet as required by equipment location. Contractor shall verify location of all equipment and proper location of access to filters for removal before submitting shop drawings, placing order for equipment and setting and connecting of equipment. Any filters deemed by the owner to be inaccessible after installation will be made accessible by the contractor at no additional cost to the owner.

#### 1.16 RECORD DRAWINGS

- A. The contractor shall keep daily updated accurate records of all deviations in work as actually installed from work indicated on the contract drawings. The record drawings shall be kept at the job site, available to the Owner at all times and labeled as "Project Record Information - Job Set". When work is completed one complete set of marked-up prints shall be delivered to the Owner.

#### 1.17 PERSONNEL INSTRUCTION AND OPERATING INSTRUCTIONS

- A. Operation and Maintenance Manuals
  1. The contractor shall submit for approval three (3) copies of all of the manufacturer's installation, operating and maintenance manuals for all new mechanical equipment listed in the equipment schedule, all necessary components of mechanical equipment, testing and balancing reports, equipment start-up records, equipment capacity (input and output) and a list of filter sizes and belt sizes for all mechanical equipment that requires filters and belts (this includes, but is not limited to, fan coils, unit ventilators, rooftop units, cabinet heaters, exhaust fans and air handlers).
  2. Submit four (4) copies of the operating and maintenance manuals for the automatic temperature control system components and diagrams for approval. A complete written narrative of how each system is intended to operate shall be included.
  3. Provide laminated as-built drawings and manufacturer's refrigeration piping layout showing the layout and refrigerant volume of each variable refrigerant system. This shall show actual room numbers, not from construction documents, and addressing scheme. Laminate shall have minimum thickness of 10 mil. Drawing size shall be 11" x 17". Provide multiple drawings should zones not fit onto one page. These will be

mounted in the water heater room unless otherwise shown.

4. Manuals shall be assembled in black vinyl hardback loose-leaf binders, labeled with job name, address and date. Information on each piece of equipment of system shall be in a separate tab labeled section. Provide a complete index of the contents. After approval by the Engineer the binders shall be forwarded to the Owner.
- B. After all tests are conducted and approved as specified below, furnish a competent operating engineer for a period of two days to instruct and demonstrate to the Owner or his authorized representative the operation of the system. The mechanical systems demonstration shall not coincide with the electrical demonstration. Notify the owner in writing of the person to whom this instruction was given and the date it was given.
  - C. On phased construction projects the aforementioned equipment start-up records shall be completed and made available to the owner for review prior to the occupancy of the completed phase.

#### 1.18 TESTS

- A. The contractor shall, at his expense, conduct capacity and general operating tests on each system. The test shall demonstrate the specified capacities of the various pieces of equipment and shall be conducted in the presence of the Owner or his authorized representative. The general operating tests shall demonstrate that the entire equipment is functioning in accordance with the contract documents. Furnish all instructions and test equipment.
- B. After all systems are completely tested, submit three copies of the test results to the Owner for approval before final acceptance of project.

#### 1.19 EQUIPMENT AND SYSTEMS CHECKOUT AND START-UP

- A. This contractor is responsible for the checkout and start-up of all equipment and systems. Equipment start-up shall be in accordance with the manufactures requirements and recommendations and shall be performed by personnel who are knowledgeable with the equipment and its requirements. When required by the equipment manufacturer or as noted in the specifications, equipment checkout and start-up shall be performed by personnel certified by the manufacturer. Evidence of proper certification of startup personnel shall be provided to the owner.
- B. All checkout and start-up activities are the responsibility of this contractor.
- C. This contractor shall notify FCPS two weeks prior to equipment checkout and start-up.

- D. Systems and equipment shall be operated at both full and part load conditions to ensure specified requirements can be achieved.
- E. The equipment manufacturer's checkout and start-up logs shall be completed in their entirety; should a reference be non-applicable it shall be marked as such. Copies of completed logs shall be submitted to FCPS personnel the day of checkout and start-up activities, as well as included in the Operation and Maintenance manual.

#### 1.20 WARRANTY

- A. The contractor shall deliver the work described herein in a first-class operating condition in every respect. The contractor shall also warrant that the material, equipment and workmanship furnished shall be entirely free from defects for a period of one year. All apparatus will develop capacities and characteristics specified, and that if during the period of one year - from date of substantial completion (See Section 01740) any such defects in workmanship, materials or performance appear, he will, without cost to the Owner, remedy such defects within a reasonable time. In default thereof, Owner may have such work done and charge the cost to the contractor. In cases where equipment warranties through the manufacturer exceed the periods listed in these specifications, the manufacturer's warranty shall take precedence. The contractor is responsible for all periodic service and maintenance required to maintain such warranties on completed work for the duration of the project (See Section 01740.1.05). Once the entire project is substantially complete, periodic maintenance shall be the responsibility of the owner.

#### 1.21 CONNECTING INTO EXISTING UTILITIES

- A. Procedures: The procedures used for the accomplishment of connecting into existing work shall provide for safe conduct of the work, careful removal and disposition of materials specified to be salvaged, protection of property which is to remain undisturbed, coordination with other work in progress, and timely disconnection of utility services.
- B. Scheduling of Work: Work shall be performed in the sequence, locations and time periods agreed to by the Owner prior to commencement of work.
- C. Dust Control: The amount of dust resulting from connecting existing utilities shall be controlled to avoid creation of a nuisance in the surrounding area. Masks shall be worn for protection against dust inhalation by all persons in the vicinity of work involving removal of masonry.
- D. Protection of Existing Work:
  - 1. Existing work and furnishings to remain shall be protected from damage. Work damaged by the Contractor shall be repaired to match existing work without any additional cost to the Owner.

2. Cover equipment as necessary, to protect it from dust.
  3. Floors shall be protected from damage.
  4. At the end of each workday and during inclement weather, close exterior openings with weatherproof cover.
  5. Provide temporary filter media on any portions of existing ductwork which communicate with corridors and construction areas. This media shall be checked frequently and changed as necessary.
- E. Environmental Protection: Contractor shall comply with all Federal and local regulations pertaining to Environmental Protection.
- F. Removal of Existing Equipment and Materials: Existing equipment and materials shall be dismantled and/or cut-up so as to be removable through existing building's access passages. No alterations to the building shall be made for the purpose of removing existing equipment and material.
- G. Clean-up:
1. Debris and Rubbish: Remove debris and rubbish from the site daily. Do not allow to accumulate in building or on site.
  2. Debris Control: Remove and transport debris in a manner so as to prevent spillage on site or adjacent areas.
  3. Regulations: Local regulations regarding hauling and disposal shall apply.

#### 1.22 DOWNTIME

- A. The contractor shall so arrange his work that domestic water, gas, storm sewer, sanitary sewer, air conditioning, and heating systems shall be maintained at all times while the school classes are in session.
- B. Construct work in accordance with project schedule established under Section 01310. Coordinate the schedule and operations with the Owner's Representative. There shall be no shutdown of electricity, water, sanitary/storm sewers, air conditioning, or heat during the life of the project unless approved in writing by Owner. The Contractor is responsible for providing temporary air conditioning or heating for those areas which are scheduled to be occupied for school use and the Contractor has demolished the existing air conditioning or heating system. Maintain minimum corridor temperature at 68°F during heating season.
- C. In occupied areas or spaces, where existing HVAC systems are rendered

nonfunctional, due to construction the contractor shall provide temporary HVAC and maintain space conditions per ASHRAE 55 section 5 and ASHRAE 62.1 section 6.

- D. The contractor shall submit written requests to disconnect any existing utility services and to obtain equipment downtime. Only after receiving Owner approval of these requests shall work be allowed to proceed. This contractor shall be responsible for restoring the existing utilities.
- E. If contractor fails to provide domestic hot/cold water, gas, sewers, air conditioning and/or heating systems as specified herein it is understood and agreed that there will be liquidated damages deducted in the amount as stated in Division 01010, per school per consecutive calendar day.

### 1.23 CONSTRUCTION LIMITATIONS

- A. In renewal projects which require work to be continually done, above the corridor ceilings, while school is in progress. The following requirements shall be met:
  - 1. No construction material may be stored in a corridor at any time.
  - 2. Any work done in the corridors after school hours must allow a minimum corridor of 72" to remain for safe egress. No work such as welding, soldering, etc., which is considered hazardous to the occupants of the building, may take place during school hours.
  - 3. The contractor shall immediately clean any area of debris, if work is done in any occupied space.
  - 4. No gas powered construction equipment will be allowed in the building during school hours.

END OF SECTION

## SECTION 15050

### BASIC MATERIALS AND METHODS

#### PART I - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract Requirements, Division 1 - General requirements and section 15010 - General Provisions, shall apply to this section.

##### 1.02 SCOPE

- A. The work covered under this section covers the basic materials and methods for a complete mechanical system.

#### PART 2 - PRODUCTS

##### 2.01 PIPE AND PIPE FITTINGS

- A. All materials shall be of an approved type and shall be designed for the pressures and temperatures at which they are to be operated, for the materials they are to handle and for their intended use.
- B. Materials shall conform to the standard reference numbers listed below. See individual sections of the specifications for use.
  - 1. Ductile Iron Water Pipe - (Water Service) - AWWA C151.
  - 2. Copper Tubing (Water Distribution - Type L or K) - ASTM B75, B88, B251
  - 3. Cast Iron Fittings – ASME B16.4, B16.12; ASTM A74, A888; CISPI 301
  - 4. Copper Fittings - ASME B16.15, B16.18, B16.22, B16.23, B16.26, B16.29, B16.32
  - 5. Cast Iron Soil Pipe - ASTM A74, A888; CISPI 301
  - 6. Copper Pipe (Waste, Vent, & Hydronic) - ASTM B42, B302
  - 7. Galvanized Steel Pipe (Waste & Vent) - ASTM A53
  - 8. Polyvinyl Chloride (PVC) Plastic Pipe - ASTM D2665, D2949
  - 9. Plastic Fittings - ASTM D2466, D2467, D2468, D3311, F409, F438, F439

10. Concrete Pipe - ASTM C14, C76
11. Steel Pipe - ASTM A53, A106
12. Malleable Iron Fittings - ASME B16.3
13. Steel Butt Welding Fittings - ASME B16.9
14. Steel Fittings - ASTM A420
15. Gray Cast Iron Fittings - ASTM A126
16. Steel Pipe Flanges - ASME B16.5

## 2.02 PIPING SPECIALTIES

Piping Specialties shall be designed and installed to meet the intended use including pressures and temperature.

- A. Gaskets - Shall be full face with a working pressure of 300 lbs. and temperature up to 212 \* F. Gaskets shall be manufactured by JM CLIPPER, US PIPE, FNW, or AMERICAN.
- B. Strainers - HONEYWELL-BRAUKMAN, ARMSTRONG or SARCO.
- C. Unions
  1. Unions shall be of an approved type, shall meet the requirements for the pressure and temperature at which they are to operate and shall be compatible with the pipe materials.
  2. Brass Couplings - Shall be used for connecting steel pipe to copper tubing.
  3. Die-electric unions or waterways shall not be permitted.
- D. Escutcheons - Escutcheon plates shall be stamped brass chromium plated, shall be of sufficient size to cover sleeved openings for the pipes, shall be of sufficient depth to cover sleeves projecting above floors, and shall be manufactured by BLATON AND CALDWELL, DEARBORN BRASS, MASON or GRINNELL.
- E. Gauges and Thermometers - Shall be as listed below unless otherwise specified under other sections of the specifications.
  1. Temperature Gauges or Thermometers - Shall be the separable socket, adjustable angle type, not less than 9" scale V-shaped, organic filled, blue reading column. Range shall be applicable for the service. Thermometers shall be adjustable type to permit easy reading from floor



and outside of insulation, as manufactured by ASHCROFT, WEKSLER, TAYLOR or TRERICE.

2. Pressure Gauges - Shall be of the liquid filled, bourdon-tube type with dial diameter not less than 4" and operating range 0 - 160 psig. Install a shut-off cock in line to each gauge. Gauges as manufactured by ASHCROFT, WEKSLER, TAYLOR or TRERICE.
3. Compound Gauges - Shall be of the liquid filled, bourdon-tube type with dial diameter not less than 4" and operating range 30" - 0 - 30 psig. Install a shut-off cock in line to each gauge. Gauges as manufactured by ASHCROFT, WEKSLER, TAYLOR or TRERICE.

### 2.03 PIPE HANGERS AND SUPPORTS

- A. Pipe Hangers and Supports Material - Provide a combination of pipe hangers and supports such as steel and copper clad clevis hangers, round steel rods, concrete inserts, clamps, brackets and other items as applicable. Hangers and supports shall meet the recommendations of the manufacturer. Parallel runs of horizontal piping shall be grouped together on adjustable trapeze hangers. All hangers in contact with copper pipe shall be copper-plated. Pipe hangers and support shall be of the size to accommodate the pipe and insulation where applicable. Pipe hangers and supports manufacturer: MASON, GRINNELL, CARPENTER AND PATERSON, ANVIL or NIBCO.

1. VRF Pipe hangers and supports.
  - a. Multiple runs of VRF piping shall be grouped together on preformed U channel, (trapeze) hanger spacing and hanger rods as described below.
  - b. VRF piping shall be mounted to be preformed U channel with two piece pipe straps (clamps) with cushioned insert. Klo-Shure 7 series Strut Mount Insulation Couplings or approved equal.
  - c. The two piece pipe straps (clamps) shall be sized to snugly fit the outside diameter of the pipe insulation.
  - d. Hangers shall be installed on each side of pipe direction changes and within 2 feet of each direction change.
  - e. Hangers for GelCopper pre-insulated copper tubing shall be Hydro-Zorb model TRH with 3/8 diameter rod, or approved equal.

- B. Hanger Spacing for Horizontal Pipe shall not exceed:

1. Cast Iron Soil Pipe (all diameters) 5'-0"

|    |                              |        |
|----|------------------------------|--------|
| 2. | Plastic Pipe (all diameters) | 4'-0"  |
| 3. | Schedule 40 Steel Pipe       |        |
|    | 1/2" to 1" Pipe              | 6'-0"  |
|    | 1-1/4" to 2" Pipe            | 8'-0"  |
|    | 2-1/2" to 4" Pipe            | 10'-0" |
|    | 5" and Larger Pipe           | 12'-0" |
| 4. | Type 'L' Copper Tubing       |        |
|    | 1/2" to 3/4" Pipe            | 5'-0"  |
|    | 1" Pipe                      | 6'-0"  |
|    | 1-1/4" Pipe                  | 7'-0"  |
|    | 1-1/2" to 2" Pipe            | 8'-0"  |
|    | 2-1/2" Pipe                  | 9'-0"  |
|    | 3" Pipe                      | 10'-0" |
|    | 3-1/2" Pipe                  | 11'-0" |
|    | 4" Pipe                      | 12'-0" |
|    | 5" Pipe                      | 13'-0" |
|    | 6" Pipe                      | 14'-0" |

C. Hanger Spacing for Vertical Pipe shall not exceed:

|                     |  |
|---------------------|--|
| Cast Iron Soil Pipe | At the base and at each story                    |
| Threaded Pipe       | At each story                                    |
| Plastic Pipe        | At each story and at the midpoint between floors |
| Copper Tube         | At each story                                    |

D. Hanger Rods shall be at least:

|              |               |
|--------------|---------------|
| Pipe to 2"   | 3/8" diameter |
| 2 1/2" to 3" | 1/2" diameter |
| 4" to 5"     | 5/8" diameter |
| 6" to 8"     | 3/4" diameter |
| 10" to 12"   | 7/8" diameter |

E. Sheet Metal Saddles - Supports for insulated pipes shall not contact the pipe but shall surround the unbroken covering. Provide galvanized steel sheet metal saddles properly formed to the jacket between hanger and the lower 1/3 of the circumference. The size of the saddles shall be as follows:

|               |                     |
|---------------|---------------------|
| Pipe to 3"    | 24 gauge x 12" long |
| 4" to 6"      | 18 gauge x 12" long |
| 8" and larger | 16 gauge x 12" long |

## 2.04 VALVES

- A. Valves shall be of an approved type and shall meet the requirements for the pressure and temperature at which they are to be operated, for the material they are to handle and for their intended use. Valve manufacturers are listed in the individual sections of the specifications.
- B. Valve and Tag Chart - Furnish and install on each valve a brass tag with a number and the abbreviation PLMB (for plumbing) HVAC (for mechanical systems) embossed in the brass tag for each valve and securely fastened to each valve wheel with beaded chain or brass wire. Provide a laminated chart in the water heater room, showing the locations and use of each valve. Laminating film shall be at least 10mil thick. Two charts shall be provided - one for the plumbing valves and one for the heating and cooling valves. The plumbing valves shall start with number 1 and continue consecutively until all plumbing valves are numbered. The heating and cooling valves shall start with number 1 and continue consecutively until all heating and cooling valves are numbered. A copy of the valve tag charts shall also be contained in the operation and maintenance manual.

## 2.05 ACCESS DOORS

- A. The contractor shall furnish access panels not smaller than 16 X 16" for access to concealed valves, traps, dampers, etc. where no other means of access is provided. Access panels shall be all steel construction with nom. 16 gauge wall or ceiling and nom. 14 gauge panel door with not less than 1/8" insulation secured to inside of the door. Doors shall be supported with concealed hinges and secured with suitable clips and countersunk flush screws. Outside of access panels shall be flush with finished wall or ceilings, except that where panels are located in acoustic tile or paneling, the door shall be recessed to receive adjacent finish material. The contractor shall determine the final position of each access door and the size to be used. Access panels shall be as manufactured by MILCOR. Fire ratings of access door shall not be less than the surface on which the door is installed. Where required by specifications locking access doors shall be fitted with a HL302 lock cylinder and key.

## 2.06 ELECTRIC MOTORS

- A. The contractor shall provide and install all electric motors for equipment furnished under Division 15. All motors shall be NEMA standard design for quiet operation. The motors shall be of ample size to operate at their proper load and full speed continuously without causing noise, vibration or temperature rise in excess of the rating. Provide high efficiency motors when called for on the drawings or hereinafter specified.
- B. Motors with belted drives shall be mounted in a manner to allow for belt

adjustment. All belts shall be adjusted before turning project over to owner. All motors with belt drives shall have belt guards.

## 2.07 ELECTRIC MOTOR STARTERS

The contractor shall furnish all motor starters complete with lugs sized to receive conductors specified and with accessories as required such as stop-start push button switches, hand-off-auto selector switches, pilot lights, remote switches, auxiliary contacts, transformers, relays, fuses and overload thermal units or heaters. Contractor coil voltage shall be 24 volts. All components are to be housed within enclosure.

- A. The motor starters shall be the type to meet the requirements of the motor and shall be in accordance with NEMA Standards, sizes and horsepower ratings. The starters shall be manufactured by SQUARE 'D', GENERAL ELECTRIC, CUTLER-HAMMER or SIEMENS.
- B. Three phase motors shall have across-the-line magnetic starter and single-phase motors shall have manual starters. The starters shall have NEMA 1 enclosures unless otherwise noted or required. Outdoor starters shall have weatherproof enclosures.
- C. The starter shall have an overload thermal unit in each phase conductor. The thermal units shall be sized as recommended by the manufacturer for full protection of the motor.
- D. All three phase motors and equipment with compressors shall be provided with three phase motor protectors as manufactured by DIVERSIFIED, SLM-ASE series (match voltage to corresponding model number). Unit shall include range plug, output fuse, output switch, line adjustment, status/trouble lights and adjustable/selectable operation with built-in time delays. Unit shall be U/L labeled. Protectors as manufactured by TIMEMARK #265 or MOTECTOR Power Guardian PLUS shall also be acceptable.

## 2.08 EQUIPMENT

- A. Equipment shall be furnished and installed as listed in the specifications or as required for a complete project.
- B. All equipment shall be new and shall bear the manufacturer's name and trade name. The equipment furnished under each section of the specifications shall be essentially the standard product of a manufacturer regularly engaged in the production of the required type of equipment.
- C. All three phase equipment and equipment with compressors shall be provided with three phase motor protectors as manufactured by DIVERSIFIED, SLM-ASE series (match voltage to corresponding model number). Unit shall include range plug, output switch, line adjustment, status/trouble lights and adjustable/selectable operation with built-in time delays. Unit shall be U/L

labeled. Protectors as manufactured by TIMEMARK #265 or MOTECTOR Power Guardian PLUS shall also be acceptable.

- D. Nameplates/Labels – Provide engraved pin-attached laminated plastic nameplates for all pumps, air handling units, exhaust fans, boilers, chillers, fan powered heaters unit ventilators, fan coil units, blower coil units, terminal devices, VAV boxes, VRF units, fire dampers, smoke detectors and roof mounted equipment. Where equipment is located above the ceiling, nameplates shall be mounted on the ceiling below the device. Exhaust fans located on the roof will require two separate nameplates; one is to be attached to the fan, the other on the ceiling grid directly below the fan. Each nameplate shall identify the item served, such as “PRV-2.” or “SMOKE DETECTOR AHU-1” Laminated plastic shall be one eighth (1/8) thick, black with white center core, exception: fire damper nameplates shall be red with white center core. Nameplates shall be a minimum of one inch by three inches, with minimum one-quarter inch high block lettering. Adhesive backed, embossed lettering tape is not acceptable. Exhaust grilles or registers in each space shall be labeled. Each label shall identify the exhaust fan serving this grille or register, such as “PRV-2”. Identification labels shall be BROTHER type “P-TOUCH”, clear tape with upper case letters, minimum ¼ inch high block lettering, and black printing and shall be located on the ceiling grid next to the grille or register.
- E. Filters- Filters shall have a minimum MERV rating of 13.

### **PART 3 - EXECUTION**

#### **3.01 PIPE, FITTINGS AND JOINTS**

- A. Pipe and Fittings
1. Pipe, fittings and specialties stored at the job shall be stored in such a manner as to prevent dirt and moisture from collecting in the material. Openings in the piping system during construction shall be protected at all times from foreign matter entering the piping system. PVC piping shall not be stored in direct sunlight.
  2. Installation - The piping shall be installed complete and shall be of the size required by code. When a size is not indicated or is in conflict with other drawings, the contractor shall request the pipe size from the engineer. All piping shall be cut accurately from dimensions established at the project site and allowances shall be made for the clearance of windows, doors and other openings. No part of the building structure may be cut to allow for the installation of piping unless specifically approved in writing.

3. All piping shall be installed parallel or perpendicular to the building construction and shall be installed so as to allow for expansion and drainage. Due to the small scale of the drawings, it is not possible to show all elbows and swing joints required to allow for expansion; however, the contractor shall install three elbow swing joints at all runouts and other connection to mains.
  4. Install continuous galvanized sheet metal drip pan under all water piping passing through all rooms with electrical equipment such as electrical, elevator equipment and transformer rooms and all other spaces provided primarily for the installation of electrical equipment. Drip pan shall be channeled out of the space and be extended to the closest drain.
  5. Eccentric reducing fittings or eccentric reducing couplings shall be installed to bring top of mains in line and prevent pockets. Eccentric fittings will not be required on water mains. Ends of pipes shall be reamed out before being installed.
  6. Pipe Sleeves
    - a. Pipe sleeves shall be installed on all pipes passing through walls, ceilings and floors except floor slabs on grade. On insulated pipes the sleeves shall be large enough to pass the insulation without damaging the vapor barrier. The ends of the sleeves shall extend 1/2" above the finished floor and made watertight around sleeve. Where pipes pass through fire rated floors and wall the space between the pipe and the sleeve shall be fire stopped and smoke stopped with the appropriate U.L. rated assembly. Sleeves not in contact with the earth shall be schedule 40 black steel pipes, except sleeves in poured concrete slabs above grade may be a manufactured pipe sleeve. PVC sleeves shall not be used in plenum spaces.
    - b. Pipe Sleeves in contact with the earth shall be cast iron. The space between the pipe and the cast iron pipe sleeve shall be packed with oakum with a lead joint and made watertight. The pipe passing through and under footings and wall below grade shall have cast iron sleeves. The sleeves not entering the building need not be watertight.
- B. Piping Joints
1. Screwed Joints - Screwed joints shall be made with full cut American Standard Pipe Thread. All pipes shall be reamed to full diameter of the pipe. Pipe thread compound shall be applied to the male thread only.
  2. Welded Joints

- a. Welded joints for steel pipe 2 1/2" and larger shall be made in accordance with the procedure standard in the American Standards Association piping code, and before assigning any welder to work covered, the contractor shall provide for the approval of the name(s) of pipe welders to be employed in the work, together with certification that each of these welders has passed qualification tests as prescribed by the National Certified Pipe Welding Bureau or by other reputable testing laboratory or agency using procedures approved by the ASME or American Welding Society. The contractor shall use only approved factory manufactured welding type fitting for the intersection welding or branching to mains. Valves and specialties shall have screwed or flanged joints.
  - b. Welding tees, ells, reducers and caps shall be of wrought or forged construction similar to those manufactured by TUBE TURNS, INC. In lieu of wrought or forged welding tees for branch outlets, weldolets or welding nipples may be used; provided, first that the nipples are accurately coped in the shop to fit the pipes and leveled for field welding; and provided, second that openings in the walls of pipes are cut to full inside diameter of the nipples; and third, that the outlet diameter shall be less than 3/4 the diameter of the main.
  - c. For connections on welded piping to valves 2 1/2" and over and that of other accessories required to be flanged, weld neck or slip-on companion flanges shall be used. The flange face shall be in every case perpendicular to the axis of the pipe valve.
3. Solder Joints - the solder joint above grade shall be made, unless otherwise noted, with 95/5, lead free solder using approved flux. All underground joints and refrigeration joints shall be made with an approved silver bearing solder. Cut pipe shall be reamed to full diameter. Copper to steel pipe shall be made with proper fittings.
  4. Cast Iron Pipe Joints - for bell-and-spigot soil pipe the joint shall be firmly packed with oakum and filled with molten lead not less than 1" deep and not to extend more than one-eighth inch below the rim. The use of a neoprene gasket when installed in accordance with the manufacturer's recommendations is also acceptable.
  5. Concrete Pipe Joint - Shall be bituminous joint compound or a cement plaster installed in accordance with the manufacturer's recommendations. Joints firmly packed with oakum and filled with a concrete mortar, which shall extend mortar to 3" beyond the hub, shall also be acceptable. All joints shall be made with precast concrete fittings.

6. Flanged joint - The flanged joint shall be made with the proper number and size of bolts and with the proper gasket between the flanges.
7. Plastic Pipe Joints - Shall be made with solvent as recommended by the pipe manufacturer.

### 3.02 PIPE SPECIALTIES

- A. Pipe specialties shall be installed as indicated in the specifications and as required to make a complete system.
- B. Escutcheon Plates shall be mounted on all exposed pipes extending through wall, floor, ceiling or cabinet bases. On insulated pipes the escutcheon shall be on the outside of the insulation.
- C. Pressure and Compound Gauges shall be installed with shut-off cock in the line to each gauge.

### 3.03 PIPE HANGERS AND SUPPORTS

- A. All pipes shall be supported from the building structure, and wherever possible, parallel runs of horizontal piping shall be grouped together on adjustable trapeze hangers. Single runs of horizontal piping shall be supported with clevis type hangers. The hangers shall be on the outside of the insulation. Vertical risers shall be supported at each floor line with steel pipe clamps. All hangers in contact with copper pipe shall be copper plated. The use of wire or perforated metal to support pipe will not be permitted. In no case shall copper pipe be in contact with a ferrous metal.
- B. The pipe hanger spacing and support shall be as listed under 2.03 in this section.
- C. Where piping is supported from the steel, the support shall be attached at the top of the steel. Attachments shall be made either by welding or using top beam clamps.
- D. Any supplemental steel required between building structural members shall be provided by this contractor.

### 3.04 VALVES

- A. The contractor shall install valves where indicated on the drawings and where required for adequate control of the system. Provide shut-off valves at the base of the risers and main branches at points of take-offs from the supply or return mains. Branches shall be considered main branches when they serve three or more units or fixtures. Provide valves necessary to isolate each piece of



equipment separately from the remainder of the system. Valves shall be installed in accessible locations. Allow isolation for inspection, maintenance and repair of each piece of equipment and each service loop. Provide valves to allow for the phasing of work where required. Valve size shall be the same as the pipe size except for control valves.

- B. Valves shall be installed with their stems in an upright or horizontal position. Stems shall not be inverted.
- C. After approval of a particular valve, this type valve shall be used throughout the project. Do not mix styles or manufacturers.
- D. Ball valves shall be provided with a 2" extended handle of a non-thermal conductive material and shall include a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing the insulation. Extended handle shall be internally insulated.

### 3.05 ACCESS DOORS

- A. Install hinged and lock type access doors as required for operation and maintenance of equipment. The access doors shall be installed so that they maintain the rating integrity of the material in which they are mounted. Those with an exposed surface in a finished area shall be flush with the finished material with a recessed space for installation of flush matching materials when in panel or acoustical tile.

### 3.06 ELECTRIC MOTORS

- A. Electric motors shall be supplied with equipment furnished under Division 15. All moving parts shall be protected as required by OSHA.

### 3.07 ELECTRIC MOTOR STARTERS

- A. Electric motor starters and accessories shall be installed under Division 16.
- B. Three phase motor protectors shall be installed in accordance with manufacturers' recommendations and installation instructions. Unit shall be selected for voltage specified.

### 3.08 EQUIPMENT

- A. The contractor shall receive and properly store the equipment pertaining to the mechanical work. The equipment shall be tightly covered and protected against dirt, water, chemical or mechanical injury and theft. The manufacturer's directions shall be followed completely in the delivery, storage, protection and installation of all equipment and materials.

- B. The contractor shall provide and install all items necessary for the complete installation of the equipment as required by code without additional cost to the owner, regardless of whether the items are covered in the specifications. Such items could be - but are not limited to: concrete pad, supports, vibration eliminators, additional piping and valves, motor controllers, relief valves and piping, insulation, electrical wiring, lubrication, refrigerants and start-up and service.
- C. It shall be the responsibility of the contractor to clean the equipment, make necessary adjustments and place the equipment into operation before turning equipment over to the Owner. Any paint that was scratched during construction shall be touched-up with factory color paint. Any items that were damaged during construction shall be replaced.
- D. Where equipment is supported from the steel, the support shall be attached at the top of the steel. Attachments shall be made either by welding or using top beam clamps.
- F. Three phase motor protectors shall be installed in accordance with manufacturer's recommendations and installation instructions. Unit shall be selected for voltage specified. Motor protectors shall be installed prior to start-up.
- G. Permission for the use of new HVAC equipment to be used as a method for providing temporary heating or cooling shall be at the discretion of the owner. The use of new HVAC equipment for temporary heating or cooling shall not modify the terms of the warranty nor shall it constitute substantial completion or beneficial use. The mechanical contractor is responsible for providing a dust free HVAC system and shall correct all equipment or system damage caused by construction operations. New HVAC equipment used for temporary heating or cooling shall have the filters changed on a regular basis or as directed by the owner and prior to turning over equipment for permanent operation. The spare filters provided by the specifications shall not be used for this purpose. The equipment fan belts shall be inspected for excessive wear and replaced as directed by the owner. The equipment cooling coils, condensing coils, heat exchangers, energy recovery devices and associated ductwork shall be inspected for cleanliness and cleaned as directed by the owner, to a level satisfactory to the owner which may include this work to be done by an independent third party contractor at this contractors expense.
- H. The mechanical contractor shall set all outside air dampers to the approximate minimum position during equipment installation and prior to the start- up of equipment.
- I. The installer shall be responsible for providing and installing new fan or motor sheaves and belts when required to obtain the designed airflow.

END OF SECTION

## SECTION 15250

### INSULATION

#### PART I - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division I - General Requirements, Section 15010 - General Provisions and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include providing and installing the insulation on the items listed in this section or as shown on the drawings.

##### 1.03 QUALITY ASSURANCE

A. All insulation shall have a composite fire hazard rating as tested by ASTM E-84, NFPA 25 or UL 723 not to exceed 25 flame spread, 50 smoke developed, and 50 fuel contributed.

##### 1.04 SUBMITTALS

Provide shop drawings on proposed insulation as described in section 15010 - 1.04. Shop drawings shall include proposed uses of all insulation components.

#### PART 2 - PRODUCTS

##### 2.01 GENERAL

A. The manufacturer of the products specified in this section shall be OWENS-CORNING, CERTAIN-TEED, JOHNS-MANVILLE, ARMSTRONG, MANSON or KNAUF.

##### 2.02 PIPING INSULATION

A. The piping shall be insulated with heavy density rigid molded fiberglass pipe insulation with factory applied all service jacket (ASJ) with a 'K' factor not to exceed .25 @ 75°F mean temperature. The minimum insulation thickness for the various items shall be as follows:

1. Domestic Cold Water Piping and Cold Water Makeup Piping - 1/2".  
Exceptions: Exterior walls and plumbing chases shall be 1".

2. Trap Primer Supply Piping - 1/2" elastomeric, expanded closed cell, seamless pipe insulation from the drain tap to the trap primer valve or distribution unit.
  3. Domestic Hot Water, Tempered Water and Hot Water Recirculating Piping -1". Piping greater than 1 1/2" shall have 1 1/2" thick insulation. Exceptions: Fixture runouts in interior plumbing chases and walls may be 1/2".
  4. Storm Water (includes main and overflow piping) - The horizontal section of the rain leaders, riser to and including the interior part of the roof drains shall have 1" of insulation. The drain body and sump receiver of the roof drain shall have 1" of rigid fiberglass board insulation. Above slab piping serving open site drains shall have 1" pipe insulation from the open site drain to the rain leader.
  5. Hot Water Heating Supply and Return
    - a. Pipe Size 1-1/2" and Under - 1".
    - b. Pipe Size 2" and larger - 2".
  6. Chilled Water Supply and Return
    - a. Pipe Size 3" and under – 1 ½
    - b. Pipe Size 4" and larger – 2"
  7. Condenser Water Supply & Return – 1-1/2".
  8. Condensate Piping - 1".
  9. Refrigerant Piping - 1" closed cell, semi-slit pipe insulation with a composite fire hazard rating as tested by ASTM E-84 not to exceed 25 flame spread and 50 smoke developed. Prototype: ARMSTRONG Armaflex AP.
  10. Domestic water piping in the cells of masonry walls shall have be polyolefin pipe insulation such as "IMCOLOCK" with a ½ inch wall thickness
  11. Where chilled/hot water piping is installed within the airstream of mechanical equipment, piping shall be insulated with flexible closed cell elastomeric pipe insulation. Insulation thickness shall be 3/4 inch.
- B. Sheet Metal Saddles - See section 15050 - 2.03.
- C. Finish - Exposed Piping - Cover with 8 oz. canvas jacket.

1. Exposed piping in the kitchen shall be insulated per the specification and covered with a PVC jacket 20 mil thick, white in color, washable and approved by the USDA and the FDA.

### 2.03 PIPING, FITTINGS, VALVES AND SPECIALTIES INSULATION

- A. Fittings, valves and specialties for the piping systems shall be insulated by two-piece molded fiberglass fittings with an insulating value equivalent to the pipe insulation. Acceptable alternative insulation methods shall be as described in paragraph 3.02 D.
- B. The following piping, fittings, valves, and specialties shall be insulated.
  1. Domestic cold water piping
  2. Domestic hot water, tempered water and hot water recirculating piping
  3. Hot water heating supply and return
  4. Chilled water supply and return
  5. Condensate piping
  6. Condenser Water Supply & Return
- C. Finish - Insulation on exposed piping fittings, valves and specialties shall be covered with an 8-oz. canvas jacket.

### 2.04 EQUIPMENT INSULATION

- A. Chilled Water Pump, Chilled Water Standby Pump, Cooling Tower Pump and Cooling Tower Standby Pump- Pumps shall be encased with a sectional fabricated, flanged insulated split metal housing to provide ease of maintenance without damage to the insulation. Housing shall incorporate integral latching devices. Housing shall be tight sealing to prevent air infiltration. See drawing detail. All internal surfaces shall be insulated with 6 pounds per cubic foot density fiberglass board having a "K" value of 0.22@ 75 Deg F mean temperature with a factory applied all service jacket (ASJ). Minimum insulation thickness shall be one inch.
- B. Chiller Cooler and Chilled Water Air Separators - All cold surfaces shall be insulated with one inch thick fiberglass insulation. 'K' factor shall not exceed 0.27 @ 75°F mean temperature with a density of 6.5 pounds per cubic foot. Chilled and hot water expansion tanks are not required to be insulated.
- C. Finish - All insulation on chiller cooler and chilled water air separator shall be covered with an 8-oz. canvas jacket.

### 2.05 DUCTWORK INSULATION

- A. Concealed Supply/Return, including flexible connections (horizontal FCU's) And Outside Air Ductwork - Unless noted otherwise on the drawings shall be insulated with fiberglass duct wrap insulation at 1 pound per cubic foot density,

having a facing of laminated composite aluminum foil and kraft paper reinforced with a glass reinforcing, with a perm rating not exceeding .05. The 'K' value shall not exceed .29 @ 75 degrees F mean temperature. The duct wrap insulation shall have a minimum thickness of 2 inches. Insulate flexible connections on horizontal fan coil units.

- B. Exposed Supply/Return and Outside Air Ductwork - Unless noted otherwise on the drawings shall be insulated with 6 pounds per cubic foot density fiberglass insulating board having a facing of laminated composite aluminum foil and kraft paper reinforced with a glass reinforcing with a perm rating not exceeding .05. The 'K' value shall not exceed .23 @ 75°F mean temperature. The duct board shall have a minimum thickness of 1-1/2 inches. Exposed ductwork shall include but is not limited to, ductwork in accessible attics, equipment mezzanines, boiler rooms and equipment rooms. The exposed supply/return and outside air ductwork shall also be covered with an 8-ounce canvas jacket and be prepared for painting.
- C. See Section 15840 for description of any additional ductwork that shall be lined.

### **PART 3 - EXECUTION**

#### **3.01 GENERAL**

- A. All insulating material shall be installed in accordance with the manufacturer's recommendations by personnel regularly employed in the pipe, duct and equipment insulating trade.
- B. The insulation shall not be applied until all surfaces are clean and dry and until inspected and released for insulation application.
- C. A complete moisture and vapor seal shall be provided on cold surfaces where vapor barrier jackets or coatings are required. Anchors, hangers, and other projections shall be insulated and vapor sealed to prevent condensation.
- D. Pipe or duct insulation shall be continuous through walls and floor openings except where walls or floors are required to be fire stopped or required to have a fire resistance rating.

#### **3.02 PIPE INSULATION APPLICATION**

- A. Pipe insulation shall be installed in accordance with the manufacturer's instructions.
- B. Piping (except refrigeration piping) - Butt all joints firmly together. Ends of pipe insulation shall be sealed off with a vapor barrier coating at all fittings and valves. The insulation laps and butt strips shall be sealed by one of the following methods:

1. Insulation without self-seal laps shall have lap adhesive manually applied to all laps and butt strips. Stapling is not acceptable.
  2. Insulation with self-seal laps shall have lap adhesive manually applied to the outside of all laps and butt strips after installation. Stapling is not acceptable.
- C. Refrigeration Piping and domestic water piping using closed cell insulation – Butt joints and seams shall be joined together with contact adhesive Prototype-Armstrong 520 or manufacturer's recommended adhesive. Both surfaces to be joined shall be coated with the adhesive.
- D. Fittings and Valves - Shall be insulated with molded fiberglass fittings, segments of pipe covering, or with firmly compressed foil faced fiberglass blanket. Mitered joints are not acceptable. Secure in place with 20 gauge corrosion resistant wire and apply a smoothing coat of insulating cement. Vapor seal by applying a layer of open weave glass cloth fabric embedded between flood coats of vapor barrier mastic. Lap glass fabric 2 inches onto adjacent pipe. PVC covers are acceptable only if the item covered is fully insulated first. Insulation shall be installed so the cover cannot be deformed. Contractor shall request an inspection by the Owner of the insulated items prior to cover installation.
- E. Finish - All exposed piping, and piping fittings, valves and specialties insulation shall receive an 8 oz. canvas jacket smoothly pasted in place with lagging adhesive and sized with one brush coat of lagging adhesive. The finished surface shall be suitable for painting. Exposed piping includes piping in accessible attics, equipment mezzanines, boiler rooms and equipment rooms.
- F. Outdoor Piping - Weatherproofing Finishes for All Outdoor Insulation.
1. Piping - Apply aluminum metal jacket 0.016" with moisture barrier around pipe and slip edge into preformed Z lock positioned to shed water. Butt next jacket section leaving approximately 3/8" gap. Place preformed 2" butt aluminum band and wing seal.
  2. Fittings - Apply prefabricated metal fittings in composition to pipe jacketing.
- G. Sheet Metal Saddles shall be provided and installed on all pipe hangers as stated under section 15050, 2.03.
- H. Pipe Insulation Support - All insulated piping shall be supported at hanger and sleeve locations by either using a high density pipe insulation or wooden blocking, installed inside the vapor barrier for all pipe sizes one inch and larger. High-density pipe insulation shall be of the type as recommended by the manufacturer and shall be substituted for no less than the bottom half section of the fiberglass pipe insulation. The lengths of the high-density insulation shall be at least two inches longer (each end) than the length of the saddle. The lengths



of wooden blocking shall be eight inches. Wooden blocking shall be the same thickness as the pipe insulation, the same width as the pipe, shall be tapered within the insulation and shall be centered at the hanger. Remove portions of the fiberglass pipe insulation by peeling back the factory applied all service jackets from the insulation and cut out and replace the required sections for either method of insulation support. Re-wrap the vapor barrier to completely enclose the installation. Manually apply lap adhesive to the outside lap and apply butt strips. The installations shall also meet any additional requirements recommended by the insulation manufacturer.

I. Underground Pipe Insulation

1. Insulation- insulation shall be cellular glass insulation manufactured in accordance with ASTM C 552. The insulation shall be fabricated in half sections wherever possible. For large diameter piping where half sections are not practical, curved sidewall segments are permitted.
2. Jacketing- a 50 mil (1.3mm) thick self-sealing, modified bituminous membrane reinforced with a glass fabric, and a 1mil (0.3mm) aluminum top film on the outer surface.
3. Mastic- shall be asphalt cutback mastic.
4. Reinforcing Fabric- shall be open mesh polyester fabric with 6x5.5 mesh/inch configuration.
5. Sealant- shall be a non-setting butyl sealant.
6. Banding- shall be ½ inch aluminum or fiberglass reinforced nylon for insulated lines with OD's of 48 inches or less.

3.03 EQUIPMENT INSULATION APPLICATION

- A. Chiller Cooler and Chilled Water Air Separators - Shall be insulated with fiberglass insulation cut to a smooth uniform fit with butting edges. Complete installation shall not have wrinkles, bulges or overlapping edges. Secure insulation to all surfaces with adhesive designed for that purpose.
- B. Finish - All insulation on chilled water chiller cooler and chilled water air separator shall be covered with an 8-oz. canvas jacket installed as described in paragraph 3.02 D.

3.04 DUCTWORK INSULATION APPLICATION

- A. Fiberglass Duct Wrap Insulation - The duct wrap insulation shall be secured to the ductwork with fire retardant adhesive in sufficient quantities to prevent sagging. Ducts with a width of over 30" shall be further secured on the underside with mechanical fasteners on 18" maximum centers. Insulation shall

be butted with facing overlapping all joints at least 2" and sealed with fire retardant vapor barrier adhesive. Seal all breaks and punctures with vapor barrier tape and same type of fire retardant adhesive. Stapling is not acceptable.

B. Fiberglass Insulating Board Application

1. The insulating board shall be secured to the ductwork with mechanical fasteners. The fasteners shall be spaced 12" to 18" on center with a minimum of two rows per side of duct. Secure insulation in place with washers firmly embedded in insulation. Seal all joints, breaks and punctures with fire retardant vapor adhesive reinforced with a 3" wide strip similar to that of facing.
2. Finish - A glass cloth shall be applied over the facing into a wet coat of fire retardant adhesive, overlapping seams at least 2". Apply finish coat of same fire retardant adhesive.

END OF SECTION

## SECTION 15350

### NATURAL GAS PIPING

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

- A. The work under this section shall include a complete natural gas piping system.

##### 1.03 QUALITY ASSURANCE

- A. All work shall conform with the International Fuel Gas Code, NFPA 54 - National Fuel Gas Code, local gas code, and local gas supplier's requirements.
- B. The entire piping system shall be tested and approved before being placed in operation.

##### 1.04 SUBMITTALS

Provide shop drawings on all piping and valves as described in Section 15010 – 1.04. Shop drawings shall include proposed uses of all items.

#### PART 2 - PRODUCTS

##### 2.01 PIPE AND FITTINGS

- A. Gas Piping Above Ground - Shall be schedule 40 black steel pipe with malleable screwed 125 psi fittings or schedule 40 black steel pipe with 150 psi weld fittings.
- B. Gas Piping Underground - Shall be plastic pipe and compatible fittings conforming with ASTM D2513, and shall be installed as recommended by the pipe manufacturer and local requirements.
- C. Gas Piping Below Floor Slab on Grade - Shall be schedule 40 black steel pipe with malleable screwed 125 psi fittings run inside a pipe sleeve that is vented to the outside atmosphere. Pipe sleeves that are located below floor slabs, in walls or non-plenum spaces shall be schedule 40 PVC pipe and fittings. Pipe sleeves located in plenum spaces shall be welded schedule 40 black steel pipe with 150 psi welded fittings. Pipe sleeves shall terminate to the outside atmosphere

through the roof or exterior wall, shall be turned down to prevent water from entering system and shall have a bug screen over the end of pipe.

## 2.02 VALVES

- A. Gas valves shall be of the approved type with an AGA/UL label and shall be installed as required. Gas valves shall not be located in plenum spaces. Provide operating nut in lieu of lever handle for all valves located outside of the building. Pressure regulating valves shall be as manufactured by SENSUS or MAXITROL.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The Contractor shall coordinate the service with the local gas supplier.
- B. The Contractor shall make the gas connection to all gas equipment.
- C. The Contractor shall coordinate the gas pressures required with the local gas supplier. Gas piping to the emergency generator shall be supplied at 2 psi from the meter and throttled down to a minimum of 11" W.C. at the generator, and shall have a dedicated line from the meter to the generator.
- D. Unions shall not be located in plenum spaces.
- E. Provide locking access doors at classroom gas shut off valves in science areas.
- F. All pressure regulating valves inside the building shall be vented, with Sch. 40 black steel pipe, through the roof and terminated with a gooseneck and stainless steel insect screen. All exterior pressure regulating valves shall be installed so that the vent opening is clear and protected from debris and freezing.

END OF SECTION

## SECTION 15351

### COMPRESSED AIR PIPING SYSTEM

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

- A. The extent of compressed air piping work and auxiliary equipment is indicated by drawings and schedules and by requirements of this section, and is hereby defined to include (but not necessarily be limited to) air compressor, receiver, air dryer, belt guard, all required air piping, needle valves, automatic tank drain and outlets as indicated and as specified. Provide blow-off valves at low points and intake filter silencer on exterior of building, piped to compressor.

##### 1.03 QUALITY ASSURANCE

- A. ANSI Code Compliance - Comply with applicable provisions of ANSI B 31.1, "Power Piping."
- B. ASME Code Symbol Stamps - Provide compressed air receivers and safety (pressure relief) valves complying with applicable ASME codes, and stamped with appropriate code symbols.
- C. CGA Standards - Materials shall comply with Compressed Gas Association standards.
- D. UL Labels - Provide electrical components which have been listed and labeled by Underwriters Laboratories.

##### 1.04 SUBMITTALS

Provide shop drawings on all equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 COMPRESSED AIR PIPING

- A. Piping shall be galvanized schedule 40 steel pipe with galvanized screwed, 150 pound type fittings.

- B. Air Pressure Reducing Valve - Bronze body, sized for capacity of system and set for 125 psi outlet pressure.
- C. Pressure Gauges – 2” minimum dial with safety blowout brass gauge cock.
- D. Couplings - Provide Hansen quick connect-disconnect couplings. Type shall be suitable for use with Owner’s equipment.
- E. Valves - Safety relief valve shall be 2 piece, full-port, chrome plated ball valve rated for 125 psi operating pressure.

## 2.02 AIR COMPRESSOR

- A. General - Furnish and install a self-contained compressor unit, consisting of a compressor, motor, V-belt drive, and pressure regulator, all mounted on a vertical ASME receiver. Suitable interconnecting piping between the compressor, receiver and pressure regulator shall be included.
- B. Performance - The compressor shall deliver not less than the scheduled cubic feet of free air per minute at inlet conditions compressed to the indicated pressure. Inlet conditions of 14.7 psia and ambient temperature of 90°F. Provide the Owner with a copy of the test/start-up record.
- C. The Tech Lab air compressor shall deliver 10.9 ACFM free air delivered at 125 PSIG, 80 gallon ASME receiver, 3 HP V(select) PH(select) 60HZ. Options shall include; ASME pressure relief valve, automatic tank drain, stop-start control, belt guard, low oil control, starting unloader, and intake filter silencer. Provide phase protector as required in section 15050.
- D. Receiver shall be built in accordance with ASME “Unfired Pressure Vessel Code” for a working pressure of 150 PSI, and shall be stamped with official ASME symbol, name of manufacturer, maximum allowable working pressure, year built, and National Board Number. Provide an ASME approved safety valve set to relieve at a pressure not in excess of working pressure of receiver. Valve shall be installed directly in receiver. Receiver shall be provided with a pressure gauge having not less than 2” dial graduated to not less than 1½ times maximum operating pressure. Gauge shall be installed on, or connected directly to receiver.
- E. Compressor and receiver shall be installed on a concrete foundation not less than 4” high, having vibration isolation pads.
- F. Automatic Condensate Trap - Automatic condensate trap shall be provided to remove accumulated moisture from the discharge receiver and aftercooler.

**PART 3 - EXECUTION**

## 3.01 INSTALLATION

- A. General - Comply with requirements of section 15010 for installation of basic piping materials. Install compressed air piping products and equipment in accordance with manufacturer's written instructions, applicable requirements of ANSI B 31.1, and in accordance with recognized industry practices.
- B. The manufacturer shall provide the services of a qualified representative to review the installation of the compressors and all components, test and start the compressors, and instruct the Owner's operating personnel in the operation and maintenance of the systems.
- C. Extend compressed air lines from receiver to rooms and outlets indicated on the drawing and connect to all equipment requiring compressed air.
- D. Pitch piping in direction of flow and provide drip pockets and nipples at low points. Provide stopcocks and unions to permit disconnection at equipment.

## 3.02 PIPE TEST

Compressed Air Piping Leak Test - Prior to initial operation of piping system, purge lines with oil-free air, and perform a 24-hour standing pressure time-test. Charge line with compressed air to 150 psi; maintain test pressure for 24 hours with a pressure loss no greater than 5 psi. During pressure test, test joints and fittings for leaks with soap bubble solution.

END OF SECTION

## SECTION 15401

### DOMESTIC WATER PIPING SYSTEM

#### PART I - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include a complete domestic water piping system.

##### 1.03 QUALITY ASSURANCE

All water piping shall be tested for leaks before the insulation is applied and before the piping is covered up. The test shall be at least 100 psi of water pressure for duration of 12 hours.

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

All casting used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

##### 1.04 SUBMITTALS

Provide shop drawings on all piping and valves as described in Section 15010 - 1.04.

#### PART 2 – PRODUCTS

##### 2.01 PIPE AND FITTINGS

- A. Water service piping- Shall be class 150 ductile iron lined tar coated piping with mechanical or slip joints.
- B. Water piping below grade- Shall be type 'K' soft drawn copper tubing with 125 psi wrought copper sweat fittings soldered with silver solder.
- C. Water piping below grade (trap primer supply) - Shall be type 'K' soft drawn copper continuous tubing.



- D. Water piping above grade- Shall be one of the following:
1. Type 'L' hard drawn copper tubing with 125 psi wrought copper sweat fittings and all joints soldered with 95/5 or silver solder.
  2. The use of mechanically formed tee connections is acceptable. Branches shall be formed up to the run tube size as shown in ASTM 2014. Forming procedures shall be in accordance with tool manufacturer's recommendations.
  3. Grooved mechanical pipe couplings, fittings, valves and other grooved components may be used as an option to brazing, soldering or flanged methods. All grooved components shall be of one manufacturer and conform to local code approval. Grooved end product manufacturer to be ISO-9001 certified. Grooved couplings shall meet the requirements of ASTM F-1476. Grooved components shall be manufactured by VICTALUIC. Grooved components manufactured by GRINNELL or ANVIL INT. are acceptable providing all aspects of the specification are met. No substitutions.
    - a. All products shall be UL classified in accordance with ANSI /NSF-61 for potable water service and shall meet the low-lead requirements of NSF-372.
    - b. Copper pipe shall be roll grooved in accordance with manufacturer's current listed standards.
    - c. Mechanical couplings for joining copper pipe shall be cast of ductile iron conforming to ASTM A-395, grade 65-45-15 and ASTM A-536, grade 65-45-12. Housings shall be cast with an angle pattern bolt pad for direct connection of copper without flaring to IPS dimensions. Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to physical properties of ASTM A-449 and ASTM A-183. Couplings shall be coated with copper colored alkyd enamel paint. Zinc electroplated bolts and nuts conforming to ASTM B633 shall be provided for couplings.
    - d. Gaskets for grooved piping shall be molded of synthetic rubber in a configuration conforming to the copper tube size outside diameter and coupling housing. Gaskets shall be "E" EPDM compound designated for domestic water use and complying with ASTM, UL/ULC and ANSI/NSF standards.
    - e. Couplings shall be installation-ready, for direct slab installation without field assembly.

- f. Fittings for grooved piping shall be full flow smooth turn copper fittings with copper tube size grooves designed to accept grooved end couplings. Fittings shall be wrought copper per ASTM B-75 alloy C12200 and ANSI B16-22; bronze sand castings per ASTM B-584 copper alloy CDA 836 (85-5-5-5) per ANSI B16.18. Victaulic copper connection.
4. Exposed water piping to plumbing fixtures - Shall be chrome plated brass piping and fittings and chrome plated standoff hangers.

## 2.02 VALVES

Valves shall be manufactured by VICTAULIC, STOCKHAM, JENKINS, HAMMOND, MILWAUKEE, CONBRACO INDUSTRIES, INC., APOLLO VALVES, FAIRBANKS, CRANE, WATTS, NIBCO or JOMAR. All valves shall be certified to be lead free in accordance with NSF/ANSI 61 section 8, which states that the wetted surfaces of all plumbing valves shall have a weighted-average lead content of no more than 0.25%.

- A. Ball valves 2 1/2" and smaller- These valves shall be sweated bronze full port, with chrome plated ball, have extended insulated handles (such as NIBCO'S Nib-seal or Apollo Valves Therma-seal) and rated at not less than 200-pound wog.
- B. Gate valves larger than 2 1/2" - Shall be flanged iron body OS & Y gate valve with stainless steel or bronze trim, ductile iron wedge and a minimum rating of 125 psi and 200-pound wog.
- C. Check valves 2 1/2" and smaller - Shall be sweated bronze, horizontal swing check valves with solid bronze discs and a minimum rating of 200-poundwog.
- D. Check valves larger than 2 1/2" - Shall be flanged ductile iron, horizontal swing check valves with stainless steel or cast iron disc and a minimum rating of 200-pound wog.
- E. Balancing valves – Valves shall be manufactured by CIRCUITSOLVER with integrated union assembly model CSUA. Thermostatic balancing valve assembly shall include union body and ball valves. CIRCUITSOLVER vales size 1/2" to 1", based on pipe size, shall be rated for the return system temperature (110°F, 120° F, 140°F). Acceptable manufacturers shall include HAYS FLUID CONTROLS.

## 2.03 PRESSURE REDUCING VALVES

Pressure reducing valves shall be as shown on drawings and shall be manufactured by MUELLER, WATTS or A.W. CASH.

2.04 STOP VALVES

- A. Stop valves shall be bronze and shall be manufactured by NIBCO, BRASS CRAFT, McGuire, APOLLO, T & S BRASS or as identified in Section 15450 or 15451. Stop valves shall be loose-key type under all wall hung fixtures and shall be 1/4 turn ball valves with chrome plated ball, under all countertop fixtures. Compression fittings are not acceptable.

2.05 TRAP PRIMER VALVES

- A. Trap primer valves shall be as shown on drawings and shall be manufactured by MIFAB, SMITH, JAY R JOSAM or ZURN. The prototype for trap primer valves is MIFAB model MR-500 (discharging 1/2 ounce of water each time a line pressure drop of 3 PSI is registered), with MIFAB model MI-DU distribution unit when multiple traps are supplied with a single primer valve.

**PART 3 - EXECUTION**

3.01 PIPING SUPPORTS

Piping supports in general shall be as called for in section 15050. The water piping in the plumbing chases shall be supported from the waste and vent pipes. The manufactured support system shall hold pipes secure to prevent vibration, to assure outlets are in proper position for fixture setting, and provide electrolytic isolation. Support of pipe, tubing and equipment shall be accomplished by means of engineered products, specific to each application. Makeshift, field devised methods shall not be allowed. The Supports shall be as manufactured by HOLDRITE, M-CO., ADJUSTO-SYSTEM, SUMMER SYSTEM, CARPENTER&PATTERSON, or BRACKET SYSTEM.

3.02 SHOCK ABSORBERS

Shock absorbers shall be installed on the branch pipe supply to all quick opening and closing fixtures (including flush valves). Shock absorbers shall be sized in accordance with Plumbing and Drainage Institute Standard PDI-WH201 and shall be located as recommended by that Standard so as to protect all flush valves on a branch pipe. Provide access panels for all shock absorbers located in concealed locations. Shock absorbers shall be constructed of a stainless steel shell with an elastomer bellows, stainless steel adaptor and male threaded plug. Shock absorbers shall be manufactured by JOSAM, JAY R. SMITH, or ZURN.

3.03 CLEANING/DISINFECTION OF PIPING SYSTEM

The entire piping system shall be flushed, disinfected and restored to operation in accordance with the provisions of the international plumbing code and the Health Department requirements. All new, repaired or extensions of existing piping systems

shall be flushed and disinfected prior to utilization. Provide owner with a copy of the disinfection report. The report shall include as a minimum, chlorine solution concentration/duration method used, system pH level data including levels prior to commencement of work, levels during pre-flushing and levels during post flushing. System cleaning shall be witnessed by the owner.

### 3.04 VALVES

- A. Gate Valves/Ball Valves - Shall be installed at the service entrances, at the base of all risers and in the distribution system to isolate a group of three or more fixtures as well as at each shock absorber location.
- B. Stop Valves - Shall be installed at each fixture.
- C. Pressure Reducing Valves - Shall be installed at the service entrance when the water pressure exceeds 60 psi. Renewal projects shall have existing pressure reducing valves replaced. All valves shall have pressure gauges.
- D. Check Valves- Shall be installed in water supply lines to all Mop Basins, Laundry Trays and kitchen 3 compartment sink.

### 3.05 PIPE INSULATION

Pipe insulation shall be as called for in section 15250.

### 3.06 WATER SERVICE PIPING

Water service piping shall be installed below the recorded frost line but not less than three feet below the finished grade.

### 3.07 MECHANICALLY FORMED OUTLETS

- A. Mechanically formed outlets shall have a collar height not less than three times the thickness of the branch tube wall. The branch shall be notched to conform to the inner curve of the run and shall be dimpled or otherwise impeded from penetrating the run pipe/tube. The branch tube shall also be dimpled to indicate the location of the notches with respect to the run. Such marking shall be at a sufficient distance from the face of the joint to allow for a visual point of inspection after the joint is brazed. All joints constructed using this method shall be brazed. Note: soft soldered joints will not be permitted.

### 3.08 GROOVED PIPING

- A. Pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for the proper gasket sealing.
- B. Gasket style and material shall be verified as suitable for the intended service.

- C. Grooved end fittings, couplings, flange adapters, and valves shall be sized to copper tube dimensions. Flaring of pipe ends to IPS dimensions is not allowed.
- D. All grooved components shall be of one manufacturer.
- E. Grooved connections shall not be installed in inaccessible concealed locations.
- F. Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions.
- G. Gaskets shall be molded and produced by the coupling manufacturer, and shall be verified as suitable for the intended service.

END OF SECTION

## SECTION 15405

### SOIL, WASTE, AND VENT SYSTEM

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include a complete soil, waste and vent system.

##### 1.03 QUALITY ASSURANCE

The entire system shall be tested and approved as required by the plumbing code and local requirements before the system is covered up.

##### 1.04 SUBMITTALS

Provide shop drawings on all piping and fittings as described in Section 15010 - 1.04.

#### PART 2 - PIPE AND FITTINGS

##### 2.01 PIPE AND FITTINGS

###### A. Materials

1. Cast Iron Soil Pipe and Fittings- Hubless Cast Iron pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International. Hubless Couplings shall conform to CISPI Standard 310 and be certified by NSF International. Heavy Duty couplings shall conform to ASTM C 1540 and shall be used if indicated. Gaskets shall conform to ASTM C 564. All pipe and fittings to be produced by a single manufacturer and are to be installed in accordance with manufacturer's recommendations and applicable code requirements. Couplings shall be installed in accordance with the manufacturer's band tightening sequence and torque recommendations. Hub and Spigot Cast Iron pipe and fittings shall be manufactured from grey cast iron and shall conform to ASTM A 74. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International. Manufacturers shall be one of the following:

- a. AB & I Foundry
  - b. Charlotte Pipe and Foundry
  - c. Tyler Pipe
2. PVC Schedule 40 Pipe and Fittings- shall be manufactured from PVC compound with a cell class of 11432 per ASTM D 4396 for pipe and 12454 per ASTM D 1784 for fittings and conform with National Sanitation Foundation (NSF) Standard 14. Pipe shall be iron pipe size (IPS) conforming to ASTM D 2665. Injection molded fittings shall conform to ASTM D 2665. Fabricated fittings shall conform to ASTM F 1866. All pipe and fittings to be produced by a single manufacturer and be installed in accordance with manufacturer's recommendations and local code requirements.

#### B. Pipe Schedule

1. Soil and Waste Pipe and Fittings Below Grade: Shall be service weight cast iron bell-and-spigot pipe and fittings or schedule 40 PVC plastic pipe and PVC-DWV fittings.
2. Soil, Waste and Vent Pipe and Fittings Above Grade: Shall be service weight cast iron bell-and-spigot pipe and fittings, schedule 40 galvanized steel pipe with screwed cast iron drainage pattern fittings, cast iron no-hub piping and fitting or schedule 40 PVC plastic pipe and PVC-DWV fittings except as noted in paragraph '3'. PVC plastic piping shall not be used in plenum spaces. DWV copper tubing and copper drainage pattern fittings shall be used for piping at the 3-compartment sink. All piping between the science prep room sinks and the acid neutralization basin shall be acid resistant polypropylene pipe and fittings.
3. Soil, Waste and Vent Stacks - shall be cast iron bell and spigot pipe and fittings or cast iron no-hub.

#### 2.02 VENT FLASHINGS

Vent flashings shall be 3 lb. per square foot lead flashings or 2 1/2 lb. per square foot for prefabricated flashings, except on roofs where the manufacturer of the roof requires a special flashing to tie in his roofing system.

### PART 3 - EXECUTION

#### 3.01 PIPE AND FITTINGS

- A. All soil and waste piping shall be run at a minimum grade of 1/4" per foot unless otherwise noted on the drawings. The contractor shall field check all proposed soil and waste piping to verify that the piping system can be installed at the

required grade before any soil and waste piping is installed.

- B. When the Building Sewer piping is installed using non-metallic piping, an insulated tracer wire, 18 AWG minimum in size and suitable for direct burial shall be installed in the same trench as the sewer within 12 inches of the pipe, this tracer wire shall terminate at the cleanout access cover.
- C. Buried PVC schedule 40 pipe shall be installed in accordance with ASTM D 2321. Solvent cement joints shall be made in a two-step process with primer manufactured for thermoplastic piping systems and solvent cement conforming to ASTM F 656 and ASTM D 2564.
- D. Solvent cement PVC joints shall be protected from chemical agents, fire-stopping materials, thread sealant, plasticized-vinyl products or other aggressive chemical agents not compatible with PVC compounds. The system shall be hydrostatically tested after installation.
- E. All openings in the piping system during construction shall be securely capped to prevent foreign matter from entering the piping system.
- F. Piping to cleanouts shall be as shown on the drawings and as required by the local plumbing code.
- G. The minimum depth of the building sewer shall be no less than two feet below finished grade.
- H. Double sanitary tee fittings shall not be allowed for piping receiving the discharge from fixtures or appliances.
- I. PVC flanges shall not be allowed for water closets or urinals.
- J. Copper pipe and fittings shall not be used on waste piping for urinals.

### 3.02 VENTS AND VENT FLASHINGS

- A. Vent pipes shall extend 12" above the roof unless otherwise required. The minimum size vent through roof shall be 2".
- B. The lead vent flashings shall be turned down on the inside of the vent. On roofing systems where the roofing manufacturer requires a special flashing, the contractor shall install flashing as required.
- C. Vent piping shall not terminate within ten feet of outside air intake.

END OF SECTION



## SECTION 15406

### ROOF DRAINAGE SYSTEM

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include a complete roof drainage system.

##### 1.03 QUALITY ASSURANCE

The roof drainage system shall be tested for leaks before the insulation is applied and before the piping is covered up. The test shall be filling the system with water.

##### 1.04 SUBMITTALS

Provide shop drawings on all piping and fittings as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 PIPE AND FITTINGS

###### A. Materials

1. Cast Soil Pipe and Fittings- Hubless Cast Iron pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International. Hubless Couplings shall conform to CISPI Standard 310 and be certified by NSF International. Heavy Duty couplings shall conform to ASTM C 1540 and shall be used if indicated. Gaskets shall conform to ASTM C 564. All pipe and fittings to be produced by a single manufacturer and are to be installed in accordance with the manufacturer's recommendations and applicable code requirements. Couplings shall be installed in accordance with the manufacturer's band tightening sequence and torque recommendations. Tighten bands with a properly calibrated torque limiting device. Hub and Spigot Cast Iron pipe and fittings shall be manufactured from grey cast iron and shall conform to ASTM A 74. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and listed by NSF International. Manufacturers shall be one of the following.

- a. AB&I Foundry
  - b. Charlotte Pipe and Foundry
  - c. Tyler Piper
2. PVC Schedule 40 Pipe and Fittings- shall be manufactured from PVC compound with a cell class of 11432 per ASTM D 4396 for pipe and 12454 per ASTM D1784 for fittings and conform with National Sanitation Foundation (NSF) Standard 14. Pipe shall be iron pipe size (IPS) conforming to ASTM D2665. Injection molded fittings shall conform to ASTM D 2265. Fabricated fittings shall conform to ASTM F 1866. All pipe and fittings to be produced by a single manufacturer and to be installed in accordance with manufacturer's recommendations and local code requirements.
- B. Pipe Schedule
1. Storm Water Piping Below Grade: Shall be service weight cast iron bell-and-spigot pipe and fittings or schedule 40 PVC plastic pipe and PVC-DWV fittings.
  2. Storm Water Piping Above Grade: Shall be service weight cast iron bell-and-spigot pipe and fittings, cast iron no-hub piping and fittings, schedule 40 galvanized steel pipe with screwed cast iron drainage pattern fittings, or schedule 40 PVC plastic pipe and PVC fittings. PVC plastic piping shall not be used in plenum spaces.
  3. Storm water piping below grade from 5 feet outside of the building to the storm water structure may be reinforced concrete bell-and-spigot pipe with precast matching fittings.

## 2.02 ROOF DRAINS AND CLEANOUTS

Roof drains and cleanouts shall be as listed under section 15420.

## PART 3 - EXECUTION

### 3.01 PIPE AND FITTINGS

- A. All piping shall be run at a minimum grade of 1/4" per foot unless otherwise noted on the drawings. The contractor shall field check all proposed storm water piping to verify that the piping system can be installed at the required grade before any piping is installed.
- B. When the Building Sewer piping is installed using non-metallic piping, an insulated tracer wire, 18 AWG minimum in size and suitable for direct burial shall be installed in the same trench as the sewer within 12 inches of the pipe, this tracer wire shall terminate at the cleanout access cover.

- C. Buried PVC schedule 40 pipe shall be installed in accordance with ASTM D 2321. Solvent cement joints shall be made in a two-step process with primer manufactured for thermoplastic piping systems and solvent cement conforming to ASTM F 656 and ASTM D 2564.
- D. Solvent cement PVC joints shall be protected from chemical agents, fire stopping materials, thread sealant, plasticized-vinyl products or other aggressive chemical agents not compatible with PVC compounds. The system shall be hydrostatically tested after installation.
- E. All openings in the piping system during construction shall be securely capped to prevent foreign matter from entering the piping system.
- F. Piping to cleanouts shall be as shown on the drawings and as required by the local plumbing code.
- G. The piping to the roof drains shall have a minimum of 5 feet offset between the vertical rain leader and the riser to the drain for expansion unless otherwise noted.
- H. The minimum depth of the building storm sewer shall be no less than two feet below finished grade.

### 3.02 PIPE INSULATION

The horizontal section of the rain leaders, riser to and including the interior part of the roof drain, shall be insulated to prevent condensation. Pipe insulation shall be as listed under section 15250.

### 3.03 ROOF DRAINS

The roof drains and accessories shall be installed to meet the requirements of the roofing system. The roof drains shall be flashed with a 4-foot square sheet of 4-lb. lead. On roofing systems where the roofing manufacturing requires a special flashing, the contractor shall install the flashing as required.

END OF SECTION

## SECTION 15420

### PLUMBING EQUIPMENT

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include furnishing and installing the plumbing equipment and making the final connections of equipment furnished by others.

##### 1.03 SUBMITTALS

Provide shop drawings on all equipment as described in Section 15010 - 1.04. Shop drawings shall include uses of all items.

#### PART 2 - PRODUCTS

2.01 The following equipment shall be as manufactured by J. R. SMITH. Equipment fully equal to the item specified manufactured by CONBRACO INDUSTRIES, INC., APOLLO VALVE, JOSAM MANUFACTURING, WADE, WATTS, MIFAB or ZURN shall be acceptable.

- A. Cleanouts (CO) - J.R. SMITH 4031L inside, provide carpet marker(-Y) when necessary, 4293L outside, stack cleanout 4510 tapped bronze plug to accept screw for 4710 round stainless steel access cover and 4111L-U for cleanouts located in sidewalks with 4915-CO frame and access cover. Cleanouts at the Building Drain/Building Sewer junction shall have a 18"x18"x6" concrete pad with 4915-CO frame and access cover.
- B. Roof Drains (RD) - J.R. SMITH 1010 Y-C-R-AD-U, non-adjustable, aluminum dome, vandal proof, with deck clamp and drain receiver.
- C. Wall Hydrants (WH) - Shall be J.R. SMITH 5519-WC Series automatic draining, non-freeze wall hydrant with vacuum breaker and wall box with chrome finish; provide wall clamp.
- D. Mixing Type Wall Hydrants (WH-1) - Shall be J.R. SMITH 5560QTseries, automatic draining, non-freeze, hot and cold water mixing type wall hydrant with vacuum breaker; provide wall clamp; provide shutoff valve and check valve in

both of the supplies to the hydrant.

- E. Floor Drains (FD) toilet rooms & kitchen - J.R. SMITH 2005-A5NB-U-B vandal proof, sediment bucket, round bronze top and adjustable strainer. Provide SureSeal model SS3009V inline floor drain trap seal barrier.
- F. Floor Drains (FD-1) mechanical rooms and sprinkler rooms - J.R. SMITH 2220L -PB-P050 with sediment bucket and round bronze top. Provide SureSeal model SS3009V inline floor drain trap seal barrier.
- G. Floor sink (FS) - J.R. SMITH 3200-12.
- H. Shock Absorbers - J.R. SMITH 5000 SERIES.
- I. Traps for art room sinks in middle and high schools - J.R. SMITH 8730; provide slip fittings.
- J. Grease Interceptors - \* J.R. SMITH 8200 with extended top for in-floor installations and 8000/81000 for on-floor installations, see drawings for type used; provide flow control fitting and hub adapters.
- K. Check valve (condensate drains) – WATTS CV series, bronze, straight pattern swing check.
- L. Open site drain with backwater valve - J.R. SMITH 2005L-F37NB-V with ball float valve. Provide SureSeal model SS3009V inline floor drain trap seal barrier on all drains connected to the sanitary sewer.
- M. Hose Bibb (HB)- Woodford model 21 wall faucet with vacuum breaker. Hose bibs in occupied rooms shall be chrome plated with a loose tee key. Hose bibs in mechanical rooms and unoccupied spaces shall be brass finish with wheel handle.
- N. Downspout Boot (DS Boot)-JAY R. SMITH1786 series.
- O. Downspout Scupper Nozzle (DSN)-JAY R. SMITH 1770-BS cast bronze nozzle and flange with bird screen.
- P. Floor Drains (Existing to Remain) – Raise or lower floor drain to the new floor elevation. Provide new floor drain strainer and sediment bucket to fit existing drain. Provide SureSeal model SS3009V inline floor drain trap seal barrier. It is the intent of this requirement that the existing floor drains is to finish flush with new floor surfaces.
- Q. Area Drain (AD)- JAY R. SMITH 2253C-U-G large capacity drain with vandal proof grate and galvanized parts. Set drain in 24"x24"x 6" concrete pad.

## 2.02 BACKFLOW PREVENTERS

- A. Refrigerators with ice makers or ice machines – CONBRACO INDUSTRIES, INC., APOLLO VALVE Model DUCLF4N series. Backflow preventers fully equal to the items specified as manufactured by WATTS shall be acceptable.
- B. Backflow preventers for cold water make-up –CONBRACO INDUSTRIES INC. APOLLO VALVES 4ALF-200 series, reduced pressure, with captured spring cartridges and domestic ball valve shutoffs with stainless steel handles and trim, with air gap and drain line extended to floor drain. Products fully equal to the item specified as manufactured by WATTS or WILKINS shall be acceptable.
- C. Backflow preventers for irrigation systems – CONBRACO INDUSTRIES INC. APOLLO VALVES 4ALF-200 series. Product fully equal to the item specified as manufactured by WATTS or WILKINS shall be acceptable.

### 2.03 TEMPERING VALVES

- A. Tempering Valves – LEONARD LF-370 manifold, ASSE 1070 approved, with unions, balls valves, and thermometers, and TM-356-W/HA for whirlpools. Tempering valves fully equal to the item specified as manufactured by CONBRACO INDUSTRIES INC. APOLLO VALVES, POWERS, HONEYWELL, LAWLER or SYMMONS shall be acceptable.
- B. Tempering valves for locker room showers shall be CONBRACO model MVHL series, ASSE 1069 compliant with locking enclosure cabinet (no substitutions).
- C. Tempering valves for emergency showers LEONARD TM-800-STSTL-REC emergency water mixing valve mounted in a recessed stainless steel cabinet. Valve shall have an internal cold water bypass capable of 20GPM upon failure of hot water supply. Tempering valves fully equal to the items specified as manufactured by CONBRACO INDUSTRIES INC. APOLLO VALVES, POWERS, LAWLER or SYMMONS shall be acceptable.

### 2.04 ELEVATOR SUMP PUMP

STANCOR model SE-50 submersible effluent pump, 1/2 HP, 115 volts, 3600 RPM, 2" discharge connection. Pump control panel shall be STANCOR Oil Minder System, 115 volts, with built-in audible and visual alarms when pump does not run due to oil in pti or high liquid alarm. Provide silencing button for internal audible alarm. Panel shall have additional contact for remote alarm location. Junction box shall be provided with multi-pin connector and cord in lengths as required. Provide additional control panel for remote alarm in Building Engineer's Office or as shown on drawings.

### 2.05 KITCHEN EQUIPMENT FILTER (**ENGINEER TO SELECT**)

\*(normal use, engineer to edit)\*

Kitchen equipment filter- Alkalinity and pH control system filter for combi-steamer shall be manufactured by EVERPURE, Kleensteam model# EV9797-21 with model#7CB5 replacement cartridge and SS-10 cartridge model#EV9797-02 SR-X scale reducing feeder and deliming system. Provide with shutoff valve, pressure gauge and accessories recommended by the manufacturer. Connect system filter to boiler side of combi steamer.

#### 2.06 KITCHEN EQUIPMENT REVERSE OSMOSIS SYSTEM (single combi)

\*(to be used in hard water areas, engineer to edit)\*

Kitchen equipment - reverse osmosis system- Reverse osmosis/blended water system for combi-steamer shall be manufactured by EVERPURE, MRS-225CC System model# EV9970-09 with model #EV9607-41 carbon filter, model# EV9627-03 RO cartridge, model# EV9627-05 calcium cartridge, Pre-filter kit model# EV9795-81, model# EV9534-40 pre-filter cartridge and model# DEV3115-69 storage tank. Provide with shutoff valves, pressure gauges, interconnecting piping and accessories as recommended by the manufacturer. Connect system to boiler side of combi steamer.

#### 2.07 KITCHEN EQUIPMENT REVERSE OSMOSIS SYSTEM (double combi)

(to be used in hard water areas, engineer to edit)

Kitchen equipment -reverse osmosis system- Reverse osmosis/blended water system for combi-steamer shall be manufactured by EVERPURE, MRS-350CC System model# EV9970-18 with model #EV9607-41 carbon filter, model# EV9627-07 RO cartridge, model#EV9627-05 calcium cartridge, Pre-filter kit model# EV9795-81, model# EV9534-40 pre-filter cartridge and model# DEV3115-70 storage tank. Provide with shutoff valves, pressure gauges, interconnecting piping and accessories as recommended by the manufacturer. Connect system to boiler side of combi steamer.

### **PART 3 - EXECUTION**

#### 3.01 EQUIPMENT INSTALLATION

- A. Floor drains shall be installed complete including trap primer if required by local authorities. Floor drains shall be flashed with a 3-foot diameter sheet of 4 pound lead when installed above ground. The size of the floor drains shall be as shown on the drawings.
- B. Cleanouts shall be installed in an accessible location. Install carpet markers, cleanout access covers or access panels where required for accessibility. The size of the cleanouts shall be as shown on the drawings. Cleanout plugs shall be installed with a non-hardening type pipe dope on threads to allow for easy removal of plugs.

- C. Roof drains shall be installed as listed in section 15406. The size of the roof drains shall be as shown on the drawings.
- D. Wall hydrants shall be installed with backflow preventer and a stop and waste valve in an accessible location. The hydrants shall be selected to match the wall thickness at the location to be installed. Provide Owner with separate 'T' handle key for each wall hydrant.
- E. Shock absorbers shall be installed as listed in section 15401 and as required by local authority, in an accessible location.
- F. Interceptors shall be installed complete. The interceptor shall be installed as recommended by the manufacturer and local codes. Flow control devices shall be installed in the drain line from the 3-compartment sink.
- G. Air Gaps shall be installed as required by the local codes. Provide air gap fitting for all dishwashers in Home EC areas unless unit is provided with integral air gap.
- H. Neutralizing tanks shall be installed complete and as recommended by the manufacturer and local codes.
- I. Silver Recovery systems shall be owner provided and contractor installed complete as recommended by the manufacturer and local codes.
- J. Tempering valves shall be installed as recommended by the manufacturer and shall be mounted no higher than 66 inches above floor. After installation is complete, the contractor shall have the manufacturer's authorized representative verify that the installation complies with the manufacturer's requirements. The representative shall take apart and clean valve, set-up and adjust the valve for proper operation at the end of project, but before final inspection. Provide the owner with a copy of the inspection and set-up report.
- K. Elevator sump pump shall be installed in elevator pit sump as recommended by the manufacturer and as detailed. The Division 15 contractor shall install all wiring between the sump pump and the pump control panel. The Division 16 contractor shall install all power wiring.
- L. Elevator sump pump remote alarm shall be installed as recommended by the manufacturer and by the local authority. The remote alarm panel shall be furnished under Division 15. The Division 15 contractor shall install the remote alarm panel, and all wiring between the pump control panel and the remote alarm panel.
- M. The kitchen equipment reverse osmosis system shall be rack or wall mounted in an accessible location or as shown on drawings. Interconnecting piping between the reverse osmosis system, storage tank and combi steamer shall be Type L copper.



**3.02 BACKFLOW PREVENTERS**

Backflow preventers shall be installed as shown on the drawings or as required by the local codes and shall be mounted no higher than 66 inches above finished floor. Air gap and drain line shall be piped to the nearest floor drain.

END OF SECTION

## SECTION 15422

### DOMESTIC RECIRCULATING PUMP

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, section 15010 - General Provisions, and section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install the domestic recirculating pump as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

- A. Pump shall be rated to a maximum of 145 PSI and 230 degrees Fahrenheit and bear the approval symbol of the required regulatory body (NSF/ANSI 61).
- B. Electrical assemblies (circuitry, wiring terminals and internal connections) of the circulating pumps shall be certified and registered to bear the emblem of UL, CSA or ETL as required. Electrical assembly shall meet codes and standards established by national bodies.
- C. All pumps shall be factory tested prior to shipment to the job site.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 DOMESTIC RECIRCULATING PUMP

The domestic recirculating pump shall be of the centrifugal inline mounted type and of the size, capacity and voltage shown on the drawings. The pump shall be manufactured by BELL & GOSSETT. Pumps fully equal to the specified pump and manufactured by WILO or GRUNDFOS are acceptable.

- A. Circulating pumps shall be constructed with lead free, stainless steel, NSF-61 Annex G certified materials.
- B. Pump flanges shall be combination 1.25" - 2 bolt commercial oval type (rotated 90 degrees).
- C. Shafts shall be constructed of high quality stainless steel.

- D. Motor bearings shall be metal-impregnated carbon.
- E. Impellers with three-dimensional curved blades are constructed of Polyphenylene Sulfide (PPS) plastic, 40% glass filled.
- F. The circulating pumps shall have a high quality composite terminal box with NPT electrical connections and a secure, gasketed cover, Class 2 protection level. The face of the terminal box shall have an adjustment button and the display shall indicate; Operation status, Control mode, differential pressure or speed/setpoint, and fault and warning signals.
- G. Wet rotor, glandless inline circulating pumps shall include electronic variable speed control to operate at constant/variable differential pressure control without external sensors. Automatic night setback control shall be available as standard using "self taught, FUZZI" technology.
- H. Pumps shall include integrated synchronous motors using ECM technology with permanent rotors, special sensorless electronics and single phase electronic converters.
- I. Integrated overload motor protection shall protect the pump against over/under voltage, over temperature of motor and/or electronics, locked rotor and dry run (no load condition).
- J. Fault contact "FC" terminals shall be included in the terminal box and shall be potentially free, normally closed contacts that open on the event of a failure.

## 2.02 SPECIALTIES

Specialties shall be provided for all pumps, which shall include, but not be limited to, isolation valves, unions, thermometers, and check valves.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The pump shall be installed and serviced in accordance with the manufacturer's recommendations and as shown on the drawings.
- B. The pump shall be installed with the motor shaft in a horizontal plane with no exceptions. The electrical terminal box shall be installed either horizontally with the IR window to the left of the "red Button" (wiring connections to the right of the terminal box) or vertically with the IR window above the "Red Button" (wiring connections below the terminal Box).
- C. Coupling guards shall be installed per ANSI and OSHA standards.

END OF SECTION

## SECTION 15423

### DOMESTIC RECIRCULATING PUMP

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, section 15010 - General Provisions, and section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install the domestic recirculating pump as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

- A. Pump must be selected from published test curves showing actual brake horsepower. The selection point shall be confined to the left of center of the efficiency curve for the impeller being furnished.
- B. All pump motors shall meet NEMA Standards and shall be U/L listed.
- C. All pumps shall be factory tested prior to shipment to the job site.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 DOMESTIC RECIRCULATING PUMP

The domestic recirculating pump shall be of the centrifugal inline mounted type and of the size, capacity and voltage shown on the drawings. The pump shall be manufactured by BELL & GOSSETT. Pumps fully equal to the specified pump and manufactured by ARMSTRONG, WEINMANN, or PATTERSON are acceptable.

- A. Pump - Shall be quiet operating, horizontal, oil lubricated, inline, single stage, vertical split case design, and shall be all-bronze construction for domestic water applications. The pump internals shall be capable of being serviced without disturbing piping connections. The pump shall have a dynamically balanced impeller keyed and locknuttetted to a ground and polished steel shaft with hardened integral thrust collar. Shaft shall be supported by oil lubricated bronze sleeve bearings. Water tight mechanical seal faces shall be carbon on cast iron or ceramic.

- B. Coupling - Shall be self aligning, flexible type connecting the pump and motor.
- C. Motor - Shall be open drip proof, journal bearing, resilient mounted, 1750 rpm, and shall be especially selected for quiet operation. The electrical characteristics of the motor shall be as shown on the drawings. The horsepower of the motor shall be of such a size as to insure non-overloading of the motor throughout the capacity range of the pump. The motor shall have sealed bearings.
- D. Testing - The pump shall be factory tested, thoroughly cleaned, and painted with one (1) coat of machinery enamel prior to shipment. A set of installation instructions shall be included with the pump at the time of shipment.
- E. Starter - Provide a manual starter for single phase units and magnetic across-the-line starter for three phase units. The starter shall have HAND-OFF-AUTOMATIC switch and red running light. See Section 15050 paragraph 2.07.

## 2.02 SPECIALTIES

Specialties shall be provided for all pumps, which shall include, but not be limited to, isolation valves, unions, thermometers, and check valves.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The pump shall be installed and serviced in accordance with the manufacturer's recommendations and as shown on the drawings.
- B. Coupling guards shall be installed per ANSI and OSHA standards.

END OF SECTION

## SECTION 15424

### DOMESTIC ELECTRIC WATER HEATERS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include providing and installing complete electric water heaters.

##### 1.03 QUALITY ASSURANCE

- A. The water heater shall meet the requirements of the current ASHRAE Standard 90.1, for energy conservation.
- B. The electric water heater shall be factory wired in accordance with the National Electrical Code, and the heater shall bear the UL label.
- C. The water heater shall be tested at a pressure of 300 psi and shall have a water working pressure of 150 psi.
- D. The water heater shall be installed as recommended by the manufacturer and local codes.
- E. The water heater installation shall include the start-up and check out procedures as recommended by the manufacturer. Provide the owner with a copy of the start-up record.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment, including an installation diagram, as described in Section 15010, 1.04.

#### PART 2 - PRODUCTS

##### 2.01 ELECTRIC WATER HEATERS

- A. The size, type and capacity of the water heaters are shown on the drawings along with the specified manufacturer. Water heaters fully equal to the water

heater specified on the drawings and manufactured by RUUD (UNIVERSAL), A. O. SMITH, STATE, HUBBELL, BOCK or LOCHINVAR are acceptable.

- B. Tank - The steel tank shall be glass lined with magnesium anode to resist corrosion, unless otherwise noted on the drawings. The tank shall be insulated to meet the current ASHRAE 90.1 requirements and shall be covered with baked enamel paint.
- C. Heating Element - The heating element shall be the low watt density and screw-in design. The voltage shall be as shown on the drawings and shall be stamped on the water heater.
- D. Controls
  - 1. The water heater shall have an adjustable thermostat for operating control. The adjustable thermostat shall maintain the correct water temperature as stated on the drawings or required by Code.
  - 2. The water heater shall have a high limit or over temperature control to cut off the power in excess temperature situations.

## 2.02 PRESSURE AND TEMPERATURE RELIEF VALVE

The combination pressure and temperature relief valve for water heater(s) shall be rated equal to or greater than the maximum hourly heat input rate of the water heater. Each relief valve shall be ASME listed, rated and stamped. Pressure relief setting shall be 150 psi or less and temperature relief of 210 degrees F, all bronze body with stainless steel spring, test level and mounted to monitor the temperature within 6" of the tank.

## 2.03 EXPANSION TANK

Shall be ASME labeled and size listed on the drawings. Provide the tank with the required tapings and a prime coat of paint. The expansion tank shall be BELL & GOSSETT, TACO, JOHN WOOD, WESSELS or ARMSTRONG.

# PART 3 - EXECUTION

## 3.01 INSTALLATION

- A. The water heater shall be installed as shown on the drawings in an accessible location. Gate valves shall be installed on both the cold water supply pipe and the hot water pipe. A vacuum relief shall be installed on the cold water pipe between the gate valve and tank, and shall be located above the top of the tank. A thermometer shall be installed in the hot water pipe above the top of the

heater. All valves shall be mounted so as to be accessible while standing on the floor.

- B. Where water heaters are mounted above the floor, provide and install a shelf to carry the water heater. The shelf shall have the capability of carrying the water heater filled with water.
- C. A drip pan, where shown on the drawings or required by Code, shall be provided and installed. The drip pan shall be of a size to accommodate the water heater. The drip pan shall be fabricated with a minimum of 22 gauge galvanized steel. The drip pan shall be piped full size to a receptor.
- D. The relief valve shall be piped full size to a receptor.
- E. The thermostats in the water heater shall be adjusted to produce the water temperature called for on the drawings.
- F. The water heater instruction booklet shall be secured to the water heater.
- G. Provide a spare fuse for the water heater.
- H. Provide ASME rated expansion tank. Install as recommended by manufacturer.

END OF SECTION



## SECTION 15425

### DOMESTIC GAS WATER HEATERS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include providing and installing complete the forced draft gas water heater as shown on the drawings.

##### 1.03 QUALITY ASSURANCE

- A. The gas water heater shall conform with NFPA 54 - Natural Fuel Gas Code Requirements.
- B. The gas water heater shall conform with the current International Fuel Gas Code.
- C. The water heater shall meet the requirements of the current ASHRAE Standard 90.1, for energy conservation.
- D. The gas water heater shall bear the AGA label.
- E. The water heater shall be tested at a pressure of 300 psi and shall have a water working pressure of 150 psi.
- F. Water heaters with an AGA rating of 200,000 BTU/hr input or greater shall be ASME constructed and bear the UL label.
- G. Water heaters with an AGA rating of 300,000 BTU/HR input or greater shall have the manufacturers IRI rated gas train assembly installed.
- H. The water heater shall be installed as recommended by the manufacturer and local codes.
- I. The water heater installation shall include the start-up and check out procedures as recommended by the manufacturer. Provide the owner with a copy of the start-up record.

#### 1.04 SUBMITTALS

Provide shop drawings on this equipment, including an installation diagram, as described in section 15010, 1.04.

### **PART 2 - PRODUCTS**

#### 2.01 GAS WATER HEATER

- A. The rating, type and capacity of the water heater are shown on the drawings along with the specified manufacturer. Water heaters fully equal to the water heater specified on the drawings and manufactured by RHEEM/RUUD, A. O. SMITH, RAYPACK, STATE, BOCK or LOCHINVAR are acceptable.
- B. Tank - the steel tank shall be glass lined with magnesium anode to resist corrosion unless otherwise noted on the drawings. The tank shall be insulated to meet the current ASHRAE Standard 90.1 requirements and shall be covered with a baked enamel jacket.
- C. The contractor shall totally regulate the gas supply to main and pilot burners. The heater shall also be equipped with an automatic gas shut off device to shut off entire gas supply in the event of excessive temperature in tank and pilot safety shut off. The gas controls shall have an adjustable temperature setting to deliver hot water at the temperature called for on the drawings.

#### 2.02 PRESSURE AND TEMPERATURE RELIEF VALVE

The combination pressure and temperature relief valve for the water heater(s) shall be rated equal to or greater than the maximum hourly heat input rate of the water heater. Each relief valve shall be ASME listed, rated and stamped. Pressure relief setting shall be 150 psi or less and temperature relief of 210 degrees F, all bronze body with stainless steel spring, test level and mounted to monitor the temperature within 6" of the tank. A thermometer shall be installed in the hot water pipe above the top of the tank.

#### 2.03 EXPANSION TANK

Shall be ASME labeled and size listed on the drawings. Provide the tank with the required tappings and a prime coat of paint. The expansion tank shall be BELL & GOSSETT, TACO, JOHN WOOD, WESSELS or ARMSTRONG.

### **PART 3 EXECUTION**

3.01 INSTALLATION

- A. Gas Water Heater - The water heater shall be installed as shown on the drawings in an accessible location. Gate valves shall be installed on both the cold water supply pipe and the hot water pipe. A vacuum relief shall be installed on the cold water pipe between the gate valve and tank, and shall be located above the top of the tank. A thermometer shall be installed in the hot water pipe above the top of the tank. All valves shall be mounted so as to be accessible while standing on the floor.
- B. Piping - The relief valve shall be piped full size to a receptor or to the floor.
- C. Thermostats - The thermostats in the water heater shall be adjusted to produce the water temperature called for on the drawings.
- D. Instructions - The water heater instruction booklet shall be secured to the water heater.
- E. Provide a spare fuse for the water heater.
- F. Provide ASME rated expansion tank. Install as recommended by manufacturer.

END OF SECTION

## SECTION 15426

### CONDENSING DOMESTIC GAS WATER HEATER

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include providing and installing complete the forced draft gas water heater as shown on the drawings.

##### 1.03 QUALITY ASSURANCE

- A. The gas water heater shall conform with NFPA 54 - Natural Fuel Gas Code Requirements.
- B. The gas water heater shall conform with the current International Fuel Gas Code.
- C. The water heater shall meet the requirements of the current ASHRAE Standard 90.1, for energy conservation.
- D. The gas water heater shall bear the AGA or CSA label.
- E. The water heater shall be tested at a pressure of 225 psi and shall have a water working pressure of 150 psi.
- F. Water heaters shall be ASME constructed and bear the UL label. ASME fabrication documents shall accompany the submittal data.
- G. Water heaters with an AGA rating of 300,000 BTU/HR input or greater shall have the manufacturer's GE-GAP (IRI) /CSD-1 rated gas train assembly installed.
- H. The water heater shall be installed as recommended by the manufacturer and local codes.
- I. The water heater installation shall include factory start-up. Start up on the unit shall be performed by factory trained and authorized personnel. Provide the Owner with a copy of the start-up record.
- J. First year service policy, including parts and labor, shall be provided at no additional cost to the owner.

1.04 SUBMITTALS

Provide shop drawings on this equipment, including an installation diagram, as described in Section 15010, 1.04.

**PART 2 - PRODUCTS**

2.01 GAS WATER HEATER

- A. The rating, type and capacity of the water heater are shown on the drawings along with the specified manufacturer. Water heaters fully equal to the water heater specified on the drawings and manufactured by PVI, BOCK, LOCHINVAR or A. O. SMITH, are acceptable.
- B. Tank - The steel tank shall be glass lined or an unlined pressure vessel constructed from phase-balanced austenitic and ferritic duplex stainless steel. The tank shall be insulated to meet the current ASHRAE Standard 90.1 requirements.
- C. Water heaters with full rated input below 600,000 BTU will operate at a minimum 96% thermal efficiency at full firing rate when tested to the ANSI Z21.10.3 thermal efficiency test protocol (DOE 10 CFR 431). Water heaters with full rated input above 600,000 BTU will operate at a minimum 94% thermal efficiency at full firing rate when tested to the ANSI Z21.10.3 thermal efficiency test protocol (DOE 10 CFR 431). The water heater shall be ETL listed as a complete unit. The heater shall satisfy current Federal Energy Policy Act standards for both thermal efficiency and stand-by heat losses as established for gas fired water heaters.
- D. Combustion will be provided by a premix, fan-assisted surface burner with a gas train meeting UL, ANSI and FM standards for the input specified. Burner will be stainless steel.
- E. Water heater will be a category IV, condensing appliance and vent through PVC or CPVC. Water heater will satisfy requirements for sealed combustion. Vents for inlet and exhaust can terminate in different pressure zones.
- F. The Contractor shall totally regulate the gas supply to main and pilot burners. The heater shall also be equipped with an automatic gas shut off device to shut off the entire gas supply in the event of excessive temperature in tank and pilot safety shut off. The gas controls shall have an adjustable temperature setting to deliver hot water at the temperature called for on the drawings.
- G. The water heater shall be a vertical fire tube, design that is constructed and stamped in accordance with Section IV, Part HLW of the ASME code. Water

heater will be National Board Registered for a working pressure of 150 psi and will be pressure tested at 1-1/2 times working pressure. Materials shall meet ASME Section II material requirements and be accepted by NSF 61 for municipal potable water systems. All tank connections/fittings shall be nonferrous or stainless steel. The water heater shall employ an electronic operating control with digital temperature readout. Operator shall be capable of connecting to a building automation system through serial connection using Modbus RTU protocol. At a minimum, the water heater shall be equipped with the following:

1. Electronic flame monitoring.
2. Electronic low water cutoff.
3. An immersion operating control.
4. An immersion UL listed temperature limiting device.
5. Condensate neutralization system (Part#121778)
6. Concentric Vent Kit (Part#12574).

#### 2.02 PRESSURE AND TEMPERATURE RELIEF VALVE

The combination pressure and temperature relief valve for the water heater(s) shall be rated equal to or greater than the maximum hourly heat input rate of the water heater. Each relief valve shall be ASME listed, rated and stamped. Pressure relief setting shall be 150 psi or less and temperature relief of 210 degrees F, all bronze body with stainless steel spring, test level and mounted to monitor the temperature within 6" of the tank. A thermometer shall be installed in the hot water pipe above the top of the tank.

#### 2.03 EXPANSION TANK

Shall be ASME labeled and the size listed on the drawings. Provide the tank with the \* required tapings and a prime coat of paint. The expansion tank shall be BELL & GOSSETT, TACO, JOHN WOOD, WESSELS, or ARMSTRONG.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Gas Water Heater - The water heater shall be installed as shown on the drawings in an accessible location. Gate valves shall be installed on both the cold water supply pipe and the hot water pipe. A vacuum relief shall be installed on the cold water pipe between the gate valve and tank, and shall be located above the top of the tank. A thermometer shall be installed in the hot water pipe above the top of the tank. All valves shall be mounted so as to be accessible while standing on the floor. Start up on the water heater shall be performed by factory trained and authorized personnel. A copy of the start up report shall be provided to the contractor and Owner.

- B. Piping - The relief valve shall be piped full size to a receptor or to the floor.
- C. Thermostats - The thermostats in the water heater shall be adjusted to produce the water temperature called for on the drawings.
- D. Instructions - The water heater instruction booklet shall be secured to the water heater.
- E. Start up on the unit will be performed by factory trained and authorized personnel. A copy of the start up report will be provided to the contractor and Owner.
- F. Provide a spare fuse for the water heater.
- G. Provide an ASME rated expansion tank. Install as recommended by manufacturer.

END OF SECTION

## SECTION 15432

### DOMESTIC WATER PRESSURE BOOSTER SYSTEM

(Engineer to edit to make job specific)

#### PART I - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract Requirements, Division 1 - General Requirements, section 15010 - General Provisions, and section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

- A. The work covered under this section shall include providing, installing and testing a complete domestic water pressure booster system.

##### 1.03 QUALITY ASSURANCE

- A. The domestic water pressure booster system shall be installed to meet the requirements of the local plumbing code, the National Electrical Code and the Virginia Statewide Health Department. The pumps and controls shall be U/L listed.

##### 1.04 SHOP DRAWINGS

- A. Provide shop drawings on this equipment as described in Section 15010 - 1.04.
- B. The submittal data for the pumping system shall include:
  - 1. Pump curves.
  - 2. Individual data sheets with complete system information including pressure, pipe sizing, component selection, with instrumentation and alarm data, etc.
  - 3. System drawings showing component layout, piping configuration, overall dimension, field clearances, and piping requirements.
  - 4. Complete description of control panel with sequencing data and wiring diagram.
  - 5. Certificate of insurance showing minimum \$1,000,000 liability protection.
  - 6. Copy of Independent System Third Party Certification.
  - 7. Copy of the manufacturer's UL 508 Industrial Control Panel Certificate.

#### PART 2 - PRODUCTS

##### 2.01 DESIGN

- A. The contractor shall install a full size pump bypass where the pumps will not run



if the street pressure is adequate to supply the system. A hydropneumatic storage tank shall be adjacent to the steel base for the pumps. A pressure transducer shall be provided in the suction header to operate the lead pump if the pressure falls below its setting. System shall include a low suction pressure transducer to shut down the pump system and activate a visual and audible alarm if incoming pressure is lost. Separate pressure gauges shall be provided to indicate system pressure, suction pressure, and individual pump discharge pressures. The pump system shall be factory prefabricated as a complete system package on a structural steel mounting frame, piped, tubed, mounted and wired. Unit shall be factory primed and painted with machine grade finish coat. All welding shall be performed by ASME section 9 certified welders. System shall be vertical construction. Suction and discharge headers shall be stainless steel. System manufacturer shall isolate all ferrous from non-ferrous materials. All wetted surfaces shall be certified lead free in accordance with NSF/ANSI 61 section 8. The domestic water pressure booster system shall be manufactured by SYNCROFLO Duplex "IRONHEART". Booster systems fully equal to the prototype system and manufactured by TIGERFLOW or HYDRONIC MODULES CORPORATION shall be acceptable.

## 2.02 PUMPS

- A. Pumps shall be SYNCROFLO, cast iron body, stainless steel fitted construction, mechanical seal end suction centrifugal type each dose-coupled to a 3600 RPM, 480 volt, 3 phase, 60 hertz, high efficiency motor. Each pump shall be equipped with an individual combination type non-electric temperature probe and purge assembly. Pumps fully equal to the prototype manufacturer and manufactured by AURORA or HYDRONIC MODULES CORPORATION shall be acceptable.
- B. Booster System - The system shall be rated for a system flow of 175 GPM at a system pressure of 75 PSIG, including a suction pressure of 22 PSIG.
  - 1. Pump No. 1 shall deliver 88 GPM at 122' TDH, 7.5 HP.
  - 2. Pump No. 2 shall deliver 88 GPM at 122' TDH, 7.5 HP.

## 2.03 MOTOR

- A. Motor shall be drip-proof and meet NEMA standards and shall operate within the service factor at any point on the pump capacity head curve.

## 2.04 HYDRO-PNEUMATIC TANK

- A. System shall include a 180 gallon, 200 psi factory pre-charged hydro-pneumatic tank with FDA approved replaceable flexible membrane separating air and water. Vessel shall be ASME code and National Board stamped. Tank shall be provided complete with bottom connection, air fill valve, and 2-1/2" diameter stainless steel, liquid filled gauge. The hydropneumatic tank shall be mounted adjacent to tank skid.

## 2.05 PRESSURE REGULATING VALVES

- A. Constant system pressure shall be maintained by a pilot-operated diaphragm-type pressure regulating and check valve. The main valve body shall be cast iron with fully fused epoxy coating. Valve seat, pilot regulator seat, and cover bolting shall be stainless steel.
- B. Provide one regulator on each pump discharge line. Regulators shall be selected for not more than 5 psig pressure drop at the full pump capacity.

## 2.06 ISOLATION VALVES

- A. Provide isolation valves on the suction and discharge of each pump. Valves shall be full port ball valves or lug style butterfly valves. Gate valves are not acceptable.

## 2.07 PUMP SEQUENCING

### Operator Interface (Data Access Console)

- A. The data access console shall be flush mounted in the door of the control panel. The console shall include an alphanumeric keypad with audible feedback. The following data shall be accessible through the operator interface:
  - 1. One-touch access to display system status including flow rate (GPM), current pressure, any existing system alarm (or "NO ALARMS"), the current speed of the pumps (%), and the date and time.
  - 2. One touch access to Usage History, which may be reset. Usage History shall record the maximum instantaneous flow, along with the date and time.
  - 3. A Setup Menu system for adjusting setpoints. Display and adjust flow and pressure set points and time delays. Set pump alternation to manual or automatic. Set the hour of the day for automatic alternation. Restore all factory defaults. Protect adjustable settings with a password.
  - 4. One-touch access to an Alarm History of the past 10 alarms. Each log shall include individual pump run status, flow, and alarm type.
  - 5. One-touch access to an Alarm List of all possible alarms and their current status.
- B. Automatic sequencing shall include the following features:
  - 1. Sequence shifting that adjusts the pump sequence when any pump is disabled.

2. Successive and 24 hour alternation of equal capacity pumps.
3. Pump overlap during 24-hour alternation.
4. Lag pump exerciser function.
5. Special sequencing to reduce surges during power restoration.
6. Sequential sequencing of lag pumps.
7. Minimum run and stop delay timer for each pump.
8. Field adjustable time delay for lag pump pressure start signals.

#### 2.08 POWER AND CONTROL PANEL

- A. Furnish a power and control panel complete with individual pump through-the-door disconnect motor starter protectors with class 10 overload protection, and 120 volts fused control circuit transformer. All of the above shall be factory internally pre-wired and tested in accordance with provisions of the National Electrical Code. All control wires shall be individually numbered and each component shall be labeled accordingly. All internal wiring shall be copper stranded, AWG with a minimum insulation of 90 degrees Celsius. The complete assembly shall have the UL listing mark for industrial control panels.

#### 2.09 PROGRAMMABLE CONTROLLER

- A. Provide a programmable logic controller to control all pump starts and stops and indicate alarm conditions. The controller shall have the following features: A non volatile memory with no battery backup which prevents program loss due to power failure; a program cartridge which allows program changes to be made by the factory and transmitted to the field for simple loading into the controller by the operator; input and output "on" status lights must be supplied for ease of monitoring; and controller must be designed for use in locations where electromagnetic noise, high temperature, humidity, and mechanical shock will exist.

#### 2.10 INSTRUMENTATION

- A. Each system shall have panel-mounted pressure gauges (2-1/2") for indicating suction and system discharge pressure, pump run indicating lights, multiple position selector switches, and control power light.

#### 2.11 EMERGENCY CONTROLS AND ALARMS

- A. Furnish individual temperature probes and purge valves, low suction and low system pressure alarms, indication of first activated alarm, pulsing alarm horn with silence function, and individual alarm auxiliary contacts, time delays, and indicating lights.

**PART 3 - EXECUTION****3.01 INSTALLATION**

- A. The system shall be factory prefabricated. Furnish flanged-end stainless steel suction and discharge headers complete with anti-vibration pads. The only field connections required will be to system headers, tank, over temperature drain tube, and one incoming power connection at the control panel. System shall include three fuses, two light bulbs, and one can of touch up paint.

**3.02 FACTORY TEST AND CERTIFICATION**

- A. The booster system and its component parts shall undergo a complete operational flow test from zero to 100% design flow rate under the specified suction and net system pressure conditions. This flow test shall be performed by supplying the control panel with the specified incoming voltage. Each pump's performance shall be tested over its full range of flow. All pressure regulators, pressure switches, and other devices shall be set and functions verified. Components shall be tested for hydraulic shock, vibration, or excessive noise. Any parts found to be defective must be replaced prior to shipment. Full documentation shall be maintained by the manufacturer showing flow rates, pressures, and amp draws for future service and troubleshooting reference. Include copies of the test data as recorded by an X-Y Plotter.

**3.03 WARRANTY**

- A. The Pumping system shall be guaranteed in writing by the manufacturer for a period of one year from the date of shipment against defect in design, material, or construction.

**3.04 STARTUP SERVICE**

- A. The service of a factory trained representative shall be made available on the job site to check installation and start up and instruct operating personnel.

END OF SECTION

## SECTION 15436

### SMALL RAINWATER HARVESTING SYSTEM (ABOVE GROUND)

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SUMMARY

###### A. Section includes:

1. Rainwater prefilters.
2. Storage tanks.
3. Associated piping and valves.

###### B. Related Sections:

1. Division 01: Administrative, procedural, and temporary work requirements.
2. Section 15406 – Roof Drainage System.

##### 1.03 REFERENCES

- ###### A. Underwriters Laboratories, Inc. (UL) – Listed Products Directory.

##### 1.04 SYSTEM DESCRIPTION

- ###### A. Customized rainwater harvesting system consisting of manufactured components integrated into a single system.

###### B. Design Requirements:

1. Filter, store, and deliver harvested rainwater.
2. Protect public health and safety.
3. Provide aesthetically pleasing appearance.

##### 1.05 SUBMITTALS

- ###### A. Provide shop drawings on all equipment as described in section 15010-1.04. Shop Drawings shall include uses of all items.

###### B. Submittals for Review:

1. Shop Drawings: Include system layout, components, and accessories.

2. Product Data: Provide for system components; include dimensions, capacities, operating characteristics, utility connections, and accessories.
- C. Closeout Submittals:
1. Operation and Maintenance Data:
    - a. Provide instructions on operation, calibration, troubleshooting, and servicing equipment.
    - b. Include layout drawings, parts lists, and component manufacturer's product data.

#### 1.06 QUALITY ASSURANCE

- A. System Integrator:
1. Rainwater Management Solutions, Inc., Salem, VA.
  2. Other system integrators require prior approval by the Mechanical Engineer.
- B. Manufacturer Qualifications:
1. Minimum 3 years experience in work of this section.
  2. Successful completion of minimum of 5 previous projects of similar scope and complexity.
- C. Installer Qualifications:
1. Minimum 2 years experience in work of this section.
  2. Successful completion of minimum of 3 previous projects of similar scope and complexity.
  3. Maintain factory trained technicians on staff to provide field service and warranty work.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Do not deliver system components until time needed for installation, and after proper protection can be provided.
- B. Protect components from damage and corrosion.
- C. Leave protective coverings in place until just prior to installation.

### **PART 2 - PRODUCTS**

#### 2.01 MANUFACTURERS

- A. Acceptable Manufacturers – Storage Tanks:

1. B.H. Tank Incorporated, Madera, CA.
  2. CorGal Tank, Austin, TX.
- B. Acceptable Manufacturer – Rainwater Filters, Storage Tank Accessories, and Purification Kits:
1. Jay R. Smith Mfg. Co.
  2. Wisy
  3. Rainwater Management Solutions
- C. Substitutes: Not permitted.

## 2.02 COMPONENTS

- A. Rainwater Filter:
1. Model: No. RH9520-06 With RH9520WB for securing filter to wall.
  2. Description: 12 inch stainless steel lift handle, removable stainless steel 280 micron fine mesh filter, and polypropylene filter housing.
  3. Ventilation: To suit project conditions.
- B. Storage Tank:
1. Riveted corrugated galvanized steel.
  2. Penetrations molded into tank.
  3. Storage capacity: 1650 gallons.
  4. Manway (Locking 24" square).
  5. Ventilation: To suit project conditions.
- C. Storage Tank Accessories:
1. Smoothing inlets:
    - a. Jay R. Smith Model: No. RH9530SI-04.
    - b. Description: Stainless steel smoothing inlet for a 4 inch inlet pipe.
  2. Overflow device:
    - a. Vertical plain end pipe cut at 15% angle to promote skimming.

## 2.03 ACCESSORIES

- A. Vent assembly: rodent-proof cap for tank air and vacuum relief.

**PART 3 - EXECUTION**

3.01 INSTALLATION

- A. Install system components in accordance with manufacturer's instructions and approved Shop Drawings.
- B. Arrange equipment so that components requiring removal or maintenance are readily accessible without disturbing other components. Arrange for clear passage between components.
- C. Connect to utility supplies and equipment.
- D. Deliver harvested water via hose bib mounted near tank bottom.

END OF SECTION



**(ELEMENTARY SCHOOLS ONLY)**  
**SECTION 15450**

**PLUMBING FIXTURES AND TRIM**

**PART I - GENERAL**

1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions and Section 15050 - Basic Materials and Methods, shall apply to this section.

1.02 SCOPE

The work covered under this section shall include furnishing and installing the plumbing fixtures and trim and making all final connections of equipment furnished by others.

1.03 SUBMITTALS

Provide shop drawings on these fixtures and trim items as described in Section 15010 - 1.04. Shop drawings shall include proposed uses of all fixtures and trim.

**PART 2 - PRODUCTS**

2.01 WATER CLOSETS

KOHLER COMPANY shall manufacture the following plumbing fixtures. Vitreous china plumbing fixtures fully equal to the item specified manufactured by AMERICAN STANDARD, ZURN or SLOAN, shall be acceptable. Flush valves fully equal to the item specified and manufactured by SLOAN, AMERICAN STANDARD, MOEN or ZURN shall be acceptable. Toilet seats fully equal to the item specified and manufactured by BEMIS or CHURCH shall be acceptable.

- A. Water Closet (WC) - KOHLER Wellcomme Lite Toilet, elongated K-4350, 14 3/4" high (white) or AMERICAN STANDARD 2234.001 Madera 15"; K-4670SC solid plastic, white, open front, self-sustaining check hinge, and elongated or AMERICAN STANDARD 5901.100SS solid plastic OFLC seat; flush valve - KOHLER K-10957 1.6 gpf valve with electronic infrared sensor with Tripoint technology, AMERICAN STANDARD 6065.161 DC sensor operated FV, or ZURN ZER6000 PL-CPM-WS1 sensor operated battery powered flush valve, or SLOAN Regal XL 111-1.6 SFSM, 1.6 gpf battery powered flush valve with electronic infrared sensor, or MOEN 8310 sensor operated flush valve, 1.6 GPF, battery powered, mechanical manual override button, self-cleaning heavy duty piston, Bolt caps - 52048.
- B. Water Closet (WC-1) - Adult Handicapped - KOHLER Highcliff Lite Toilet, Water

Guard elongated K-4368, 17 1/2" high or AMERICAN STANDARD 3043.001 16-1/2 height WC Madera; K-4670SC solid plastic, white, open front, self-sustaining check hinge and elongated or AMERICAN STANDARD 5901.100SS solid plastic OFLC seat; flush valve- KOHLER K-10957 1.6 gpf valve with electronic infrared sensor with Tripoint technology, AMERICAN STANDARD 6065.161 DC sensor operated FV, ZURN ZER6000 PL-CPM-WS1 sensor operated battery powered flush valve, or SLOAN Regal XL 111-1.6 SFSM, 1.6 gpf battery powered flush valve with electronic infrared sensor, or MOEN 8310 sensor operated flush valve, 1.6 GPF, battery powered, mechanical manual override button, self-cleaning heavy duty piston, handles/override push button flush valves shall be located on the wide side of stalls; Bolt caps - 52048.

- C. High Efficient Water Closet (HEWC) - KOHLER K-96053-0-Wellcomme Ultra 1.28 flushometer bowl, elongated, white or AMERICAN STANDARD 2234.001 Madera 15" height; K-4670SC solid plastic, white open front toilet seat, self-sustaining check hinge, and elongated or AMERICAN STANDARD 5901.100SS solid plastic OFLC seat; KOHLER K-10956 1.28 gpf/4.85lph touchless DC toilet flushometer with tripoint technology, polished chrome, AMERICAN STANDARD 6065.121 DC 1.28GPF FV, or ZURN - ZER6000 PL-CPM-WS1 sensor operated battery powered flush valve, or SLOAN Regal XL 111-1.6 SFSM, 1.6 gpf battery powered flush valve with electronic infrared sensor, or MOEN 8311 sensor operated flush valve, 1.28 GPF, battery powered, mechanical manual override button, self-cleaning heavy duty piston, 1" screwdriver stop and vandal proof cap.
- D. High Efficient Water Closet (Handicapped) (HEWC-1) - KOHLER K-4405 Highline 1.28 flushometer floor mounted bowl, white or AMERICAN STANDARD 3043.001 16-1/2" height WC Madera, K-4670SC solid plastic, white open front toilet seat, self-sustaining check hinge, and elongated or AMERICAN STANDARD 5901.100SS solid plastic OFLC seat; KOHLER K-10956-CP 1.28gpf/4.85lph touchless DC toilet flushometer with tripoint technology, AMERICAN STANDARD 6065.161 DC 1.28GPF FV, or ZURN - ZER6000 PL-CPM-WS1 sensor operated battery powered flush valve, or SLOAN Regal XL 111-1.6 SFSM, 1.6 gpf battery powered flush valve with electronic infrared sensor, or MOEN 8311 sensor operated flush valve, 1.28 GPF, battery powered, mechanical manual override button, self-cleaning heavy duty piston, 1" screwdriver stop and vandal proof cap.

## 2.02 High Efficient Urinal (HEUR-1)

KOHLER COMPANY shall manufacture the following plumbing fixtures. Vitreous china plumbing fixtures fully equal to the item specified, manufactured by AMERICAN STANDARD, ZURN or SLOAN shall be acceptable. Flush valves fully equal to the item specified and manufactured by SLOAN, AMERICAN STANDARD, MOEN or ZURN shall be acceptable

- A. Kohler K-4991-ET Bardon 1/8 gpf high efficiency urinal or AMERICAN

STANDARD 6590.001 0.125gpf urinal. K-10949 1/8 gpf touchless DC urinal flushometer with tripoint technology, polished chrome, screwdriver stop with vandal proof cap or AMERICAN STANDARD 6063.013 0.128gpf DC FV; Carrier-Josam 17550-UR, Watts CA-321, or Jay R. Smith 0637.

## 2.03 LAVATORIES

KOHLER COMPANY shall manufacture the following plumbing fixtures. Vitreous china plumbing fixtures fully equal to the item specified, manufactured by AMERICAN STANDARD, ZURN or SLOAN shall be acceptable. Faucets fully equal to the item specified and manufactured by T&S Brass, ZURN, SLOAN, MOEN and CHICAGO shall be acceptable. Trim items manufactured by KOHLER, AMERICAN STANDARD, NIBCO, ELKAY, McGUIRE BRASSCRAFT, T&S BRASS, MOEN or CHICAGO shall be acceptable. All trim items shall have heavy duty or extra duty components. All faucets shall be Certified Lead Free to NSF 372.

- A. Lavatory (L) - KOHLER K-1721, white, vitreous china, 20" X 18" Chesapeake with single hole faucet drilling or AMERICAN STANDARD 0356.421 single hole Lucerne, supply faucet- T&S Brass EC-3142-ST-VF05 battery powered sensor faucet w/ 5EF-0006 temp. mixing T or K-13461 CP KOHLER Sculpted Touchless lavatory faucet, or ZURN Z-6918-F-MT battery powered sensor faucet, or SLOAN 3335061, "EAF-350", optima sensor activated lavatory faucet with 0.5 gpm aerator spray head, with (Bak-Chek) tee fitting; or CHICAGO FAUCET 116.606.AB.1 with 0.5 GPM VP aerator, 6V lithium battery and remotely adjustable sensor range/meter time with 242.165.00.1 mixing tee with integral check and filter, flexible stainless steel connections; or Moen 8553, Single mount battery powered above deck electronic sensor faucet, 0.5 GPM recessed aerator, 104424 mixing tee, slow closing solenoid; K-7715 drain with perforated strainer, 1 1/4" tailpiece; P-Trap - K-8995 1 1/4" X 1 1/2" chromium plated cast brass with cleanout plug; Nipple - K-9016 1 1/2" x 6" chromium plated cast brass with escutcheon; Supplies - K-7601 with loose key stops, chromium plated with escutcheons; Carrier - JOSAM 17100-67, Watts TCA-411, or Jay R. Smith 0710-D.
- B. Lavatory (L-1) Adult Handicapped - KOHLER K-1721, white, vitreous china, 20" X 18" Chesapeake with single hole faucet drilling or AMERICAN STANDARD 0356.421 single hole Lucerne. Supply faucet -T&S Brass EC-3142- VF05 battery powered sensor faucet or K-13460 CP KOHLER Sculpted Touchless lavatory faucet, or ZURN Z-6919-ADM-F battery powered sensor faucet, or SLOAN 3335061, "EAF-350-ISM", Optima sensor activated lavatory faucet with 0.5 gpm aerator spray head; or CHICAGO FAUCET 116.222.AB.1 with 0.5 GPM VP aerator, user adjustable side mixing, 6V lithium battery and remotely adjustable sensor range/meter time; flexible stainless steel connections; or Moen 8554, Single mount battery powered above deck electronic sensor faucet with above deck mixing, 0.5 GPM recessed aerator, slow closing solenoid; K-7715 1 1/4" drain with strainer or K-13385 offset drain and K-7622 offset tailpiece for fixtures without the built-in offset; P-Trap - K-8995 1 1/4" X 1 1/2" chromium

plated cast brass with cleanout plug; Nipple - K-9016 1 1/2" X 6" chromium plated cast brass with escutcheon; Supplies - K-7601 with loose key stops, chromium plated with escutcheons, Carrier - JOSAM 17100-67, Watts TCA-411, or Jay R. Smith 0710-D. Provide TRUEBRO Model 102 white trap and supply covers. Covers as manufactured by PLUMBEREX (Pro Series) shall be acceptable.

- C. Lavatory (L-2) Child Handicapped - KOHLER K-1721, white, vitreous china, 20" X 18" Chesapeake with single hole faucet drilling or AMERICAN STANDARD 0356.421 single hole Lucerne. Supply faucet- T&S Brass EC-3142-ST-VF05 battery powered sensor faucet w/ 5EF-0006 temp. mixing T or - K13461 CP KOHLER Sculpted Touchless lavatory faucet, or ZURN Z-6918-F-MT battery powered sensor faucet, or SLOAN 3335061, "EAF-350", Optima sensor activated lavatory faucet with 0.5 gpm aerator spray head with (Bak-Chek) tee fitting; or CHICAGO FAUCET 116.606.AB.1 with 0.5 GPM VP aerator, 6V lithium battery and remotely adjustable sensor range/meter time with 242.165.00.1 mixing tee with integral check and filter; flexible stainless steel connections; or Moen 8553, Single mount battery powered above deck electronic sensor faucet, 0.5 GPM recessed aerator, 104424 mixing tee, slow closing solenoid; K-7715 1 1/4" drain with strainer or K-13885 1 1/4" offset drain and K-7622 offset tailpiece for fixtures without the built-in offset; P-Trap-K-8995 1 1/4" X 1 1/2" chromium plated cast brass with cleanout plug; Nipple - K-9016 1 1/2" X 6" chromium plated cast brass with escutcheon; Supplies - K-7601 with loose key stops, chromium plated with escutcheons, Carrier - JOSAM 17100-67, Watts TCA-411, or Jay R. Smith 0710-D. Provide TRUEBRO Model 102 white trap and supply covers. Covers as manufactured by PLUMBEREX (Pro Series) shall be acceptable.
- D. Lavatory (L-4) Kitchen - KOHLER K-1721, white vitreous china, 20" X 18" Chesapeake with single hole faucet drilling or AMERICAN STANDARD 0356.421 single hole Lucerne. Supply faucet – T&S Brass EC-3142-VF05 w/ B-0199-03-WS 1.5 gpm aerator battery powered sensor faucet or K-13460 CP Sculpted Touchless lavatory faucet with 1.5 GPM aerator, or ZURN Z-6918-XL-ADM-E battery powered faucet with a 1.5 GPM aerator, or SLOAN 3335061, "EAF-350-ISM" Optima sensor activated lavatory faucet with 1.5 gpm aerator spray head, or CHICAGO FAUCET 116.222.AB.1 with E34VP 1.5 GPM VP aerator, user adjustable side mixing, 6V lithium battery and remotely adjustable sensor range/meter; flexible stainless steel connections; or Moen 8554, Single mount battery powered above deck electronic sensor faucet with above deck mixing, 1.5 GPM recessed aerator, slow closing solenoid; K-7715 drain with perforated strainer, 1 1/4" tailpiece; P-Trap - K-8995 1 1/4" X 1 1/2" chromium plated cast brass with cleanout plug; Nipple - K-9016 1 1/2" X 6" chromium plated cast brass with escutcheon; Supplies - K-7601 with loose key stops; Carrier - JOSAM 17100-67, Watts TCA-411, or Jay R. Smith 0710-D. Provide TRUEBRO Model 102, white trap supply covers. Covers as manufactured by PLUMBEREX (Pro Series) shall be accepted.

## 2.04 SINKS

ELKAY shall manufacture the following plumbing fixtures. Stainless steel sinks fully equal to the item specified and manufactured by JUST MANUFACTURING shall be acceptable.

- A. Work Sink (S) - ELKAY Lustertone LRAD-2521, 18 gauge, 5 1/2" sink depth, with 3 faucet holes; Supply faucet T&S Brass B-2854-CR w/B-0199-06 2.2 GPM vandal resistant aerator or LK230 or CHICAGO FAUCET 1888-ABCP with 2.2 GPM vandal proof aerator; or MOEN 8225 with 52615 vandal resistant aerator (2.2 gpm); LK-35L offset grid strainer, P-Trap with cleanout plug and escutcheon; Supply valves shall be 1/4 turn ball valve with chrome plated ball, sweated and have escutcheons. Compression fittings are not acceptable.
- B. Wet and Dirty Sink (S-1) - ELKAY Lustertone DLR-2522, 18 gauge, with 3 faucet holes, 10" deep; Supply faucet T&S Brass B-2862 w/ BL-5550-31 and B-0199-07 or LK-232-S or CHICAGO FAUCET 786-GR8AE3V317AB or MOEN 8229 with S00R50 and 52615 vandal resistant aerator (2.2 gpm); all with vandal proof aerator and restricted swing spout (full swing spout faucets are not acceptable). Strainer - LK-18B, P-Trap with cleanout plug and escutcheon; Supply valves shall be 1/4 turn ball valve with chrome plated ball, sweated and have escutcheons. Compression fittings are not acceptable.
- C. Wet and Dirty Sink (S-1H) child handicapped – ELKAY Lustertone LRAD-2522, 18 gauge, 5 1/2" sink depth, with 3 faucet holes; Supply faucet T&S Brass B-2862 w/ BL-5550-31 and B-0199-07 or LK-232-S or CHICAGO FAUCET 786-GR8AE3V317AB both with vandal proof aerator and restricted swing spout (full swing spout faucets are not acceptable). LK-35L offset grid strainer, P-Trap with cleanout plug and escutcheon; Supply valves shall be 1/4 turn ball valve with chrome plated ball, sweated and have escutcheons. Compression fittings are not acceptable.
- D. Classroom Sink (S-2L & S-2R) - ELKAY Lustertone DRKAD-2220-55-C (3)(1) with faucet with vandal proof aerator and restricted swing spout (full swing spout faucets are not acceptable), 5 1/2" sink depth, off-centered drain LK-1141A flexi-guard bubbler or T&S Brass B-2360-01 bubbler and LK-35L offset grid strainer; P-Trap with cleanout plug and escutcheon; Supply valves shall be 1/4 turn ball valve with chrome plated ball, sweated and have escutcheons. Bubblers shall be mounted on the side of the sink, opposite any sidewalls. See drawings for bubbler locations. CHICAGO FAUCET 786-GR8AE3V317AB with vandal proof aerator and restricted swing spout, is also acceptable (full swing spout will not be accepted). Compression fittings are not acceptable.
- E. Clinic Sink (S-3) – ELKAY Lustertone LRAD-2521, 5 1/2" sink depth, 18 gauge, with 3 faucet holes; Supply faucet T&S Brass B-2862 w/ BL-5550-31 and B-0199-07 or LK-232-S-BH-5, 5" wrist blades with rigid connections and gooseneck spout, or CHICAGO FAUCET 786-GR8AE3V317AB or MOEN 8229 with

S00R50; Strainer LK-18B, P-Trap with cleanout plug and escutcheon; Supply valves shall be 1/4 turn ball valve with chrome plated ball, sweated and have escutcheons. Compression fittings are not acceptable.

## 2.05 SHOWERS

KOHLER shall manufacture the following plumbing fixtures. Showers fully equal to the item specified and manufactured by SYMMONS, MOEN or POWERS shall be acceptable.

- A. Shower (SH) Handicapped -Showerhead -KOHLER K8520 hand held shower with slide bar; supply elbow - K-T6913-4; Shower valve - K-304-KS pressure balanced mixing valve with integral stops and K-T6913-4 valve trim.

## 2.06 EXISTING TO REMAIN EQUIPMENT

- A. Existing to remain water closets - Provide and install KOHLER K-4670SC solid plastic, white, open front, self-sustaining check hinge and elongated or AMERICAN STANDARD 5901.100SS solid plastic OFLC seat for all existing water closets. Replace closet flange, wax ring, bolts, bolt caps and spud gasket. Provide and install new flush valves for all existing water closets that are to remain, refer to section 2.01 for appropriate flush valve replacement.
- B. Existing to remain lavatories - Provide and install new faucets, refer to section 2.03 for appropriate faucet replacement. Provide vandal proof aerator. Supply stops for each KOHLER K-7601 chrome angle loose key, provide threaded tailpiece supply extensions. Replace waste outlet and provide chromium-plated p-trap with cleanout plug and nipple with escutcheon.
- C. Existing to remain shower (SH(E)) - Provide and install KOHLER K-7371 showerhead; shower arm K-7397; and shower valve K-6913-4 pressure balanced mixing valve with integral stops.
- D. Existing to remain lavatory kitchen - Provide new faucet, refer to section 2.03 for appropriate faucet replacement. Provide K-7601 supplies with loose key stops. Provide threaded tailpiece supply extensions.
- E. Existing to remain service sinks and mop basins - Replace faucet with one of the following faucets respectively - KOHLER K-8905 or K-8907 with wall bracket. T&S Brass B-0669-02 or 665-BSTR, Chicago faucet 305-VB-RCF or 897-RCF with wall bracket shall also be accepted. All with integral vacuum breakers.

## 2.07 ELECTRIC WATER COOLERS AND DRINKING FOUNTAINS

The following electric water coolers (and/or drinking fountains) shall be manufactured by ELKAY. Fixtures fully equal to the item specified as manufactured by HALSEY TAYLOR, OASIS, or HAWS shall be acceptable. Fixtures with plastic bubbler

components will not be acceptable.

- A. Electric Water Cooler (EWC) - ELKAY wall mounted cooler model No. EWCA-14, complete with flexi-guard bubbler and all standard accessories. Finish by Architect.  
Carrier - JOSAM 17550-WC, WATTS TCA-411 or JAY R. SMITH 0830.
- B. Electric Water Cooler (EWC-1) Child Handicapped – ELKAY EZ-S8 universal mount barrier free cooler complete with flexi-guard bubbler and standard accessories, finish by architect. Carrier - JOSAM 17550-WC, WATTS TCA-411 or JAY R. SMITH 0830.
- C. Electric Water Cooler (EWC-2) Adult Handicapped – ELKAY EZ-S8 universal mount barrier free cooler complete with flexi-guard bubbler and standard accessories, provide vandal proof resistant bubbler; finish by architect. Carrier - JOSAM 17550-WC, WATTS TCA-411 or JAY R. SMITH 0830.
- D. Electric Water Cooler (EWC-3) Handicapped – ELKAY handicapped model # EZS8WSLK accessible water cooler with Bottle filling station, flexi-guard bubbler and all standard accessories. Finish by Architect. Carrier - JOSAM 17550-WC, WATTS TCA-411 or JAY R. SMITH 0830.
- E. Drinking Fountain (DF) – KOHLER Semi Recessed K-5293, vitreous china with 34902 condensation plate assembly, 35301 bubbler assembly, 79186 supply stop assembly, 35314 trap and 52054 wall screw access pack.

## 2.08 MOP BASIN AND LAUNDRY TRAY

FIAT shall manufacture the following plumbing fixtures. Mop basins fully equal to the item specified and manufactured by STERN WILLIAMS shall also be acceptable.

- A. Mop Basin (MB) - FIAT Model TSB-700 with stainless steel caps on curbs, 36" X 24" X 12"; Faucet, with integral vacuum breaker – T&S Brass 665-BSTR or FIAT 830-AA or CHICAGO FAUCET 897-RCF or MOEN 8124 with internal vacuum breaker, integral check stops; Hose and hose bracket - 832AA. Silicone sealant 833-AA.
- B. Mop Basin (MB-1) – STERN WILLIAMS HL-2100 with 6" drop and stainless steel cap on threshold, 36" X 24 X 12"; Faucet, with integral vacuum breaker - 830-AA or CHICAGO FAUCET 897-RCF or MOEN 8124 with internal vacuum breaker, integral check stops; Hose and hose bracket - 832AA. Silicone sealant 833-AA.
- C. Laundry Tray (LT) – FIAT Model FL -1 floor mounted laundry tray; N0. A-1 faucet with WATTS N0. 8A vacuum breaker on faucet or T&S Brass B-1110 or CHICAGO FAUCET 891- 2E27CP.

## 2.09 WASH BOX

- A. Wash Box – GUY GRAY MANUFACTURING CO., INC. model NWFBED-200TS. Provide with ½” hot and cold water hose bibbs, a 20 amp, 120V duplex receptacle for washer, and a 30 amp, 220V, 4 wire dryer receptacle.

## 2.10 OTHER FURNISHED EQUIPMENT

- A. The Contractor shall make a complete waste, vent, hot and cold water rough in for all fixtures, equipment and food service equipment as indicated on the drawings. Furnish and install 1/4 turn shut off valves for all countertop fixtures and KOHLER K-7601 supplies for all wall hung fixtures; traps, tailpieces, sink strainers, supply pipes, air gaps, escutcheons, and make all final connections for a complete installation. All sinks that are shown to be handicapped accessible (see Architectural drawings) shall have offset tailpieces.
- B. The Contractor shall consult the architectural drawings and other sections of the specifications for equipment requiring roughing in and final connection under this section of the contract.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The water supply to each surface mounted fixture shall have angle, loose key stop valves. On fixtures without integral stops, install stop valves. Fixtures which are installed in case work or fixtures with plumbing components which are not visible from the occupied space shall have ¼ turn sweated ball valves with chrome plated ball and escutcheons. The water supply piping for fixtures located in casework shall be type L copper from the valve to the fixture, piping shall be run in such a manner as to allow the space below the fixture to be utilized as storage.
- B. Wall hung fixtures such as urinals, lavatories, sinks, electric water coolers, and drinking fountains, shall have carriers. The specified carriers may not be compatible for all fixture manufacturers. Carriers shall be coordinated between the fixture manufacturer and the carrier manufacturer. Where the carrier is not specified with the fixture, the fixture carrier shall be a 1/8 inch steel plate embedded or anchored in the wall with all-thread rods bolted or welded to the plate and extending through the finished wall for the fixture hanger installation. The minimum size rod shall be 1/4". The fixture carrier shall be installed while the wall is being built.
- C. The plumbing fixtures shall be installed at the mounting heights required by Fairfax County Public Schools standards. Where mounting heights are not stated, the plumbing fixtures shall be roughed-in in accordance with the manufacturer's rough-in information.



- D. The contractor shall provide a complete rough in and make all final connections to the equipment furnished by others.
- E. The contractor shall provide watertight seals at all joints formed where fixtures come in contact with walls or floors.
- F. Remove all existing to remain fixtures in toilet rooms to allow for re-tiling of walls and floors. Remount fixtures at existing heights, except fixtures that get remounted at handicapped heights, after tile work is completed.
- G. All exposed piping components for lavatory faucets shall be chrome plated or stainless steel if such components appear below the apron of the fixture. Faucets with exposed brass pigtails will not be acceptable.
- H. All sinks and lavatories that are indicated to be handicapped accessible shall have offset tailpieces.
- I. At the time of project closeout all battery powered urinal flush valves, battery powered water closet flush valves and battery powered faucets shall have the batteries removed and replaced with new batteries. Owner's representative shall verify battery replacement.
- J. Provide check valves on incoming water supply for all mop basins and laundry trays.

END OF SECTION

**(INTERMEDIATE AND HIGH SCHOOLS ONLY)**  
**SECTION 15451**

**PLUMBING FIXTURES AND TRIM**

**PART 1 - GENERAL**

1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions and Section 15050 - Basic Materials and Methods, shall apply to this section.

1.02 SCOPE

The work covered under this section shall include furnishing and installing the plumbing fixtures and trim and making all final connections of equipment furnished by others.

1.03 SUBMITTALS

Provide shop drawings on these fixtures and trim items as described in section 15010 - 1.04. Shop drawings shall include proposed uses of all fixtures and trim.

**PART 2 - PRODUCTS**

2.01 WATER CLOSETS AND URINALS

KOHLER COMPANY shall manufacture the following plumbing fixtures. Vitreous china plumbing fixtures fully equal to the item specified, manufactured by AMERICAN STANDARD, ZURN or SLOAN shall be acceptable. Flush valves fully equal to the item specified and manufactured by SLOAN, AMERICAN STANDARD, ZURN or MOEN shall also be acceptable. Toilet seats fully equal to the item specified and manufactured by KOHLER, BEMIS or CHURCH shall be acceptable.

- A. Water Closet (Handicapped) (WC-1) - Kohler K-4368 Highcliff Lite Toilet, elongated, water-guard, flush valve toilet, 17 1/2" high; 52048 bolt caps or AMERICAN STANDARD 3043.001 16-1/2" height WC Madera; BEMIS model 1955SSCT, black, extra heavy duty, open front toilet seat with self-sustaining check hinge; KOHLER K-10957 1.6 gpf flush valve with electronic infrared sensor with Tripoint technology, AMERICAN STANDARD 6065.161 DC 1.6gpf FV, ZURN- ZER6000 PL-CPM-WS1 sensor operated battery powered flush valve, MOEN 8310 sensor operated flush valve, 1.6 GPF, battery powered, mechanical manual override button, self-cleaning heavy duty piston or SLOAN Regal XL 111-1.6 SFSM, 1.6 gpf battery powered flush valve with electronic infrared sensor, 1" screwdriver stop and vandal proof cap.
- B. Water Closet (WC) - Kohler K-4350 Wellcomme Lite Toilet, elongated, water-

guard, flush valve toilet; 52048 bolt caps or AMERICAN STANDARD 2234.001 Madera 15" height WC; BEMIS model 1955SSCT, black, extra heavy duty, open front toilet seat with self-sustaining check hinge; KOHLER K-10957 1.6 gpf flush valve with electronic infrared sensor with Tripoint technology AMERICAN STANDARD 6065.161 DC 1.6gpf FV, ZURN- ZER6000 PL-CPM-WS1 sensor operated battery powered flush valve, MOEN 8310 sensor operated flush valve, 1.6 GPF, battery powered, mechanical manual override button, self-cleaning heavy duty piston or SLOAN Regal XL 111-1.6 SFSM, 1.6 gpf battery powered flush valve with electronic infrared sensor, 1" screwdriver stop and vandal proof cap.

- C. Water Closet (WC-2) (rear outlet, floor mounted) Kohler K-4386 Anglesey elongated siphon jet flush valve toilet; 52048 bolt caps or AMERICAN STANDARD 3690.001; BEMIS model 1955SSCT, black, extra heavy duty, open front toilet seat with self-sustaining check hinge; KOHLER K-10957 1.6 gpf flush valve with electronic infrared sensor with Tripoint technology, AMERICAN STANDARD 6065.161 DC 1.6gpf FV, or ZURN- ZER6000 PL-CPM-WS1 sensor operated battery powered flush valve, MOEN 8310 sensor operated flush valve, 1.6 GPF, battery powered, mechanical manual override button, self-cleaning heavy duty piston or SLOAN Regal XL 111-1.6 SFSM, 1.6 gpf battery powered flush valve with electronic infrared sensor, 1" screwdriver stop and vandal proof stop.
- D. High Efficient Urinal (HEUR & HEUR-1) KOHLER COMPANY shall manufacture the following plumbing fixtures. Vitreous china plumbing fixtures fully equal to the item specified manufactured by AMERICAN STANDARD, ZURN or SLOAN shall be acceptable. Flush valves fully equal to the item specified and manufactured by SLOAN, MOEN or ZURN shall be acceptable.

KOHLER K-4991-ET Bardon 1/8 gpf high efficiency urinal or AMERICAN STANDARD 6590.11 Washbrook Flowise urinal. K-10949 1/8 gpf touchless DC urinal flushometer with tripoint technology, polished chrome, screwdriver stop with vandal proof cap or AMERICAN STANDARD 6063.013 DC 0.125gpf FV; Carrier - JOSAM 17550-UR or JR Smith 0637, WATTS CA-321 or JAY R. SMITH 0637.

- E. High Efficient Water Closet (Handicapped) (HEWC-1) KOHLER K-4405 Highline 1.28 flushometer floor mounted bowl, white or AMERICAN STANDARD 3043.001 16-1/2 height WC, BEMIS model 1955SSCT, black, extra heavy duty, open front toilet seat with self-sustaining check hinge; KOHLER K-10956-CP 1.28gpf/4.85lpf touchless DC toilet flushometer with tripoint technology, or AMERICAN STANDARD 6065.121 DC 1.28gpf, or ZURN - ZER6000 PL-CPM-WS1 sensor operated battery powered flush valve, or SLOAN Regal XL 111-1.6 SFSM, 1.6 gpf battery powered flush valve with electronic infrared sensor, or MOEN 8310 sensor operated flush valve, 1.6 GPF, battery powered, mechanical manual override button, self-cleaning heavy duty piston, 1" screwdriver stop and vandal proof cap, Bolt caps - 52048.

- F. High Efficient Water Closet (HEWC) KOHLER K-96053-0-Wellcomme Ultra 1.28 flushometer bowl, elongated, white or AMERICAN STANDARD 2234.001 Madera Flowise WC; BEMIS model SSCT, black, extra heavy duty, open front toilet seat with self-sustaining check hinge; KOHLER K-10956 1.28 gpf/4.85lpf touchless DC toilet flushometer with tripoint technology, polished chrome or AMERICAN STANDARD 6065.121 DC 1.28gpf FV, or ZURN - ZER6000 PL-CPM-WS1 sensor operated battery powered flush valve, or SLOAN Regal XL 111-1.6 SFMS, 1.6 gpf battery powered flush valve with electronic infrared sensor, or MOEN 8310 sensor operated flush valve, 1.6 GPF, battery powered, mechanical manual override button, self-cleaning heavy duty piston, 1" screwdriver stop and vandal proof cap, Bolt caps - 52048.

## 2.02 LAVATORIES

KOHLER COMPANY shall manufacture the following plumbing fixtures. Vitreous china plumbing fixtures fully equal to the item specified, manufactured by AMERICAN STANDARD, ZURN or SLOAN, shall be acceptable. Faucets fully equal to the item specified and manufactured by AMERICAN STANDARD, ZURN, SLOAN, MOEN and CHICAGO shall be acceptable. Trim items manufactured by KOHLER, AMERICAN STANDARD, NIBCO, ELKAY, McGUIRE BRASSCRAFT, T&S BRASS, or CHICAGO shall be acceptable. All trim items shall have heavy duty or extra duty components. All faucets shall be Certified Lead Free to NSF 372.

- A. Lavatory (L) - KOHLER K-1721, white, vitreous china, 20" X 18" Chesapeake with single hole faucet drilling or AMERICAN STANDARD 0356.421 single hole Lucerne, Supply faucet- T&S Brass EC-3142-ST-VF05 battery powered sensor faucet w/ T&S 5EF-0006 temp. mixing T or K-13461 CP KOHLER Sculpted Touchless lavatory faucet, or ZURN Z-6918-F-MT battery powered sensor faucet, or SLOAN 3335061, "EAF-350", Optima sensor activated lavatory faucet with .5 gpm aerator spray head, with (Bak-Chek) tee fitting, or CHICAGO FAUCET 116.606.AB.1 with 0.5 GPM VP aerator, 6V lithium battery and remotely adjustable sensor range/meter time with 242.165.00.1 mixing tee with integral check and filter; flexible stainless steel connections; or Moen 8553, Single mount battery powered above deck electronic sensor faucet, 0.5 GPM recessed aerator, 104424 mixing tee, slow closing solenoid; K-7715 drain with perforated strainer, 1 1/4" tailpiece; K-8995 1 1/4" X 1 1/2" chromium plated brass 'P' trap with cleanout plug; K-9016 1 1/2" X 6" chromium plated brass nipple with chromium plated brass escutcheon; K-7601 lavatory supplies complete with chromium plated brass angle loose key stops, and escutcheons; Carrier - JOSAM 17100-67, WATTS TCA-411 or JAY R. SMITH 0710-D.
- B. Lavatory (L-1) Adult Handicapped - KOHLER K-1721, white, vitreous china, 20" X 18" Chesapeake with single hole faucet drilling or AMERICAN STANDARD 0356.421 single hole Lucerne, Supply faucet T&S Brass EC-3142-VF05 battery powered sensor faucet or K-13460 CP Kohler Sculpted Touchless lavatory faucet, or Zurn Z-6919-ADM-F battery powered sensor faucet, or SLOAN

3335061, "EAF-350-ISM", Optima sensor activated lavatory faucet with .5 gpm aerator spray head, or CHICAGO FAUCET 116.222.AB.1 with 0.5 GPM VP aerator, user adjustable side mixing, 6V lithium battery and remotely adjustable sensor range/meter time; flexible stainless connections; Moen 8554, Single mount battery powered above deck electronic sensor faucet with above deck mixing, 0.5 GPM recessed aerator, slow closing solenoid; K-7715 1 1/4" drain with strainer or K-13385 offset drain and K-7622 offset tailpiece for fixtures without the built-in offset; P-Trap - K-8995 1 1/4" X 1 1/2" chromium plated cast brass with cleanout plug; Nipple - K-9016 1 1/2" X 6" chromium plated cast brass with escutcheon; Supplies - K-7601 with loose key stops, chromium plated with escutcheons; Carrier - JOSAM 1710067, WATTS TCA-411 or JAY R. SMITH 0710-D. Provide TRUEBRO Model 102 white trap and supply covers. Covers as manufactured by PLUMBEREX (Pro Series) shall be acceptable.

- C. Lavatory (L-2) Student Handicapped – K-1721, white, vitreous china, 20" X 18" Chesapeake with single hole faucet drilling or AMERICAN STANDARD 0356.421 single hole Lucerne, Supply faucet- T&S Brass EC-3142-ST-VF05 battery powered sensor faucet w/ T&S 5EF-0006 temp. mixing T or K-13461 CP KOHLER Sculpted Touchless lavatory faucet, or ZURN Z-6918-F-MT battery powered sensor faucet, or SLOAN 3335061, "EAF-350", Optima sensor activated lavatory faucet with .5 gpm aerator spray head with (Bak-Chek) tee fitting, or CHICAGO FAUCET 116.606.AB.1 with 0.5 GPM VP aerator, 6V lithium battery and remotely adjustable sensor range/meter time with 242.165.00.1 mixing tee with integral check and filter; flexible stainless steel connections; or Moen 8553, Single mount battery powered above deck electronic sensor faucet, 0.5 GPM recessed aerator, 104424 mixing tee, slow closing solenoid; K-7715 1 1/4" drain with strainer or K-13385 offset drain and K-7622 offset tailpiece for fixtures without the built-in offset; K-8995 chromium plated brass 'P' trap with cleanout plug; K-9016 chromium plated brass nipple with chromium plated brass escutcheon; K-7601 supplies with chromium plated brass angle loose key stops, and escutcheons; Carrier - JOSAM 17100-67, WATTS TCA411 or JAY R. SMITH 0710-D. Provide TRUEBRO Model 102, white trap and supply covers. Covers as manufactured by PLUMBEREX (Pro Series) shall be acceptable.
- D Lavatory (L-4) Kitchen – KOHLER K-1721, white vitreous china, 20" X 18" Chesapeake with single hole faucet drilling or AMERICAN STANDARD 0356.421 single hole Lucerne, Supply faucet -T&S Brass EC-3142-VF05 w/ B-0199-03-WS 1.5gpm aerator battery powered sensor or K-13460 CP Sculpted Touchless lavatory faucet with 1.5 GPM aerator, or ZURN Z-6918-XL-ADM-E battery powered faucet with a 1.5 GPM aerator, or SLOAN 3335061, "EAF-350-ISM" Optima sensor activated lavatory faucet with 1.5 gpm aerator spray head, or CHICAGO FAUCETS 116.222.AB.1 with E34VP 1.5 GPM VP aerator, user adjustable side mixing, 6V lithium battery and remotely adjustable sensor range/meter time; flexible stainless steel connections; or MOEN 8554, Single mount battery powered above deck electronic sensor faucet with above deck mixing, 1.5 GPM recessed aerator, slow closing solenoid; K-7715 drain with perforated strainer, 1 1/4" tailpiece; P-Trap - K-8995 1 1/4" X 1 1/2" chromium

plated cast brass with cleanout plug; Nipple - K-9016 1 1/2" X 6" chromium plated cast brass with escutcheon; Supplies - K-7601 with loose key stops; Carrier - JOSAM 17100-67, WATTS TCA-411 or JAY R. SMITH 0710-D. Provide TRUEBRO Model 102, white trap supply covers. Covers as manufactured by PLUMBEREX (Pro Series) shall be acceptable.

### 2.03 SINKS

ELKAY shall manufacture the following plumbing fixtures. Stainless steel sinks fully equal to the item specified and manufactured by JUST MANUFACTURING shall be acceptable.

- A. Clinic Sink (S-1) – ELKAY Lustertone LR-2521, 5 1/2" sink depth 18 gauge, with 3 faucet holes; Supply faucet LK-232-S-BH-5 5" wrist blades with rigid connections and gooseneck spout or CHICAGO FAUCET 786-GR8AE3V317AB or MOEN 8229 with S00R50, strainer LK-18B, P-Trap with cleanout plug and escutcheon; Supply valves shall be ¼ turn ball valve with chrome plated ball, sweated and have escutcheons. Compression fittings are not acceptable.

### 2.04 SHOWERS

LEONARD shall manufacture the following plumbing fixtures. Showers fully equal to the item specified and manufactured by KOHLER, AMERICAN STANDARD, SYMMONS, MOEN or POWERS shall be acceptable.

- A. Gang shower (Handicapped-Surface mounted) (SH) - LEONARD Surfashower SS-VO-BH-501P with single supply blade handle, hand shower mounted on slide bar. Provide SS-HC horizontal pipe cover with back plate. Exposed parts shall be vandal-resistant.
- B. Gang shower (Handicapped) (SH) - Leonard 476 volume control valve with blade handle, single supply 501P hand shower mounted on slide bar or Chicago faucet 770-317PLABCP with 151-777-037K. Exposed parts shall be vandal-resistant.
- C. Gang shower (SH-1-Surface mounted) (SH) - Leonard Surfashower SS-VO-300 with single supply, cross handle, H-06 shower head. Provide SS-HC horizontal pipe cover with back plate. Exposed parts shall be vandal-resistant.
- D. Gang shower (SH-1) - LEONARD 770 volume control valve with single supply, cross handle, H-06 showerhead or Chicago Faucet 770PLABCP with 621CP showerhead. Exposed parts shall be vandal-resistant.
- E. Shower (SH-2) (Handicapped) - Showerhead - KOHLER K-8520 hand held shower with slide bar; supply elbow - K-9664; shower valve K-304-KS pressure balanced mixing valve with integral stops and K-T6913-4 valve trim or MOEN T9346EP15, Posi-Temp pressure balancing valve shower system, hand held shower, 1-1/2" X 24" stainless steel ADA grab bar with MOEN 8371HD, Posi-Temp pressure balancing control valve with built in stops with T8370.

## 2.05 EXISTING TO REMAIN EQUIPMENT

- A. Existing to remain water closets - Provide and install BEMIS model 1955SSCT, black, extra heavy duty, open front, self-sustaining check hinge and elongated for all existing water closets. Replace closet flange, wax ring, bolts, bolt caps and spud gasket. See 2.01 for appropriate flush valve replacement.
- B. Existing to remain lavatories - See 2.02 for appropriate faucet replacement. Provide vandal proof aerator. Supply stops for each Kohler K-7601 chrome angle loose key, provide threaded tailpiece supply extensions. Replace waste outlet and provide chromium-plated p-trap with cleanout plug and nipple with escutcheon.
- C. Existing to remain shower (SH(E)) - Provide and install KOHLER K-7371 showerhead; shower arm K-7397; and shower valve K-6913-4 pressure balanced mixing valve with integral stops.
- D. Trough Sink (TS) (Existing Fixture) – Provide and install three (3) sets of CHICAGO FAUCETS Model N0. 225-261 or T&S Brass B-0316-LN w/ 132X VR lever handle faucets for each trough sink. Plug unused former bubbler mount with chrome plug.
- E. Existing to remain hand sink in kitchen – See 2.02 D for appropriate faucet replacement. Provide K-7601 supplies with loose key stops. Provide threaded tailpiece supply extensions.
- F. Existing to remain service sinks and mop basins - Replace faucet with one of the following faucets respectively - Kohler K-8905 or K-8907 with wall bracket. T&S Brass B-0669-02 or 665-BSTR or Chicago faucet 305-VB-RCF or 897-RCF with wall bracket shall also be accepted. All with integral vacuum breakers.

## 2.06 ELECTRIC WATER COOLER

The following electric water coolers (and/or drinking fountains) shall be manufactured by ELKAY. Electric drinking fountains fully equal to the item specified, manufactured by HALSEY TAYLOR, OASIS, HAWS or SUNROC shall be acceptable. Fixtures with plastic bubbler components will not be acceptable.

- A. Electric Water Cooler (EWC) - Elkay EWCA-14 wall mounted compact cooler complete with flexi-guard bubbler and all standard accessories; finish by Architect.  
Carrier - JOSAM 17550-WC, WATTS TCA-411 or JAY R. SMITH 0830.
- B. Electric Water Cooler (EWC-1) - Elkay EZ-8 universal mount barrier free cooler complete with flexi-guard bubbler and all standard accessories; finish by Architect.

Carrier - JOSAM 17550-WC, WATTS TCA-411 or JAY R. SMITH 0830.

- C. Electric Water Cooler (EWC-2) - ELKAY handicapped model # EZS8WSLK accessible water cooler with Bottle filling station, flexi-guard bubbler and all standard accessories. Finish by Architect. Carrier - JOSAM 17550-WC, WATTS TCA-411 or JAY R. SMITH 0830.
- D. Drinking fountain and cuspidor (DF) – Kohler Semi Recessed K-5293, vitreous china with 34902 condensation plate assembly, 35301 bubbler assembly, 79186 supply stop assembly, 35314 trap and 52054 wall screw access pack.

## 2.07 MOP BASIN/ LAUNDRY TRAY

FIAT shall manufacture the following plumbing fixtures. Mop basins and laundry trays fully equal to the item specified and manufactured by STERN WILLIAMS shall also be acceptable. Laundry Tray fully equal to the item specified and manufactured by JUST MANUFACTURING shall be acceptable.

- A. Mop Basin (MB-1) - FIAT Model TSB-700 with stainless steel caps on all curbs, 12" x 36" x 24"; Faucet, with integral vacuum breaker –T&S Brass 665-BSTR or FIAT 830-AA or CHICAGO FAUCETS 897-RCF or MOEN 8124 with internal vacuum breaker, integral check stops; Hose and hose bracket - 832-AA; Silicone sealant - 833-AA.
- B. Mop Basin (MB-2) - STERN WILLIAMS HL-2100 with 6" drop and stainless steel cap on threshold, 36" X 24" X 12"; Faucet, with integral vacuum breaker – T&S Brass 665-BSTR or 830-AA or CHICAGO FAUCET 897-RCF or MOEN 8124 with internal vacuum breaker, integral check stops; Hose and hose bracket - 832AA; Silicone sealant - 833-AA.
- C. Laundry Tray (LT) - ELKAY model RNSF8118LR, 16 gauge, type 304 stainless steel, floor mounted scullery sink with drainboards on both sides; Faucet shall be ELKAY model LK940AT10L2H with 2.2 GPM vandal resistant aerator, strainer LK-18B, P-Trap with cleanout plug and escutcheon; Supply valves shall be 1/4 turn sweated ball valves with chrome plated ball and escutcheons.

## 2.08 WASH BOX

- A. Wash Box – GUY GRAY MANUFACTURING CO., INC. Model NWFBED-200TS. Provide with 1/2" hot and cold water hose bibbs, a 20 amp, 120V duplex receptacle for washer, and a 30 amp, 220V, 4wire dryer receptacle.

## 2.09 OTHER FURNISHED EQUIPMENT

- A. The contractor shall make a complete waste, vent, hot and cold water rough in for all fixtures, equipment and food service equipment as indicated on the



drawings. Furnish and install 1/4 turn shut off valves for all countertop fixtures and KOHLER K-7601 supplies for all wall hung fixtures; traps, tailpieces, sink strainers, supply pipes, air gaps, backflow preventers, escutcheons, and make all final connections for a complete installation.

- B. The contractor shall consult the architectural drawings and other sections of the specifications for equipment requiring roughing in and final connection under this section of the contract.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The water supply to each surface mounted fixture shall have angle, loose key stop valves. On fixtures without integral stops, install stop valves. Fixtures which are installed in case work or fixtures with plumbing components which are not visible from the occupied space shall have 1/4 turn sweated ball valves with chrome plated ball and escutcheons. The water supply piping for fixtures located in casework shall be type L copper from the valve to the fixture, piping shall be run in such a manner as to allow the space below the fixture to be utilized as storage.
- B. Wall hung fixtures such as urinals, lavatories, sinks, electric water coolers and drinking fountains, shall have carriers. Where the carrier is not specified with the fixture, the fixture carrier shall be a 1/8 inch steel plate embedded or anchored in the wall with all-thread rods bolted or welded to the plate and extending through the finished wall for the fixture hanger installation. The minimum size rod shall be 1/4". The fixture carrier shall be installed while the wall is being built.
- C. The plumbing fixtures shall be installed at the mounting heights required by Fairfax County Public Schools standards. Where mounting heights are not stated, the plumbing fixtures shall be roughed-in in accordance with the manufacturer's rough-in information.
- D. The contractor shall make all final connections to the equipment furnished by others.
- E. The contractor shall provide watertight seals at all joints formed where fixtures come in contact with walls or floors.
- F. Remove all existing to remain fixtures in toilet rooms to allow for re-tiling of walls and floors. Remount fixtures at existing heights, except fixtures that get remounted at handicapped heights, after tile work is completed.
- G. All exposed piping components for lavatory faucets shall be chrome plated or stainless steel if such components appear below the apron of the fixture.

Faucets with exposed brass pigtails will not be acceptable.

- H. All sinks and lavatories that are indicated to be handicapped accessible shall have offset tailpieces.
- I. At the time of project closeout all battery powered urinal flush valves, battery powered water closet flush valves and battery powered faucets shall have the batteries removed and replaced with new batteries. Owner's representative shall verify battery replacement.
- J. Provide check valves on incoming water supply for all mop basins and laundry trays.

END OF SECTION

## SECTION 15500

### AUTOMATIC SPRINKLER SYSTEM

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

- A. An automatic sprinkler system shall be designed, installed, tested and approved for the entire building in accordance with Fairfax County School standards, NFPA standards, state codes, local jurisdiction's requirements and contract documents.
- B. In all renovation and addition projects the contractor shall provide temporary protection for all branch mains and bulk mains run through corridors where the ceiling has been removed. The contractor shall provide upright sprinklers (within 12" of the deck above) along the path of all water charged sprinkler branch mains and bulk mains in the corridor. When the ceilings are replaced the upright sprinklers shall be removed and the outlets they were connected to shall be capped. In projects where there is an existing sprinkler system, the existing sprinkler system shall be removed and replaced with a new sprinkler system. While work is being done in existing areas the existing sprinkler system may need to be removed and re-piped to allow for the installation of new equipment. When existing ceilings are removed for renovation, the existing sprinklers shall be removed and re-piped as upright sprinklers to provide sprinkler protection during phased construction.

##### 1.03 QUALITY ASSURANCE

- A. The automatic sprinkler system shall be tested in accordance with NFPA No. 13, FM 1637, UL 2443 and be approved by the local jurisdiction.
- B. The sprinkler contractor shall be licensed by the local jurisdiction to install the sprinkler system as required.
- C. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
  - 1. All castings used for coupling housings, fittings, and valve bodies shall be date stamped for quality assurance and traceability.

##### 1.04 SHOP DRAWINGS

This contractor shall prepare eight sets of shop drawings for the Architect to review. The local jurisdiction, the Architect and the Owner shall approve the shop drawings. The shop drawings shall include detailed working drawings at a scale no smaller than 1/8" per foot and shall also include lighting fixtures, ductwork, ceiling diffusers, grilles, HVAC and plumbing piping and any other possible obstructions. An overall plan showing the sprinkler zones shall be included on the working drawings (See paragraph 2.05). Calculations, sprinkler heads, alarm check valve, flow switches and other equipment shall also be included on the shop drawings. No sprinkler piping shall be installed until shop drawings have been reviewed.

## **PART 2 - PRODUCTS**

### **2.01 DESIGN**

The entire building shall receive a sprinkler system, hydraulically designed and zoned. Zones shall not exceed fifty thousand square feet (50,000 sq. ft.). The sprinkler design shall be a wet-pipe system for the interior of the building. Attic spaces, crawlspaces and areas subject to freezing shall receive dry system. Loading docks, Walk-in freezer and unheated outdoor storage shall have dry heads. The sprinkler contractor shall obtain current hydrant flow test information from the local water authority prior to starting any design work.

### **2.02 SPRINKLER HEADS**

The following sprinkler heads shall be manufactured by VICTAULIC. Sprinkler heads fully equal to the item as manufactured by VIKING, RELIABLE AUTOMATIC SPRINKLER CORPORATION of AMERICA or TYCO shall be acceptable. Sprinklers shall be glass bulb type, with hex-shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation. Wrenches shall be provided by the sprinkler manufacturer that directly engage the wrench boss. Sprinklers with rubber O-Rings are not acceptable.

- A. Sprinkler heads, where there are ceilings, shall be recessed mounted with a polished chrome finish and escutcheon and shall be quick response type. Heads shall be as manufactured by Victaulic model "V2708". Sprinkler heads in locker rooms and shower rooms shall have a Victaulic VC-250 corrosion resistant coating.
- B. Sprinkler heads, upright or pendent, exposed, shall be factory brass and shall be quick response as manufactured by Victaulic model "V2704 (upright) and V2708 (pendant)".
- C. Sprinkler heads, dry sidewall, shall be glass bulb, quick response with white epoxy coating and escutcheon as manufactured by Victaulic model "V3610". In lieu of rigid connections to dry sprinkler heads, a Victaulic VicFlex™ dry sprinkler, Model VS1, may be used.

- D. Sprinkler heads, sidewall, shall be wall mounted with polished chrome finish and escutcheon and shall be extended coverage quick response as manufactured by Victaulic model "V3416".
- E. Sprinkler heads, dry pendant, shall be extended type glass bulb, quick response with VC-250 corrosion resistant coating and 304 stainless steel escutcheon as manufactured by Victaulic model "V3606". Provide and install dry sprinkler boot to eliminate the air gap at the wall or ceiling. In lieu of rigid connections to dry sprinkler heads, a Victaulic VicFlex™ dry sprinkler, Model VS1, may be used. In cooler boxes and freezers a Victaulic AB6 dry pendant with VC-250 coating and stainless steel escutcheon may be used. The connection to the branch line shall be made with a flexible hose to accommodate expansion and contraction. No rubber boot/foam is required.
- F. Sprinkler heads in unoccupied spaces may be rough brass.
- G. Sprinkler heads, concealed, shall have factory finished white painted cover plate and shall be quick response as manufactured by Victaulic model "V3904". For ceilings painted black, custom black painted cover plate shall be provided.
- H. Provide sprinkler guards on all heads in the physical education rooms, gymnasiums, gym storage, walk-in coolers, loading docks, all storage rooms, gang toilets, locker rooms, boiler rooms and in mechanical rooms. Guards in occupied spaces shall be chrome plated. See 3.01.R for gang toilet and locker room exception.
- I. Escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.
- J. Sprinkler heads shall be of the same manufacturer for each type used.
- K. Escutcheon finishes shall match that of the sprinkler head they serve.
- L. Chrome plating is not an acceptable corrosion resistant coating.

### 2.03 FLOW SWITCHES

The flow switches shall be vane type. The flow switches shall be equipped with two sets of form 'C' contacts. Flow switches as manufactured by Potter Electric or Viking shall be acceptable.

### 2.04 CHROME FIRE DEPARTMENT CONNECTION (SIAMESE)

- A. Two-way projecting Siamese with cast brass, straight Y pattern, double inlet body, furnished with plugs and chains, and brass escutcheon plate lettered 'AUTO. SPKR.' Finish - polished brass chrome plated and shall be manufactured by Potter Roemer, No. 5750 with automatic ball drip. Provide low point drain for service. Siamese connections fully equal to the item specified, manufactured by ELKHART, GUARDIAN FIRE EQUIPMENT, CROKER

CORPORATION or POWHATTAN shall be acceptable. Siamese connections with a rough brass finish are not allowed. Provide a minimum 24" x 24" keyed lockable, access door, key shall be compatible to the owners HL302 key, to service check valve, ball drip and low point drain. Provide one key for each location and store in sprinkler cabinet.

- B. At the low point near each fire department connection, install a 90-degree elbow with drain connection to allow for system drainage to prevent freezing. Basis of Design: Victaulic #10-DR.

## 2.05 SPRINKLER ZONE GRAPHIC

- A. Provide two sets of small scale floor plans showing the sprinkler zone diagram graphic. The graphic shall show the outline of the entire school, all rooms and corridors with multiple floors shown separately. The sprinkler zones, as shown on the drawings shall be delineated with each zone shown in a different color. The number of each zone shall be shown in its respective area and the graphic shall be titled "Sprinkler Control Zones". The graphic shall show the Siamese connection, the locations of all control, zone, test and drain valves, all low point drains, bulk drains, fire department connection drain, hose valves and shall identify the zone the valve serves and its function. The graphic shall have minimum dimensions of 11"x17" for elementary, middle, high and secondary schools. Larger drawings shall be provided if the minimum dimensions are too small to convey the required information legibly. The graphic shall be laminated. The graphic shall be professionally produced; hand shading will not be accepted. Provide shop drawings on this graphic with sprinkler shop drawings.
- B. One zone diagram shall be wall mounted next to the sprinkler service entrance and shall be framed and covered by 1/8" clear plastic. The second zone diagram shall be turned over to the owner for sprinkler shop records.

## 2.06 VALVES

- A. Sprinkler system valves shall be as manufactured by STOCKHAM, MILWAUKEE, NIBCO, MUELLER, UNITED, VICTAULIC, KENNEDY or any manufacturers listed in section 2.02. Butterfly valves as manufactured by Central are not acceptable. The minimum working pressure for system components shall be 250 psi. All valves controlling the flow of water to sprinklers shall be listed indicating valves. The main system control valve shall be an O.S. & Y, equal to VICTAULIC SERIES 771H. type; other control valves may be with grooved ends or wafer type (butterfly), equal to VICTAULIC SERIES 705. Butterfly valves shall include a pressure responsive seat, and the stem shall be offset from the disc centerline to provide complete 360-degree circumferential seating. Auxiliary control valves, (elevator shaft, pit and machine room), shall be slow close ball valves, equal to VICTAULIC SERIES 728 (MILWAUKEE series BB-SCS). All control valves shall be provided with tamper switches. All valve actuators shall be weatherproof. Fire department connection check valves shall incorporate upstream and downstream pressure taps. The

inspectors test/drain valve shall be as manufactured by G/J Innovations, Inc. Model Sure-Test, combination test and drain valve with integral sight glass and test orifice. Test and drain valves manufactured by VICTAULIC TestMaster II Style 720, UNITED BRASS, Globe or AGF shall also be acceptable.

- B. Backflow prevention valve shall be a U.L., listed double check valve assembly including ball type test cocks to protect the potable water supply against backflow from the automatic sprinkler system. Shutoff valves shall be U.L./FM listed, OS&Y type with tamper switches. The assembly shall comply with ASSE 1015 or AWWA C510. The double check valve assembly shall be manufactured by CONBRACO INDUSTRIES, INC., APOLLO VALVES 4SG series. Backflow prevention valves equal to the item specified as manufactured by WATTS, AMES, FEBCO or WILKINS shall be acceptable.
- C. Service device valves shall be UL listed and FM approved, with a grooved end ductile iron body. The valves shall be rated for service of 225-psi (minimum). The valves shall be externally resettable, and all internal components shall be replaceable without removing the valve from the installed position. Basis of Design: VICTAULIC Series 751 (alarm valve), Series 769-NXT (preaction / deluge valve), and Series 768-NXT (dry valve, with required air pressure of 13-psi. Approved equal by VIKING will be acceptable.
- D. Sprinkler Specialty Control Valves: UL listed and FM approved, ductile-iron body with flanged or grooved ends, 175-psig minimum pressure rating. Riser Check Valves - UL 193, designed for horizontal or vertical installation. Basis of Design: Victaulic Series 717R. FCVA - Universal Manifold Check Valve shall be ductile iron construction, incorporating a control valve, check valve, flow switch, test and drain assembly, adjustable relief valve, and system gauges in one compact body/footprint. The test & drain assembly shall contain an adjustable relief valve, with a range of 175 to 310 psi. The UMC valve shall be rated for use at the maximum service pressure of 300 psi and shall be UL listed and FM approved. Universal manifold check valves shall be the Series UMC; a Globe brand manufactured by Victaulic.

## 2.07 PIPING

- A. All main and branch piping shall be schedule 40 or schedule 10 steel pipe. Schedule 10 piping shall only be allowed for piping larger than two inches. No piping less than schedule 10 shall be acceptable. Grooved end fittings shall be ductile iron, short-pattern, with flow equal to standard pattern fittings. Basis of Design: VICTAULIC FireLock, or approved equal.
- B. Grooved joint couplings shall consist of two ductile iron housing segments to ASTM A536, pressure responsive gasket to ASTM D2000, and zinc electroplated steel bolts and nuts to ASTM A449. Couplings shall comply with ASTM F1476 Standard Specification for the Performance of Gasketed Mechanical Couplings for Use In Piping Applications.

1. Rigid Type: Coupling housings shall be cast with offsetting, angle-pattern bolt pads to provide joint rigidity and support and hanging in accordance with NFPA-13. Couplings shall be fully installed at visual pad-to-pad offset contact. Tongue-and-recess type couplings, or any coupling that requires exact gapping of bolt pads at required torque ratings, shall be installed in strict accordance with the manufacturer's published instructions. If tongue and recess couplings are utilized, a label - initialized by installer, shall be affixed to each coupling showing proper torque was applied to joint.
    - a. Basis of Design: Victaulic Style 109, 009N and 107N, Installation-Ready, for direct stab installation without field disassembly, or standard rigid couplings Victaulic Style 005 "FireLock" and Style 07 "Zero-Flex".
    - b. In lieu of threaded steel piping systems, the Victaulic FireLock IGS System with "Installation-Ready™ fittings and couplings may be used for NPS 1 Schedule 10 and Schedule 40 carbon steel pipe in fire protection applications.
  2. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for the elimination of flexible connectors. Basis of Design: Victaulic Installation-Ready Style 177N or Style 77.
- C. Spaces with suspended acoustical ceilings shall receive flexible sprinkler drops manufactured by FLEXHEAD INDUSTRIES or VICTAULIC. Union joints shall be provided for all flexible sprinkler drops. Areas without suspended acoustical ceilings shall be hard piped using return bends. Dry pipe systems shall have galvanized piping.
- D. FlexHead industries- flexible sprinkler drops, hose assembly shall be stainless steel fully welded non-mechanical fittings, braided, leak tested with minimum one (1) inch true-bore internal corrugated hose diameter. The ceiling brackets shall be galvanized steel attachment type with integrated snap-on clip ends attached to the ceiling using tamper-resistant screws. The flexible hose attachment shall be removable hub type with set screw.
- E. Victaulic- flexible sprinkler drops, the sprinkler drops shall be stainless steel, braided with union joints factory tested to 400 psi. The drop shall include a UL Listed and FM Approved Series AH2/AH2-CC braided hose with a bend radius to 2" to allow for proper installation. No O-rings will be allowed. The flexible drop shall be attached to the ceiling grid using a one-piece open gate stainless steel bracket. The drop system shall consist of a braided type 304 stainless steel flexible tube, zinc plated steel male threaded nipple or Victaulic FireLock IGS Groove Style 108 coupling for connection to branch line piping, a zinc plated steel reducer with a female thread for connection to the sprinkler head. The sprinkler heads installed in acoustical ceiling and concealed ceiling shall be factory pre-assembled to the flexible sprinkler drops. The drops shall include all



required supports and bracing.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The sprinkler system shall be installed and tested in accordance with NFPA NO. 13 and shall be approved by the local jurisdiction. Two copies of the test results approved by the jurisdiction shall be sent to the Architect.

- A. The sprinkler piping shall be installed concealed above the ceiling and be coordinated not to interfere with the ductwork, air devices, lighting fixtures HVAC piping, plumbing piping and other items. All mains shall run below the ductwork and all branches shall be as high as possible. Branch piping that is not installed as high as possible shall be removed and re-installed at the proper height at no additional cost to the owner. Piping shall be arranged to allow for the easy removal of acoustical ceiling tiles, piping shall be a minimum of 6" above ceiling grid.
- B. The sprinkler heads in ceilings shall be installed in the center (both longitudinally and laterally) of the ceiling tile in lobbies, corridors and large rooms such as cafeterias, media centers, libraries, lecture rooms, etc. Sprinkler heads installed in corridor ceilings shall be installed in the center of the corridor. The intent is that when the corridor width allows for a single row of sprinklers, the heads shall align with the centerline of the corridor. Sprinkler heads in tiles in other spaces shall be installed in the center of tiles in at least the lateral dimension (width). Flexible sprinkler drops shall be installed in the top or side of main or branch piping (see drawing detail) inverted attachment is not acceptable.
- C. All sprinkler heads installed within the same room or space, shall be set at a uniform elevation.
- D. Test or drain lines shall discharge to the exterior of the building and shall be kept away from any entrances and off of loading docks and sidewalks.
- E. Maintain a minimum clearance of 6" between sprinkler heads and any other obstruction such as lighting fixtures, clocks, etc.
- F. The fire service main shall be lined piping outside of the building and inside up to the OS & Y valve. If a spool piece is used between the fire line stub and the OS & Y valve then the spool piece shall be galvanized. If the OS & Y valve is rated by the American Water Works Association (AWWA) as suitable for a connection to a potable water system, then no galvanized pipe is required and the OS & Y valve may be attached directly to the fire line stub.
- G. The sprinkler system shall be zoned as shown on the sprinkler zone diagram on the drawings. Each zone shall have an inspector's test and drain valve located

off the remote area of the zone.

- H. Provide high temperature sprinkler head(s) in the kitchen heat removal hood, Kiln room, near unit heaters and above gas water heaters. Heads installed within ten feet of gas clothes dryers shall be rated at 200° deg F. Heads located in the kitchen heat removal hood shall be located in the corner of the hood opposite the combi-steamer unit and rated at 360°F. Heads located in kiln hoods shall be rated at 286\* deg F. Sprinklers in the heat removal hood and in the kiln room shall be white epoxy coated or stainless steel. Provide intermediate temperature, standard response sprinkler head (200°F), at the bottom of the elevator shaft and in the elevator machine room. Provide intermediate temperature, quick response sprinkler head (200°F), in the walk-in freezer.
- I. All zone valves, control valves, test valves, hose valves and drain valves shall have laminated plastic labels attached to the valve to identify the zone the valve serves and the function of the valve (i.e. - "Control Valve - Zone 1", "Inspector's Test - Zone 1", "Drain valve – Zone 1", etc.). Laminated plastic shall be one eighth inch thick, red with white center core. Labels shall be a minimum of two inch by six inches with a minimum one quarter inch high block lettering. Peel off labels or permanent markers are not acceptable. Pre-manufactured labels with engraved information are acceptable. Where valves are located above ceilings, labels shall be screwed or riveted to the ceiling grid. In addition to the above, where valves are located in spaces which have doors, label with dimensions of 2" x10" shall be installed above the door on the occupied side of the door. Label shall read "Sprinkler control valve zone \_ \_ \_" etc. Labels attached directly to valves shall be attached by a non-ferrous metal chain.
- J. Piping shall be substantially supported from the building structure; the support shall be attached to the upper chord of the structure. Attachments shall be made either by welding or using top beam clamps. The supporting of piping from the supports of other disciplines is not acceptable.
- K. As phases of construction are completed, the sprinkler system shall be activated for any additions to the building that are turned over to the owner for occupancy. Active sprinkler mains that run through portions of the building without sprinkler protection shall be protected as required by the Fire Marshal or the Authority Having Jurisdiction. Sprinkler valve signs shall be installed in these areas. Sprinkler systems shall remain activated throughout normal school hours and any subsequent connections into active systems shall be made outside of these hours. Once construction for all phases is complete the entire sprinkler system shall be hydrostatically tested.
- L. All dry type sprinklers shall be of the same manufacturer and shall be insulated and sealed around the pipe penetration and shall have a corrosion resistant coating. Walk-in coolers/freezers shall have sprinklers located on opposite side of refrigeration equipment. All dry type sprinklers shall be 12" long unless special conditions require longer lengths.

- M. Sprinkler main and branch piping shall be flushed prior to installing any sprinkler heads. Flushing connections shall be provided on mains and shall be 2 1/2". Flushing connections shall consist of threaded nipples with hose valves and caps. Flushing connections shall remain after the flushing and testing has been completed for use as future drain valves. Two flushing connections shall be provided for each zone and shall be located within 50' of operable windows or exterior doors. Flushing connections shall be located on opposite ends of each zone. The flushing of each zone shall be witnessed and verified by the owner's representative.
- N. Check valves shall not be mounted higher than five feet above the finished floor.
- O. Fire department check valve upstream and downstream pressure taps shall have valves and be provided with capped hose end connections for future maintenance/inspection purposes.
- P. All control and zone valves located in the sprinkler room shall not be mounted higher than five feet above the finished floor.
- Q. All inspectors' test/drain valves shall be located in chases with keyed alike, lockable access doors, minimum size is 10"x10".. Key shall be compatible with owner's HL302 key. Provide one key for each location and store in sprinkler cabinet.
- R. Coordinate the spacing of heads with curtains and folding partitions.
- S. Backflow valves shall be tested by an approved testing agency after installation. In addition to the testing valves supplied with the backflow preventer, two 21/2 inch hose valves shall be provided in the bulk main, on the leaving side of the backflow preventer, for testing purposes.
- T. Provide concealed type sprinkler heads in all group toilets, locker rooms and shower rooms, for all middle, high and secondary schools. Provide concealed type sprinkler heads in bulkheads, and spaces where the ceiling height is 7 foot 6 inches or less. Provide concealed type sprinkler heads at folding partitions as to not interfere with the operation of the folding partition.
- U. Piping in exposed areas shall not be painted prior to the Fire Marshal approval of hydrostatic testing.
- V. The use of piping bushings is not acceptable.
- W. The shortest suitable length flexible braided sprinkler drop shall be used, however, avoid excessively sharp bends or stress at the takeoff from the branch line or main.
- X. The sprinkler bulb protector must remain in place until the sprinkler is completely installed and before the system is placed in service. Remove bulb protectors carefully by hand after installation. Do not use any tools to remove bulb

protectors.

- Y. Do not install sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install sprinklers with cracked bulbs.
- Z. Grooved joints shall be installed in accordance with the manufacturer's written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service.
- AA. Provide a listed relief valve per NFPA 13.

### 3.02 SPARE PARTS

- A. Provide and install cabinet adjacent to sprinkler service with spare heads, escutcheons, and wrenches for each type of sprinkler used including, but not limited to, all dry type and concealed heads, in accordance with the following schedule:

| <u>TOTAL NUMBER<br/>OF SPRINKLERS</u> | <u>NUMBER OF SPARE<br/>SPRINKLERS REQUIRED</u> |
|---------------------------------------|--|
| 1-10                                  | 1  |
| 11-299                                | 6  |
| OVER 299                              | 12   |

- B. All dry sprinklers shall be provided by the same manufacturer. Spare sprinklers shall be the same as those used on the project (temperature, color, length, etc.)
- C. Provide a spare sprinkler wrench for each type of sprinkler and provide PVC sleeves with screwed caps to house dry type sprinklers. Hang sleeves on wall adjacent to sprinkler cabinet(s). Provide allen keys for flow/tamper covers.
- D. Provide two spare flexible sprinkler drops for each length used. Provide bracket and hardware for each flexible sprinkler drop.
- E. Provide one set of Backflow Preventer repair kit.
- F. Spare wrench for recessed heads shall be socket type.

### 3.03 SPECIAL CONDITIONS

- A. The kitchen, all storage, mechanical, science rooms and science prep rooms shall be designed for Ordinary Hazard, Group One.
- B. Sprinkler heads needed for sprinkler system design but not specifically referenced under paragraph 2.02 will be considered on a case by case basis.
- C. Systems utilizing bulk mains, as shown on contract drawings, shall have zone

valve assemblies located as shown on these drawings. The zone valve assembly shall consist of a control valve with tamper switch, a check valve and a flow switch.

- D. Inspector test valves for attic dry pipe systems equal to Victaulic Series UMC/UM shall be installed in the space below, with drum drip and keyed, access door.
- E. Pool areas shall use galvanized piping and sprinkler heads with corrosion resistant coatings.

END OF SECTION

## SECTION 15540

### FIRE PUMP ASSEMBLY (ENGINEER TO EDIT TO MAKE JOB SPECIFIC)

#### PART 1 - GENERAL

##### 1.01 General

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

A complete prepackaged and hydrostatically tested fire pump system shall be installed.

##### 1.03 QUALITY ASSURANCE

A fire pumping system shall be installed and tested to meet the requirements of NFPA 20 Centrifugal Fire Pumps, state codes and the local jurisdiction.

##### 1.04 SUBMITTALS

Provide shop drawings on the complete fire pump system as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 FIRE PUMP

- A. Furnish and install as indicated on the drawings a completely piped and wired packaged fire pump system. The fire pump package shall be an electric motor driven system complete with control panel, valves, check valves, bypass, pump test header, relief valve, jockey pump, and jockey pump control panel. Fire pump shall be a packaged system mounted on a common base of fabricated steel and shall be manufactured by PEERLESS, model No. 5PVF7. Provide system as a complete split-skid package system on a rectangular structural steel mounting frame complete with all necessary pipe supports, wiring, and hard copper sensing lines for a complete package. The package shall be U/L listed as a system for its intended use. The package shall be electrically and hydrostatically tested per NFPA requirements before shipment. Unit shall be factory primed and painted with a machine grade finish coat. Packaged fire pump systems fully equal to the prototype manufacturer by SYNCROFLO or ARMSTRONG shall be acceptable.
- B. The fire pump shall be vertical in-line type with a capacity of 500 GPM at a design head of 55 PSI, 25 HP, 480 volt, 3 phase, 60 hertz, rated at 3520 RPM. Motor shall be provided by the pump manufacturer in accordance with NFPA 20

with all accessories for automatic operation. Fire pumps fully equal to the prototype manufacturer and manufactured by SYNCROFLO or ARMSTRONG shall be acceptable.

- C. The jockey pump shall be a BURKS Model E37CT7M close coupled turbine pump with mechanical seal, designed complete with a 3450 RPM,  $\frac{3}{4}$  HP, 480 volt, 3 phase ODP motor. The jockey pump shall have a capacity of 8 GPM at a design head of 76 PSI. The jockey pump pressure relief valve shall be pilot operated, UL listed,  $\frac{3}{4}$ ". Jockey pumps fully equal to the prototype manufacturer and manufactured by MTH or GRUNDFOS shall be acceptable.
- D. Pump Accessories - The manufacturer shall furnish accessories as follows:
  - a.  $\frac{1}{2}$ " Automatic air release valve, if applicable.
  - b. Set of suction and discharge pressure gauges
  - c.  $\frac{3}{4}$ " Casing relief valve, pilot operated type, UL listed.
  - d. Eccentric suction reducer, if applicable
  - e. Concentric discharge increaser, if applicable
  - f. 4" outside hose valve header, 125# flanges
  - g. Two sets of brass  $2\frac{1}{2}$ " hose valves, NST angle
  - h. Flow Meter and Return Loop

## 2.02 FIRE PUMP CONTROLLER

- A. The controller shall be a MASTER Control Systems Model "MC". Controllers fully equal to the prototype manufacturer and manufactured by TORNATECH or EATON shall be acceptable. UL/FM labeled combination manual and automatic type designed for across-the-line full or reduced voltage starting. One (1) year warranty on the entire controller, Phase Smart single phase protection, sensing lines with Y-strainer and connection located outside the enclosure. Limited service controllers will not be acceptable.
- B. The enclosure shall be a NEMA Type 2, 11 AWG steel and shall meet the requirements of the most recently mandated edition of NFPA 20 and shall be listed by Underwriters Laboratories and approved by Factory Mutual.
- C. The withstand rating of the controller shall be not less than 100,000 Amps.
- D. The controller shall include a motor rated isolating disconnect switch and circuit breaker, operated with two external handles, one for each device. The isolating disconnect switch and circuit breaker shall be mechanically interlocked so that the enclosure door cannot be opened with the handle in the ON position except by a hidden tool operated defeater mechanism.
- E. In addition to the three standard remote alarms the fire pump controller manufacturer shall supply an additional separate set of dry contacts for fire pump run in a separate alarm panel outside of the controller. The prototype is a MASTER model 48JS remote alarm junction panel. This condition shall not be pulled off the original set. It must be a dedicated separate set for independent

use.

- F. The controller shall have a minimum running period timer, set for ten minutes. Terminals shall be provided to field convert the controller from automatic to manual shutdown.
- G. The controller shall have externally mounted, individual visual indicators for POWER AVAILABLE, LOW PRESSURE, LOCAL START, REMOTE START, PHASE FAILURE, PHASE REVERSAL, INTERLOCK ON, PUMP RUNNING, and RUN TIMER ON. The controller shall be supplied with duplicate individual PHASE FAILURE, PHASE REVERSAL, and PUMP RUNNING alarm contacts.
- H. The controller shall have a pressure recorder and event log that records events for the life of the controller. Data shall be downloadable by USB port to external memory device.

#### 2.03 FIRE PUMP OVERCURRENT PROTECTION DEVICE

- A. The fire pump overcurrent protection device shall be a model OPD as manufactured by TORNATECH, rated for 460V/25HP/3 phase/60Hz and specifically designed to assure complete upstream overcurrent protection coordination with the electric fire pump controller. It shall have the following features:
  - 1. Factory assembled, wired, and tested
  - 2. UL listed for fire pump service as per NFPA 70 (NEC) 695.4(B)(2)(a)(2) and 695.3(F)(2)
  - 3. Suitable as service entrance equipment
  - 4. NEMA 2 assembly
  - 5. Flange mounted disconnect handle lockable in the ON (closed) position
  - 6. Markings as per NFPA 70 (NEC) 695.4(B)(3)(a)(2)
  - 7. All wiring between OPD and the Fire Pump Controller and Motor shall be completed and tested at the factory.

#### 2.04 JOCKEY PUMP CONTROLLER

- A. The jockey pump controller shall be a MASTER Model JPC, complete with fusible disconnect switch that is service rated, Hand-Off-Automatic selector switch, and a pressure switch in a NEMA 2R enclosure. The controller shall be rated for  $\frac{3}{4}$  HP, 3 phase, 60 cycle, 480 volt operation.
- B. Provide the following items:
  - 1. Control circuit transformer
  - 2. Power available pilot light

#### 2.05 SPECIALTIES

- A. Specialties shall be provided to meet the requirements of NFPA 20 including but



not limited to pipe, fittings, valves, check valves, eccentric reducers, concentric increasers, strainers, relief valves, pressure gauges, pressure switch including wiring and air vents. A ceiling lifting lug shall be provided directly over the fire pump motor. The lifting lug shall be sized to lift no less than 400 Lbs.

## 2.06 TEST MANIFOLD

- A. The test manifold for fire pump test connection shall be as shown on the drawings. The flush type wall hydrant shall be cast brass, double inlet body with male NPT inlet(s) and furnished with caps and chains, and cast brass escutcheon plate marked "Pump Test Connection". Finish shall be polished chrome plated, size 6" x 2-1/2" x 2-1/2", as manufactured by Potter-Roemer, Model 5862-7, complete with male snoots, caps and chains and removable swivel hose valves. Provide automatic ball drip. After the tests are complete and approved, the valves shall be removed and stored in lockable wall cabinet, 20" x 20" x 9", with solid door, as manufactured by Potter-Roemer, Model 1815. Locate cabinet in pump room. Pump test manifolds fully equal to the item specified, manufactured by CROKER or Elkhart, and shall be acceptable.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The fire pump system shall be installed and tested as shown on the drawings and specified herein and in accordance with NFPA 20, state and local codes. Two (2) copies of the test report approved by the local jurisdiction shall be submitted to the Owner.
- B. All power supplies to the fire pump and jockey pump controller shall be provided by the onsite electrical contractor. The left or right rotation shall be confirmed at release to production.
- C. The fire pump supplier shall provide the services of a factory qualified technician to align pump coupling and check all items prior to fire pump test. Provide the Owner with a copy of this report.
- D. Relief valves that discharge into floor drains shall not cause splashing of water in the pump room.
- E. Unless prohibited by code, drains shall discharge to the exterior of the building.
- F. Install unions between relief valves, jockey pump, and fire pump.
- G. Secure all piping with hangers or clamps.
- H. All drain lines for drip cup and relief valves shall be PVC, CPVC, or copper pipe.

## 3.02 TESTS

- A. The automatic fire pump shall be tested for capacity and flow in accordance with NFPA 20.
- B. The Certified Technician for the Fire Pump Manufacturer and Controller Manufacturer shall be present for the field acceptance test. The technician shall be a duly authorized representative of the fire pump, fire pump controller and driver manufacturer. Each shall submit documentation certifying such authorization, and shall comply with the requirements of NFPA-20 4.3, 2010. Technician(s) will comply with all Arc-Flash protective clothing requirements per NFPA 70. Provide contact information for warranty and service calls to be forwarded to the owner or owner's representative. Provide a start-up check list for the fire pump and fire pump controller to be completed by the Fire Pump Representative at completion of Start Up and Testing.
- C. Preliminary Start-up with flow test shall be conducted prior to the fire marshal test and include the following:

## Attested By and Date

- 1. Confirm Piping arrangement is in accordance with NFPA 20.
- 2. Confirm Electrical Inspection is complete.
- 3. Confirm Motor is wired correctly and rotation is correct.
- 4. Check and confirm align the coupling and forward the detailed report for record to engineer.
- 5. Calibrate the transducer or pressure switch between fire and jockey
- 6. Record pressures for each:

a. Fire/Jockey Off \_\_\_\_\_ Jockey On \_\_\_\_\_ Fire On \_\_\_\_\_

Attested By \_\_\_\_\_ Date \_\_\_\_\_

END OF SECTION

## SECTION 15601

### ATMOSPHERIC MODULAR BOILERS

#### PART 1 - GENERAL

##### 1.01 RELATED DOCUMENTS

The General Conditions, Special Conditions, Division 1, and the applicable portion of Division 15, Mechanical General Provisions including sections 15060, 15080, and 15100, are a part of this Section.

##### 1.02 SCOPE OF WORK

The work covered under this section of the specifications shall include the furnishing and installation of the modular boilers and associated items specified and/or indicated and all necessary piping and electrical connections required for a complete system as shown on the drawings and hereinafter specified.

##### 1.03 QUALITY ASSURANCE

- A. Each boiler shall be designed, constructed and pressure tested in accordance with the provisions of the ASME Boiler and Pressure Vessel Code for Heating Boilers and shall be stamped with the required official ASME symbol.
- B. Each boiler shall be rated to standards developed by the American Boiler Manufacturers Association.
- C. Each boiler shall be tested, certified, and listed in accordance with the requirements of the American Gas Association.
- D. The boiler control panels shall be approved and listed by the Underwriters Laboratory and shall include the official UL Label.
- E. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

- A. Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

**PART 2 - PRODUCTS**

## 2.01 BOILER &amp; ACCESSORIES

## A. General Requirements

1. Provide complete modular, low pressure, cast iron, hot water boiler system arranged for operation with natural gas, with atmospheric draft as shown on the drawings.
2. Packaged boilers shall be manufactured by Burnham, Weil McLain, or Hydrotherm.
3. The boiler shall be constructed in accordance with the provisions of Section IV of the ASME Boiler and Pressure Vessel Code and shall be stamped with the ASME symbol. It shall be tested, approved, and listed by IBR, shall be capable of developing full IBR gross output capacity of 100% firing rate and shall include the IBR certification symbol. The burner shall comply with the requirements of the Underwriters Laboratories.
4. The boiler shall be ASME stamped and all data reports signed and approved by a national board pressure vessels inspector with the unit.
5. The entire boiler, base frame and other components shall be factory-painted before shipment, using a hard-finished enamel.
6. The flue gas exit temperatures shall not fall below the dew point of the flue gases to prevent condensation corrosion within the boiler.
7. Unit shall be fully assembled and wired, with burner, controls, trim, and insulated steel jacket.

## B. Boiler Trim

1. Safety valves, size and quantity shall be in strict accordance with ASME Code requirements.
2. Provide all water trim, including a combination pressure altitude gauge and thermometer, ASME rated water relief valves, high limit aquastat, and low water cutoff.

## C. Water Manifolds

Water manifolds shall be provided that are designed for primary/secondary circulation. One combination supply and return manifold with interconnecting boiler-to-manifold piping shall be installed by the contractor.

D. Gas Valve Train

1. Each boiler shall be furnished with an AGA certified gas train.
2. The gas control train of each boiler shall be factory assembled and consist of a combination 24 volt redundant gas valve with 100% shut-off and a 1/8" N.P.T. pressure tapping.

E. Controls

1. Individual Boiler Module Gas Controls
  - a. Each boiler ignition system shall be of the EI type electronic control system which shall provide an electrically ignited intermittent gas pilot and permit the main gas valve to open only when the pilot burner is proven to be lit. Should a loss of pilot flame occur, the main gas valve will close and the spark will recur within 0.8 seconds. If pilot fails to ignite within 90 seconds, control will attempt to relight after 5 minutes. System shall include an electronic ignition module, pilot assembly, and pilot gas valve. Boilers shall be controlled by the Building Automation System (BAS). Boiler sequence of operation shall be as described in Section 15900.
2. All conduit for controls shall be liquid-tight. See specification Section 16110.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. The boiler shall be assembled as recommended by the boiler manufacturer and set above the boiler room floor on a 4" high concrete pad where shown on the drawing. The installation shall meet all ASME requirements.
- B. A level foundation (4" concrete base) shall be provided by the Contractor with full consideration given to the overall boiler dimensions and assembled and operating weight.
- C. The boiler shall be installed to permit all required access for complete servicing and maintenance.

3.02 START-UP

- A. Start-up service shall be provided by the equipment manufacturer's authorized representative and shall include complete testing of all controls, burner adjustment and overall boiler operation. The Contractor is responsible for a monitored start-up. The monitoring agency (Washington Gas Light Company) shall record the main gas supply pressure at inlet of gas line control assembly, gas manifold pressure, and control settings. Copies of this data are to be supplied to the Owner.
- B. The boiler shall be thoroughly cleaned in accordance with the manufacturer's instructions prior to being placed into service.
- C. Three complete operating and maintenance manuals, including wiring diagrams, start-up and operating sequence and material list shall be turned over to the Owner. See specification Section 01730 1.03 A.

3.03 TESTS

All burner units shall receive factory tests to check the construction, controls, and operation of the unit.

3.04 COMBUSTION TEST

The Contractor, upon completion of the fuel burning system, shall submit a written report on the operation of each burner to the Owner and will include the following information:

**GAS BURNER**

**Make** \_\_\_\_\_ **Model** \_\_\_\_\_

**Serial No.** \_\_\_\_\_

**CO<sub>2</sub>**  
 High Fire \_\_\_\_\_  
 Low Fire \_\_\_\_\_

**CO**  
 High Fire \_\_\_\_\_  
 Low Fire \_\_\_\_\_

**Net Stack Temp.**  
 High Fire \_\_\_\_\_  
 Low Fire \_\_\_\_\_

**Gas Burning Rate**  
 High Fire \_\_\_\_\_  
 Low Fire \_\_\_\_\_

**Gas Pressure at Orifices**

High Fire \_\_\_\_\_

Low Fire \_\_\_\_\_

**Gas Pressure Upstream of All Valves**

High Fire \_\_\_\_\_

Low Fire \_\_\_\_\_

**Microamp or Voltage Reading for flame supervision \_\_\_\_\_ Microamps (Volts)**

END OF SECTION

## SECTION 15604

### FUEL OIL PIPING AND ACCESSORIES

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions and Section 15050 -Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

- A. The work covered under this section shall include a complete fuel oil piping system.

##### 1.03 QUALITY ASSURANCE

- A. The fuel oil piping shall meet the requirements of NFPA 30 - Flammable Combustible Liquids Code, and NFPA 31 - Oil Burning Equipment, state and local codes.
- B. The fuel oil piping system shall be tested with 5 pounds per square inch air pressure for a minimum of 30 minutes.

##### 1.04 SUBMITTALS

- A. Provide shop drawings on the proposed piping arrangement and on all accessories as described in section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 UNDERGROUND PIPING

- A. The fill and sounding lines, vent line, and fuel oil supply and return piping shall be of fiberglass and resin construction, U/L listed for underground installation. Piping shall be inert to all petroleum products. Piping shall be Dualoy 3000L as manufactured by AMERON or Red Thread II by SMITH FIBERGLASS PRODUCTS INC.
- B. Fuel Oil Gauge Conduit - Shall be schedule 40 PVC with factory fittings.
- C. Observation Wells - Shall be schedule 40 PVC with factory installed 0.02 inch slots.



2.02 ABOVE GROUND PIPING

- A. Vent Line - Shall be schedule 40 black steel.
- B. Fuel Oil Gauge Conduit - Shall be pvc plastic schedule 40 with fittings.
- C. Fuel Oil Supply and Return Piping - Shall be black malleable iron with fittings.

2.03 VALVES

- A. Valves shall be threaded bronze gate valves with screw-in bonnet, rising stem, solid wedge and shall be rated for oil.

2.04 FUEL OIL GAUGE

- A. The gauge unit shall be HERSEY model VR-2 transducer and model 5000 indicator or equal by Pneumercator or Petrometer.

2.05 FUEL OIL STRAINER

- A. A fuel oil strainer shall be provided to each burner. Strainer basket shall be removable brass construction with wire mesh suitable for number 2 fuel oil.

**PART 3 - EXECUTION**

3.01 INSTALLATION

- A. Fuel oil piping shall be installed as shown on the drawings.

3.02 OIL VALVES

- A. Oil valves shall be installed in the supply pipe where the oil enters the boiler room and at each boiler.

3.03 FUEL OIL GAUGE

- A. The fuel oil gauge shall be installed in accordance with the manufacturer's recommendations.

3.04 FUEL OIL STRAINER

- A. The fuel oil strainer shall be installed in accordance with the manufacturer's recommendations.

3.05 OBSERVATION WELLS

The observation wells shall be installed with all accessories as detailed on the drawings and as noted below:

- A. Manhole Cover - Shall be cast with a full size equilateral triangle that shall be painted black.
- B. Locking Cap - Shall be keyed differently from the fill and sounding box-locking cap.
- C. Warning Message - Install a laminated plastic label inside the manhole with the following warning:

OBSERVATION WELL

WARNING: Do not place petroleum products or other substances in this well.

END OF SECTION

## SECTION 15605

### FUEL OIL TRANSFER PUMPS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010- General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include a complete fuel oil transfer pumping system.

##### 1.03 QUALITY ASSURANCE

- A. The pumping system shall meet the requirements of NFPA 31 - Oil Burning Equipment, state and local codes.
- B. The transfer pump shall be U/L listed for fuel oil use.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 FUEL OIL TRANSFER PUMPS

Provide and install a duplex fuel oil pump package as shown on the drawings. The fuel oil transfer pump shall be manufactured by VIKING. Pumps fully equal to the specified pump and manufactured by TUTHILL, WEBSTER or SUNDSTRAND are acceptable.

- A. Type - The pump shall be positive displacement internal gear rotary type in standard cast iron construction. Provide cast iron mounting foot.
- B. Capacity shall be as shown in equipment schedule on drawings.
- C. Rotor - Iron heads shall be hydraulically balanced to assure instant priming and constant flow. Rotor, shaft and idler shall be steel.
- D. Seal - The pump shall employ a mechanical face-type seal, with carbon graphite casing bushing.

- E. Bearings - the bearing shall be Teflon impregnated outboard type.
- F. Motor - Pump shall be mounted on formed steel base direct connected through flexible coupling with guard to 1200-rpm open drip-proof motor.
- G. Starter - Provide a manual starter for single-phase units and magnetic across-the-line starter for three phase units. The starter shall have ON-OFF switch and red running light. See section 15050, article 2.07.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The fuel oil transfer pumps shall be installed as shown on the drawing and as recommended by the manufacturer.

END OF SECTION

## SECTION 15607

### UNDERGROUND STORAGE TANK AND ACCESSORIES

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010- General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include a complete installation of a double wall fiberglass underground fuel oil storage tank with an electronic fuel oil gauge, overfill and spill prevention system, hydrostatic tank monitoring system, and all other measures required by local, state, and national governing bodies having jurisdiction over the installation and as shown on the drawings and in the specifications.

##### 1.03 QUALITY ASSURANCE

- A. The system shall meet the requirements of NFPA 30, "Flammable and Combustible Liquids Code", and NFPA 31, "Standards for Installation of Fuel Burning Equipment", Commonwealth of Virginia State Water Control Board regulation VR 680-13-02, "Underground Storage Tanks; Technical Standards and Corrective Action Requirements", and the County of Fairfax building code.
- B. The storage tank shall bear a UL label.
- C. The complete tank and piping system shall be tested as follows:
  - 1. Primary and secondary tank shall be leak tested by the manufacturer prior to shipment.
  - 2. Leak test primary and secondary tanks before installing in ground. Pressure test primary tank to 5 psig for thirty (30) minutes using gauge pressure to check for leaks. Connect primary and secondary tanks together, pressure test to 5 psig for one hour using gauge pressure to check for leaks. Soap entire tank during this period to check for leaks.
  - 3. After installing the tank in the ground repeat the above tests using gauge pressure to check for leaks.
  - 4. After installation is completed, perform precision test of entire tank and piping system. Test method shall be able to detect leaks of .05 gallons per hour in accordance with Virginia Regulation VR 680-13-02 part 2.1-D and NFPA 329.

5. Perform operation test of hydrostatic tank monitoring system by temporarily raising and lowering fluid in annular space.

#### 1.04 SUBMITTALS

Provide shop drawings for tank, piping, and all ancillaries as described in Section 15010, 1.04.

#### 1.05 WARRANTY

The installed tank specified in this section shall warranted not to fail or leak due to internal or external corrosion or structural damage under normal use and services. If within 30 years from the date of acceptance by the Architect the tank should fail, the manufacturer shall repair or replace it. Installation costs after the first year are not a part of this warranty.

### **PART 2 - PRODUCTS**

#### 2.01 FIBERGLASS-REINFORCED POLYESTER UNDERGROUND STORAGE TANK

- A. Provide and install double-wall storage tank as shown on the drawings. The storage tank shall have corrosion resistant construction of glass fiber reinforcement and isophthalic resin. Capacity and dimensions of the tank shall be as shown on the drawings. The tank shall be manufactured by FLUID CONTAINMENT or XERXES. Tank shall be double wall fiberglass reinforced plastic (FRP) underground storage tank with a primary (internal) tank and a secondary (external) tank.
- B. Loading Conditions – Tank shall meet the following design criteria:
  1. Internal Load: Primary and secondary tanks shall withstand 5 psi air pressure test with 5 to 1 safety factor.
  2. Vacuum Test: Tank shall be vacuum tested by the tank manufacturer to assure structural integrity. Primary tank shall be tested to 11.5 inches mercury and secondary tank tested to 9.5 inches mercury vacuum.
  3. Surface Loads: Tank shall withstand surface H-20 axle loads when properly installed according to current manufacturer's installation instructions.
  4. External hydrostatic pressure: Buried in ground with 7' of overburden over the top of the tank, the hole flooded and a safety factor of 5:1 against general buckling.

5. Tank shall be designed to support accessory equipment such as drop tubes when installed according to manufacturer's recommendations and limitations.

C. Product Storage Requirements

1. Tanks shall be capable of storing petroleum with specific gravity up to 1.1, shall be chemically inert to petroleum products, and shall be capable of storing fuel oil at temperatures not to exceed 150 degrees F.
  2. The primary tank shall be vented to atmospheric pressure. The tank is not designed as a pressure vessel.
- D. Materials – Tanks (primary and secondary) shall be manufactured with 100% isophthalic polyester resin and glass fiber reinforcement with no sand fillers.
- E. Brine Filled Annular Space – Tank shall have a space between the primary and secondary shell walls to allow for the free flow and containment of all leaked product from the primary tank.

2.02 TANK ACCESSORIES

- A. Anchor straps – Provide FRP anchor straps as manufactured by tank manufacturer. Number and location of straps shall be specified in current literature of tank manufacturer. Each strap shall be capable of withstanding the buoyancy load for tank diameter as follows:
- 4'-4,200 lbs. 8'-25,000 lbs. 12'-26,000 lbs.  
6'-18,000 lbs. 10'-32,000 lbs.
- B. Tank Flanged Manway shall be 22" I.D. flanged complete with U.L. listed gaskets, bolts and covers.
- C. Gauge Plates shall be installed by the manufacturer under each fitting and manway to prevent damage from dipstick abuse and ladders.
- D. Annular Space
1. Tank shall have a space between the primary and secondary shell walls to allow for the free flow and containment of all leaked product from the primary tank.
  2. Tank shall have one 4" NPT fitting located at each end of the tank for monitoring access to the space between the primary and secondary shell walls. Tank shall also include one 4" NPT fitting in the reservoir on the top of the tank.

- E. NPT Threaded Fittings
  1. All threaded fittings shall be a material of construction consistent with the requirements of the U.L. label. Fittings shall withstand a minimum of 150 foot pounds of torque and 1000 foot pounds of bending both with 2:1 factor of safety.
  2. All standard thread fittings shall be half couplings and shall be 4" in diameter. Reducers are to be used for smaller sizes where shown and provided by contractor.
  3. Suction Line – Shall be installed by contractor on site. Pipes shall terminate a minimum of 4" from bottom of tank.
  4. Return line shall be installed by contractor and shall terminate at the top of the tank.
- F. Hydrostatic Monitor Reservoir – An integrally mounted reservoir installed by the manufacturer shall be installed on the top of the tank. Reservoir shall be constructed of fiberglass reinforced plastic and shall have a 4" NPT monitoring fitting on top.
- G. Deadman Anchors – Deadman shall be a concrete beam with a total length 12" greater than the length of the tank. Deadman for 6' and 8' diameter tanks shall be 12" X 12" and deadman for 10' diameter tanks shall be 24" X 18".
- H. Certification Plate – Underwriter Laboratory label shall be permanently affixed to tank.
- I. Lifting Lugs – Provide lifting lugs on tank. Lugs shall be capable of withstanding weight of tank with a safety factor of 3 to 1.
- J. On 4,000 gallon tanks only, the Contractor shall install a foot valve in the supply line inside of the oil tank. The valve shall be single poppet style with an 8-mesh protective screen. Prototype: OPW model 91.

### 2.03 FUEL OIL GAUGE SYSTEM

The fuel oil gauge system shall consist of a liquid level transducer in the tank with an electronic indicator mounted in the boiler room complete with all necessary wiring. The tank gauging system shall be Hersey Model VR-2 transducer and model 5000 indicator or equal by Pneumercator or Petrometer, providing all aspects of the following are met:

1. The liquid level transducer shall extend to the bottom of the tank with the connection section mounted on the top outer tank shell. The transducer shall



convert the position of a floating magnet to a variable resistive signal output to the indicator. The transducer shall be enclosed in a stainless steel housing, have a resolution of 1/8", include zener barriers for intrinsically safe operation, and be Factory Mutual approved for fuel oil tanks.

2. The electronic indicator shall be compatible with level transducer and have a calibrated 250°F 10-1/2 inch diameter dial, an accuracy of 1.5% full scale, a standard proportional 4-20 mA output, an integral terminal connection block, and four alarm contacts. Power supply to the unit shall be 115 volt and low voltage power supply shall be internal to the unit. The indicator shall in a NEMA 3R housing and surface mounted in the boiler room. Wiring between the transmitter and the indicator and from the 115 volt power source to the indicator shall be under this section of the specifications.
3. Buried conduit for fuel oil gauge and reservoir sensor conductors shall be 3/4" non-metallic. Conduit exposed in manhole shall be rigid metallic. Conduit within the boiler room shall be rigid metallic or IMC. Junction boxes shall be in manholes and shall be NEMA type 6, submersible watertight. Minimum conductor size shall be AWG #18 type THHN.

#### 2.04 OVERFILL AND SPILL PREVENTION SYSTEM

The overfill and spill prevention system shall consist of an automatic overfill prevention valve, a spill containment basin, product fill tube, and manhole with lid and lockable fill cap. Overfill and spill prevention shall be the product of a single manufacturer. System shall be Emco/Wheaton model A1000 or equal provided all aspects of this specification are met. Components shall meet the following:

1. Overfill Prevention Valve – Valve shall be mounted within the spill containment basin for access. Valve shall shut off flow when the tank is 95% full, have a two-stage reset, a test button, and a spill basin drain assembly. Valve shall be cast aluminum with teflon floats protected with a shroud, with buna seals and 4" NPT fittings on each end. Prototype: OPW 61-60 overfill valve with drop tube, fill adapter and lockable cap.
2. Spill Prevention Basin – Basin shall have a 5 gallon capacity and shall contain an expandable inner shield within a rigid outer housing. The overfill prevention valve shall be mounted in the inner shield of the basin. Basin shall be constructed of fuel resistant plastic. Prototype: EMCO/WHEATON Model A1003.
3. Fill Tube – Tube shall be supplied with the overfill prevention valve, shall be aluminum, and shall extend to 4" from the bottom of the tank.
4. Manhole Cover – Manhole shall be cast iron or aluminum and be capable of a 7-1/2 ton bearing load. Paint the cover green.

5. Fill Tube Cap – Cap shall be water tight and lockable.
6. Sound Line Cap – Cap shall be watertight and oil wrench operated. Provide one oil wrench for the Owners use. Mount the wrench on the wall next to the fuel oil gauge or monitoring system.

#### 2.05 HYDROSTATIC TANK MONITORING

The hydrostatic tank monitoring system shall be supplied by the tank manufacturer and shall consist of a brine solution in the annular space between tanks, a level sensor in the monitoring reservoir, an alarm panel, and all necessary wiring. The monitoring system shall be capable of detecting a leak in the primary and/or secondary tank as small as .05 gallons per hour regardless of the oil level in the tank or ground water conditions. Components shall be as follows:

1. Brine Solution - The annular space between tanks shall be filled with environmentally safe, non-toxic brine solution able to provide freeze protection to minus 40 degrees F and UL listed for compatibility with the tank.
2. Level Sensor - The sensor shall be mounted in the monitoring reservoir on the tank and shall complete a circuit to generate alarm signals for normal, high, and low brine levels.
3. Alarm Panel - The alarm panel shall have a 120 volt power source. The panel shall have a normal operation lamp, an alarm indicator lamp, a bell alarm, a test button, a silencing switch, terminal contacts for external monitoring, two spare light bulbs, NEMA 2 enclosure, and a hasp for a padlock. Each lamp or switch shall be permanently labeled. A wiring diagram for the monitoring system shall be provided.

#### 2.06 VENT CAP

The fuel oil tank vent line shall be extended to at least ten (10) feet above grade. Provide a rain roof cap on vent opening.

#### 2.07 MANHOLE COVER

Manholes shall be 30" diameter, round with cast iron lid and steel rim. Manholes shall be set in 8" thick concrete extending at least 18" in all directions. Concrete shall slope away from hole to ensure drainage.

#### 2.08 MANWAY RISERS

Riser shall be fiberglass, 48" diameter. Bottom of riser shall be within 6" of top of the tank.

2.09 TANK NAMEPLATE

Provide an engraved aluminum or brass nameplate (minimum 10" x 8") permanently mounted in the concrete at the tank fill valve or on the building adjacent to the trench. Nameplate shall state the following: "TANK CAPACITY IN GALLONS", "DIAMETER OF TANK", "TANK MANUFACTURER", "TANK U/L #", "DATE OF INSTALLATION", "TYPE OF FUEL", "TANK #" (if more than one tank). Engraved letters shall be one inch high.

**PART 3 - EXECUTION**

3.01 FUEL OIL TANK

- A. Tank shall be installed according to current installation instructions provided by the manufacturer. Tank system shall be tested according to manufacturer's instruction and part 1.03 of this section.
- B. A 12 inch deep layer of pea gravel (1/8" to 3/4" diameter) or fine stone crushings (1/8" to 1/2" diameter) (ASTM D-448 & C-33-9.1) shall be spread evenly under the entire tank as a bed to separate the tank from the earth.
- C. Before placing the tank in the excavation, all dirt clods and similar foreign matter shall be cleaned from the tank and areas of coating damages shall be repaired with a compatible coating.
- D. Equipment to lift the tank shall be of adequate size to lift and lower the tank without dragging or dropping to ensure do damage to the tank. Tanks shall be carefully lifted and lowered by use of cables of adequate length attached where recommended by the manufacturer. Under no circumstances will chains or slings around the tank shell be used.
- E. Special care should be exercised when installing hold down straps to ensure that the straps are separated from the tanks by separating pad made of an inert insulating material. The separating pad should be at least 2 inches wider than hold down straps width and must be carefully placed anywhere on the tank where hold down straps would come into direct contact with the tank shell.
- F. Backfill consisting of pea fine gravel or #8 crushed stone shall be placed along bottom sides of tank by shoveling and tamping to ensure the tank is fully and evenly supported around bottom quadrant. The backfill shall be deposited carefully around tank and to a depth over tank shown on the drawings.
- G. The plugs at unused tank openings, shall be removed; a pipe compound shall be added, and the plugs shall be reinstalled in the unused openings. The plugs in tank openings which are to be used should not be overtightened as this may

cause the bushing thread or damage the nonmetallic bushings when replacing plugs or installing required tank piping.

- H. Anchoring - Concrete pad or Deadman as shown on plans shall be located and installed as recommended by the tank manufacturer.
- I. The tank shall be filled to 100% of capacity with new number 2 fuel oil.

### 3.02 ANCILLARY EQUIPMENT

All ancillary equipment including the fuel oil gauge system, overfill and spill prevention system, hydrostatic tank monitoring system, vent caps manholes, etc. shall be installed in accordance with the manufacturer's instructions.

### 3.03 INSTALLATION FIRM

The storage tank system shall be installed by experienced mechanics regularly employed by a specialty firm that is in the full time business of designing and installing petroleum storage tank and fuel dispensing systems. The firm shall have a minimum of five (5) years successful history in the design, installation, and maintenance of petroleum storage systems. Submit a written description of the firm's experience and a listing of at least three (3) of its installations of a comparable size and complexity.

### 3.04 TANK INSTALLATION DOCUMENTATION

Contractor shall provide the Owner with the following information for each tank installed within thirty days after installation.

1. Facility address.
2. Fire Marshal or other installation inspection reports.
3. Manufacturers installation instruction sheet with UL# and procedures checked.
4. MSDS sheets on materials supplied.
5. Precision test results.
6. Virginia Water Control Board (VWCB) amended form 7530-1 completed and signed.
7. Copy of approved drawings and permit from local building authority.

END OF SECTION

## **SECTION 15608**

### **UNDERGROUND STORAGE TANK REMOVAL**

#### **PART 1 - GENERAL**

##### **1.01 GENERAL**

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions shall apply to this section.

##### **1.02 SCOPE**

- A. The work covered under this section shall include the removal of the existing underground fuel oil storage tank and associated piping, and all other measures required by local, state, and national governing bodies having jurisdiction over the existing installation and as shown on the drawings and in the specifications.
- B. The oil tank area shall be restored to grade and re-paved.

##### **1.03 QUALITY ASSURANCE**

The demolition/removal shall meet the requirements of the Commonwealth of Virginia State Water Control Board regulation VR 680-13-02, "Underground Storage Tanks; Technical Standards and Corrective Action Requirements", the County of Fairfax building code, and Fire Marshal Regulations.

#### **PART 2 - PRODUCTS**

##### **2.01 BACKFILL**

Backfill shall be installed in accordance with section 02200.

##### **2.02 PAVEMENT AND SUBBASE**

Pavement and Subbase shall be installed in accordance with section 02510.

#### **PART 3 - EXECUTION**

##### **3.01 FUEL OIL TANK AND PIPE REMOVAL:**

- A. Contractor shall remove and dispose of the existing fuel oil tank, concrete pad, and soil in a manner as required and approved by all federal, state, and local agencies. The contractor shall be responsible for the removal of ten inches (10") or less of oil/water in the tank. Additional liquid will be disposed of at an

additional cost to FCPS. A Certificate of Compliance with these requirements shall be submitted to the Owner.

- B. Contractor shall remove and dispose of the existing oil piping in the boiler room, and any piping within the tank excavation area. Remaining underground oil piping shall be drained and abandoned in place.
- C. If evidence of contamination exists (as determined by the Fire Marshal Official, or by soil tests submitted to the state) the Contractor shall immediately notify the Owner and take necessary steps to limit any future contamination of surroundings. The state and local governing authorities will dictate corrective action to be taken subject to guidelines established by The Environmental Protection Agency. Corrective actions will be done by change order to the contract.
- D. Any additional or backfill soil shall be free of all debris and shall be compacted to 95 percent density. Contractor shall be responsible for providing all backfill soil. See Specification 02200.
- E. All tank cleaning and disposal costs shall be included in contract price.
- F. Prior to removal of existing underground fuel oil tank, the Contractor shall notify the office of the Fire Marshal and obtain all necessary permits.
- G. An official from the office of the Fire Marshal will witness the tank removal and, subject to his determination, backfilling of excavation shall be permitted or denied.
- H. Excavated soil shall be piled in multiple piles by soil condition at an Owner approved location either on site within property or at a site provided by Contractor. Costs for loading, hauling, and dumping shall be included in the bid. Pile(s) shall be on plastic sheets with seams taped and surrounded by hay bales.

### 3.02 EXISTING UTILITIES

- A. The Contractor shall contact "Miss Utility" to determine the location of any conflicting utilities in the oil tank excavation area. Provide adequate means of protection during earthwork operations of any utilities.
- B. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, the Contractor shall notify the Owner's Representative immediately.
- C. The Contractor shall not move or interrupt existing utilities without first coordinating with the Owner's Representative.

### 3.03 EXCAVATING, SHEETING, SHORING, AND BRACING

- A. Existing asphalt and concrete surface shall be cut neatly and cleanly.
- B. Stability of Sides: Slope sides of excavations over 4' deep to angle of response of material excavated; otherwise, shore and brace where sloping is not possible either because of space restrictions, stability of material excavated or nearby utilities.
  - 1. Maintain sides and slopes of excavations in a safe condition until completion of backfilling by scaling, benching, shelving or bracing.
  - 2. Take precautions to prevent slides or cave-ins when excavations are made in locations adjacent to backfilled excavations, and when sides of excavations are subjected to vibrations from vehicular traffic or the operation of machinery, or any other source.
- C. Shoring and Bracing shall be installed in accordance with section 02250.

#### 3.04 BACKFILL

Backfill shall be installed in accordance with section 02200.

#### 3.05 PAVEMENT AND SUBBASE

Pavement and Subbase shall be installed in accordance with section 02510.

#### 3.06 BARRICADES, WARNING SIGNS AND LIGHTS

Comply with recognized standards and code requirements for the erection of substantial, structurally adequate barricades where needed to prevent accidents and losses. Paint with appropriate colors, graphics and warning signs to inform personnel at the site and the public, of the hazard being protected against. Provide lighting where appropriate and needed, including flashing red lights where appropriate.

#### 3.07 ENCLOSURE FENCE

When excavation or other substantial elements of the work begin, install a general enclosure fence with suitable lockable entrance gates. Enclose substantially the entire site or portion thereof determined to be sufficient to accommodate the entire construction operation. Install fence in a manner that will prevent persons, dogs and similar animals from easily entering the site. Fence shall be a minimum height of 6 feet.

END OF SECTION

## SECTION 15616

### BOILER AND WATER HEATER VENT

\*(Engineer to coordinate with Plumbing for water heater vent selection)\*

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this Section.

##### 1.02 SCOPE

Provide and install a complete factory-built vent system as called for on the drawings.

##### 1.03 QUALITY ASSURANCE

The vents shall meet the requirements of NFPA standards and The International Fuel Gas Code, be UL listed, and satisfy all state and local codes.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 GAS FIRED BOILER VENTS

Provide and install the boiler vents complete as shown on the drawings and specified herein. The vents shall be UL listed for this application and meet the requirements of NFPA standard No. 211. The boiler vent shall be double walled using AL29-4C stainless steel. Model SAF-T Vent CI Plus as manufactured by SELKIRK. Vents manufactured by METAL-FAB or SCHEBLER are acceptable provided they are fully equal to the vent specified.

##### 2.02 GAS FIRED WATER HEATER VENT

Provide and install the water heater vent complete as shown on the drawings and specified herein. The vents shall be UL listed for this application and meet the requirements of NFPA standard No. 54 and/or No. 211. The vents shall be as manufactured by SELKIRK METALBESTOS. The water heater vent for atmospheric type heaters shall be model RV for 3" to 8" and model QC for 10" vents. The water heater vent for power burner type heaters shall be model PS. High efficient condensing water heater vent shall be double walled using AL29-4C stainless steel, Model SAF-T Vent CI Plus as manufactured by SELKIRK. Vents manufactured by METAL-FAB or



SCHEBLER are acceptable provided they are fully equal to the vent specified.

2.03 WATER HEATER VENT

The water heaters shall have the outside combustion air intake and the exhaust vent ducted with chlorinated polyvinyl chloride (CPVC) duct pipe. Duct pipe shall be extruded from a chlorinated polyvinyl chloride (CPVC) compound with a cell classification of 23447 per ASTM D1784. The duct pipe shall have a maximum service temperature of 200°F. Duct pipe and fittings shall be from the same manufacturer.

**PART 3 - EXECUTION**

3.01 GAS FIRED BOILER VENTS

The boiler vents shall be installed in accordance with the manufacturer's recommendations and to meet the requirements of NFPA No. 211, state and local codes. Provide barometric dampers when recommended by boiler manufacturer.

3.02 WATER HEATER VENT

The water heater vent shall be installed in accordance with the manufacturer's recommendations and to meet the requirements of NFPA No. 54 and/or No. 211, state and local codes. Provide barometric dampers when recommended by water heater manufacturer.

3.03 CONNECTIONS TO CHIMNEYS

Vent connections to chimneys shall be made with thimbles. The thimble shall be permanently cemented in place, utilizing heat-resistant cement. The metal vent shall be flush with the inside wall of the chimney.

END OF SECTION

## SECTION 15620

### HIGH EFFICIENCY BOILERS

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

- A. Provide a complete packaged low pressure condensing firetube water boiler arranged for operation with natural gas.

##### 1.03 QUALITY ASSURANCE

- A. The boiler shall be constructed in accordance with the provisions of Section IV of the ASME Boiler and Pressure Vessel Code and shall be stamped with the ASME symbol. The burner shall comply with the requirements of AGA.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

- A. Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

##### 1.05 WARRANTY

- A. The boiler manufacturer will repair or replace any part of the boiler that is found to be defective in workmanship or material within eighteen (18) months of shipment from the factory or twelve (12) months from start-up, whichever comes first.
- B. The boiler's pressure vessel is warranted against failure due to thermal shock for a period of ten (10) years from the date of shipment from the factory is installed, controlled, operated and maintained in accordance with the Installation, Operation and Maintenance Manual.
- C. The pressure vessel and heat exchanger is covered against failures resulting from flue gas corrosion and/or defective material or workmanship for a period of ten (10) years from the date of shipment from the factory. Waterside corrosion or scaling is not covered. The manufacturer will repair, replace, exchange or

credit at their option, FOB factory, the pressure vessel as defined above, provided this equipment has been installed, operated and maintained by the buyer in accordance with the Installation, Operation and Maintenance Manual.

## **PART 2 - PRODUCTS**

### **2.01 HIGH EFFICIENCY BOILER**

The boiler assembly shall consist of packaged pulse boiler, a natural gas burner, controls and an insulated jacket. Capacity shall be as shown on the drawings. Boiler shall be manufactured by Fulton Boiler Works, Inc. Boilers by Viessmann Manufacturing, Inc. and Lochinvar are acceptable providing capacities and arrangement can be furnished.

#### **A. Boiler**

1. The boiler shall be completely factory assembled as a self-contained unit.
2. The pressure vessel design and construction shall be in accordance with Section IV of the ASME Code for heating boilers. The boiler shall comply with CSD-1 code requirements.
3. The firetube area of the heat exchanger where the flue gases will condense shall be constructed using duplex alloys of stainless steel.
4. Heat exchange capability shall be maximized within the pressure vessel via the use of corrulator fire tube technology. All heat transfer enhancements shall be stainless steel; aluminum heat transfer enhancers are unacceptable.
5. Boilers with heat exchangers using cast aluminum, cast iron or copper finned tube design platforms are unacceptable.
6. The boiler shall be a fire tube design. The furnace location shall be such that all furnace components are within water-backed areas.
7. The burner shall be a premix low emission design with a build in flame arrestor functionality.
8. The burner shall feature direct spark ignition.
9. A zero flow or low flow condition shall not cause any harm to the pressure vessel or heat exchanger of the boiler. Flow switches, dedicated circulator pumps, or primary/secondary piping arrangements are not required to protect the heat exchanger or pressure vessel from thermal shock or other system related considerations. Boilers requiring the use of

flow switches or primary/secondary piping arrangements are unacceptable.

10. A lock up regulator upstream of the fuel train shall be furnished by the boiler manufacturer as a standard component integral to the boiler cabinet. Factory test fire of the boiler with the provided lock up regulator is required.

**B. Boiler Controls**

1. The control shall provide a prepurge and postpurge cycle. The control shall maintain a running history of operating hours, number of cycles, and the most recent sic flame failures.
2. The boiler shall be equipped for modulated gas input. Fuel flow shall be controlled by a valve in the fuel train. Air flow shall be controlled by a butterfly valve located in the exhaust vent. Both valves shall be connected to a modulation motor. Turn down shall be 5:1.
3. Combustion controls shall be of on/off operative type and are to include:
  - a. Operating temperature controller for automatic start and stop of the combustor.
  - b. High limit temperature controller with manual reset.
  - c. One low water cutoff probe in the boiler shell with manual reset and push-to-test capability.
  - d. Air safety switch to prevent operation until sufficient prepurge air is assured.
  - e. High condensate cut-off switch located in the exhaust decoupler.
  - f. Proof of flame switch to prove combustion based on pressure.
  - g. Gas pressure regulator shall be furnished factory, field installed.
  - h. Full modulation combustion control system shall be furnished which shall provide a turndown rate of 5 to 1 over the input range from low to high fire. The supply temperature and setpoint temperature shall be displayed at all times by an LED readout.
  - i. All controls shall be panel mounted and located on the boiler to provide ease of servicing the boiler without disturbing the controls. All controls shall be mounted and wired according to AGA requirements.

**PART 3 EXECUTION**

### 3.01 INSTALLATION

- A. The boiler shall be assembled as recommended by the boiler manufacturer and set above the boiler room floor on a 4" high concrete pad where shown on the drawing.
- B. The boiler shall be mounted on vibration isolators. Piping shall be supported with hangers with vibration isolation
- C. Intake and exhaust mufflers shall be installed. When required by the boiler manufacturer.
- D. The condensate drain shall be trapped and extended to the floor drain.

### 3.02 VENTING

Boilers shall be vented per manufacturer's requirements as shown on the drawings and described in Section 15616.

### 3.03 GAS PIPING

Gas piping shall be installed as shown on the drawings and described in Section 15350.

### 3.04 START-UP

Service shall be provided by the equipment manufacturer's authorized representative and shall complete testing of all controls, burner adjustment and overall boiler operation. The Contractor is responsible for a monitored start-up. The monitoring agency (Washington Gas Light Company or owner approved company) shall record the main gas supply pressure at inlet of gas line control assembly, gas manifold pressure, and control settings. Copies of this data shall be supplied to the Owner.

### 3.05 COMBUSTION TESTS

The contractor, upon completion of the fuel burning system, shall submit a written report on the operating of each burner to the engineer and will include the following information.

**COMBUSTION TEST REPORT**

Job Name:  
Manufacturer:  
Model #  
National Board #

Operating Set Point: \_\_\_\_\_  
High Limit Set Point: \_\_\_\_\_

Gas Supply Pressure LF \_\_\_\_\_ / HF \_\_\_\_\_  
Last Elbow Pressure LF \_\_\_\_\_ / HF \_\_\_\_\_

**Low Fire**

O<sub>2</sub> \_\_\_\_\_  
CO \_\_\_\_\_  
CO<sub>2</sub> \_\_\_\_\_  
Stack Temp \_\_\_\_\_

**Mid Fire**

O<sub>2</sub> \_\_\_\_\_  
CO \_\_\_\_\_  
CO<sub>2</sub> \_\_\_\_\_  
Stack Temp \_\_\_\_\_

**High Fire**

O<sub>2</sub> \_\_\_\_\_  
CO \_\_\_\_\_  
CO<sub>2</sub> \_\_\_\_\_  
Stack Temp \_\_\_\_\_

END OF SECTION

## SECTION 15622

### CAST IRON BOILERS AND BURNERS

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

- A. Provide a complete field assembled low pressure wet base cast iron sectional water boiler arranged for operation with a combination natural gas and No. 2 light oil forced draft power burner.

##### 1.03 QUALITY ASSURANCE

- A. The boiler shall be constructed in accordance with the provisions of Section IV of the ASME Boiler and Pressure Vessel Code and shall be stamped with the ASME symbol. It shall be tested, approved and listed by IBR, shall be capable of developing full IBR gross output capacity at 100% firing rate and shall include the IBR certification symbol. The burner shall comply with the requirements of the Underwriters Laboratories. The complete fuel burning system shall further be in full accordance with Industrial Risk Insurers (IRI).
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

- A. Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 CAST IRON BOILER/BURNER UNIT

The boiler assembly shall consist of multiple cast iron sections, a natural gas and light oil fired combination burner, fuel trains, water and control connections, controls and an insulated jacket. Capacity shall be as shown on the drawings. Boiler shall be as manufactured by PEERLESS. Boilers manufactured by BURNHAM, WEILMCLAIN, SLANT-FIN or H.B. SMITH are acceptable providing capacities and arrangements can be furnished. Burners shall be as manufactured by WEBSTER ENGINEERING. Burners

manufactured by POWER FLAME are acceptable providing capacities and arrangements can be furnished.

A. Boiler

1. The boiler shall consist of cast iron sections constructed in conformity with ASME Code requirements and tested hydrostatically for a 50 psi water working pressure. The boiler sections shall be of the three-nipple design with internal waterway baffles to provide for balanced water circulation.
2. Jacket - The boiler shall be provided with a metal jacket to be installed after the supply and return piping is in place. The jacket shall cover the entire boiler excluding the burner and shall be completely insulated between the jacket and the boiler with fiberglass insulation. The jacket shall have a factory applied baked enamel finish. Provide an extended jacket when noted in the equipment schedule.
3. Trim - Provide all water trim, including a combination pressure altitude gauge and thermometer, ASME rated water relief valves, high limit aquastat, and two low water cutoffs (one float type and one probe type).

B. Pressure Atomizing Burners

1. Furnish and install UL labeled combination gas-oil mechanical pressure atomizing type oil burners. Oil burner shall be capable of burning No. 2 fuel oil and shall be capable of burning natural gas. Burner shall have rated capacity as specified.
2. The oil burner shall burn the specified quantity of fuel without objectionable vibration, noise, or pulsation with not more than 20% excess air and no CO in the products of combustion on gas firing, and maximum of No. 2 smoke as measured on the Bacharach Scale.
3. The burners shall incorporate a stainless steel flame retention type combustion head for long life and efficient operation. Burners that have refractory of cast iron type combustion heads will not be approved.
4. A permanent observation port shall be provided in the burner to allow observation of both the pilot and main flame.
5. Supply voltage will be volts, phase, 60 hertz. All motors shall be suitable for use on this voltage. All burner controls are to be for use on 120 volts, 1 phase, 60 hertz. The 120-volt control voltage shall be supplied through an isolating step-down control transformer from the supply voltage. Transformer shall be supplied as part of the burner controls and mounted in the control cabinet.



## C. Burner Accessories

1. A two-stage oil pump shall be provided for each burner. This shall be supplied as an integral part of the burner.
2. Two approved automatically operated safety shut-off valves shall be provided in the oil supply to the burner; valves are to be piped in series but wired in parallel.
3. Supply an oil pressure gauge (liquid filled with 1 1/2" diameter face) to indicate the discharge oil pump pressure. Provide 1/4 turn gauge cock.
4. Install a manual gate valve, fuel oil filter or strainer, and vacuum gauge on the suction side of the oil pump.
5. Install a fusible link actuated safety cut-off valve in the oil supply line between the oil tank and the manual gate valve at the oil pump.
6. Oil pressure supervision shall be provided by an approved pressure switch interlocked to accomplish a non-recycling safety shutdown in the event of low oil pressure.
7. Oil piping connections to the burners shall consist of, on the inlet side: shut-off valve, filter, union, and pressure gauge; and on the outlet side: check valve, shut-off valve, pressure gauge and union. Relief valve or pressure regulators shall be installed per burner manufacturer's recommendations.

## 2.02 BURNER CONTROLS

- A. The on/off operation of the burner(s) shall be controlled by water temperature by means of a temperature control.
- B. An additional high-limit safety temperature control of the manual reset type shall be provided to control each burner.
- C. Pre- and post-purge operation of the burner fan shall be provided.
- D. A manual restart of the burner shall be necessary in the event of shutdown due to flame failure.
- E. All three phase motors shall be controlled and protected by an automatic starter with thermal overload protection. Starter shall be interlocked to prevent burner operation when overload relays are tripped out.
- F. Supply a burner mounted airflow switch to prevent the energization of the main

fuel valves in the event of insufficient combustion air.

- G. Manual reset of system shall be required to restart burner after airflow failure has occurred.
- H. A factory prewired control cabinet shall be supplied with each burner. Cabinet shall be mounted on burner. Cabinet shall house the flame safeguard control, programming purge timer, burner motor starter, fuses, control switches, alarm bell with automatic reset silencing switch to ring on low water or flame failure, control transformer, indicating lamps as specified hereinafter and relays that may be required. Alarm bell shall be EDWARD's 4" diameter AC adaptable. Provide an engraved nameplate permanently affixed to the front of the cabinet with the following information.

Installing Contractor:

Contractor Phone No.

Date Warranty - FROM: \_\_\_\_\_ TO:

- I. Provide in each control cabinet individual lights with nameplates to indicate "power on," "main fuel valve on," "call heat," "ignition on," "pilot failure," "low water," and "main flame failure."
- J. Furnish and install on the control cabinet for each boiler an electrical non-resettable elapsed time indicator, minimum of 99,999.9 hours, minimum 2 1/2" round face, UL listed, with NEMA standard round and square detachable bezels. Units by Cramer-Grainger's model no. 6X137.
- K. The changing from one fuel to the other shall be manual by means of fuel selector switch. No burner adjustments shall be required to switch from one fuel to the other.
- L. The burners shall be equipped with suitable fuel and air controls to assure smooth main flame ignition.
- M. Fuel-air control must be synchronized. The fuel-air drive unit shall be provided with a position-indicating switch, which shall be interlocked with the flame safeguard system to assure starting with low fire position. The flame safeguard system shall further program this drive unit to provide a full open louver purge of sufficient time to provide a four air change pre-ignition purge of the combustion chamber, heat exchanger, and a flue passages. Duration of purge shall not be less than 30 seconds.
- N. Pre-ignition purge air flow rate shall be no less than 60% maximum firing rate air flow. Interlocks shall be provided to monitor and prove 60% airflow purge when air inlet louvers are opened automatically to obtain this purge rate.

- O. Provide and install emergency shut-off switch of burners at each entrance/exit to boiler room. Switch shall be push button type by Square "D" type TR with type TM contact and type KA contact block.

### 2.03 BOILER SEQUENCING CONTROLS

- A. Provide and install as a part of the burner control systems a Lead-Lag Boiler Sequencing Control System for a two-boiler system. It shall respond to variations in the main header temperature. The system operating temperature is 180 degrees F. Two lead-lag aquastats shall be installed in the header and wired to the boiler #1 burner panel lead-lag terminals. Install a boiler #1/boiler #2 switch in the boiler #1 burner panel.
- B. In the event of power failure, the Lead-Lag system shall bring the boilers on the line in sequence after power is restored.
- C. The two boiler mounted temperature controls on each boiler, previously specified, one of which shall be the manual reset type, shall be in addition to the Lead-Lag System and shall both function as high limit controls.

### 2.04 BURNER MANAGEMENT CONTROL SYSTEM

Each burner will be equipped with a Microprocessor Based Burner Management Safeguard Control System, which shall be UL listed.

- A. Components
  - 1. Each burner will be equipped with UL/FM approved microprocessor based Burner Management Safeguard Control System that incorporates a plug-in design, with the programmer, amplifier and display module to be in separate components. A self-diagnostic circuit within the control will identify module failures and an appropriate message will be displayed for servicing. This circuit will cause a safety shutdown should any component in the control fail. For example, if the amplifier module is malfunctioning, the message center will display the message, "LOCKOUT REPLACE AMPLIFIER".
  - 2. Each component will plug into the Master Chassis and be keyed to insure that the components may be installed only into the proper location.
  - 3. The control mounting screw will secure all components in the chassis. This will prevent tampering while the control is installed in the base. The control must be removed from the base to replace any of the components.

4. The amplifier shall be the auto-check ultraviolet type.
5. The control shall be the FIREYE YB110UV Flame-Monitor with the BLI510 display module and YP100 Programmer.
6. The ultraviolet scanner shall be the FIREYE UV1A.

B. Control System Functions

1. The control will have a non-volatile memory, which allows it to remember burner history and present position, even after a power interruption. A minimum of 42 different messages will be displayed on the message center of the control (in English words and phrases) which indicates system function and diagnostic information.
2. The messages shall provide clear, concise information concerning system timing, present burner sequence position, lockout causes including wiring base terminal designations and historical data.
3. The control shall provide for direct connection of limit and operating controls, fuel valve interlock, damper position interlocks, running interlocks (such as airflow, fuel pressure and temperature), burner motor, ignition, pilot valves, firing rate motor and alarm.
4. During the firing cycle, a constant read-out of the flame signal will be displayed on the message center.
5. At the end of each firing cycle, the control will display main fuel operating hours and complete firing history.
6. The control shall accomplish a safe start component check during each start. This will prevent the burner from firing under any condition, which causes the flame to assume and hold its energized position due the presence of an actual flame, a flame simulating component failure or mechanical failure.
7. Control shall provide a purge period of not less than 30 seconds with a damper driven to the open position and an interlock circuit provided to prove airflow rate during the purge period. A starting interlock circuit is required to prove that the burner equipment is in the low fire position at the same time of ignition, plus an interlock to prove airflow during the purge and firing cycle.
8. Control shall provide limited trial-for-ignition of pilot flame restricted to 10 seconds, trial-for-main flame restricted to 10 or 15 seconds (selectable) for oil or gas.

9. Control shall provide a safety shutdown following flame failure, with fuel and ignition circuits de-energized in not more than four seconds.
10. Control shall provide a post purge period of 15 seconds following a shutdown.
11. The system shall remain automatically under control of the operating control and when power is restored following power failure. Manual reset shall be required following any safety lockout. When in a lockout condition, power interruptions will not recycle the control.
12. The control shall provide a check-run switch will allow the service technician to stop the burner sequence in any of four different positions.
  - High Fire Purge
  - Low Fire Purge
  - Pilot Trail for Ignition
  - Low Fire (Burner On)
13. Interconnection with either a computer terminal or modem communications shall be possible. When connected, such equipment will access both present control/burner status and historical information through a serial data port on the display module.
14. The message center display shall be designed to accept first out indication of an additional 16 limit condition from a separate future expansion module.

#### 2.05 GAS VALVE TRAIN

- A. The gas train piping shall include a 1/4" NPT pressure tapping with 1/4" pipe plug upstream and downstream of each valve and regulator in the gas train.
- B. Provide a gas pressure gauge to indicate the gas burner manifold pressure.
- C. Furnish and install one manually operated lubricated plug cock upstream of all valves.
- D. Provide one gas pressure regulator (of tight shut-off type) with vent to outside atmosphere, in accordance with local gas company and IRI requirements.
- E. Provide one automatically operated motorized safety gas valve. Safety valve shall be proven closed during pre-ignition by proof of valve closure interlock switch on valve.
- F. Provide a second automatically motor operated gas safety shut-off valve to

operate simultaneously with the above gas valve.

- G. A normally open, fully ported, electrically with proven closed operated valve shall be provided in a vent line connected between the two safety shut-off valves. The vent pipe shall be run independent of other vents to the outside atmosphere and provided with union to check vent valve operation. The proven closed switch shall interlock with its burner controls. Acceptable manufacturer: MAXON.
- H. A separate pilot gas cock, gas pressure regulator and pilot safety shut-off valve shall be provided for the ignition gas supply.
- I. A manually operated lubricated plug-type gas valve shall be located downstream of both automatic gas valves to permit leakage testing of the valves. A leak test gauge and gauge cock shall be provided.
- J. Gas pressure supervision shall be provided by approved pressure switches interlocked to accomplish a non-recycling safety shutdown in the event of either high or low gas pressure.

### **PART 3 EXECUTION**

#### **3.01 INSTALLATION**

- A. The boiler shall be assembled as recommended by the boiler manufacturer and set above the boiler room floor on a 4" high concrete pad where shown on the drawing. The installation shall meet all IRI requirements. Provide gas ignition when required.
- B. Burners shall have 4" deep, sealed, galvanized sheet metal oil drip pans. Pans shall be 6" larger than burner assembly (all sides).

#### **3.02 VENTING**

Boilers shall be vented as shown on the drawings and described in Section 15616.

#### **3.03 GAS PIPING**

Gas piping shall be installed as shown on the drawings and described in Section 15350.

#### **3.04 OIL PIPING**

Oil piping shall be installed as shown on the drawings and described in Section 15604.

#### **3.05 START-UP**

Start-up service shall be provided by the equipment manufacturer's authorized

representative and shall include complete testing of all controls, burner adjustment and overall boiler operation. The Contractor is responsible for a monitored start-up. The monitoring agency (Washington Gas Light Company or owner approved company) shall record the main gas supply pressure at inlet of gas line control assembly, gas manifold pressure, control settings and chimney draft-inches water column. Copies of this data shall be supplied to the Owner.

### 3.06 COMBUSTION TESTS

The contractor, upon completion of the fuel burning system, shall submit a written report on the operating of each burner to the engineer and will include the following information.

**GAS BURNER**

Make \_\_\_\_\_ Model \_\_\_\_\_

Serial No. \_\_\_\_\_

CO<sub>2</sub>

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

CO

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Net Stack Temperature

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Gas Burning Rate

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Gas Pressure at Orifices

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Gas Pressure Upstream of All Valves

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Microamp or Voltage Reading  
for flame supervision

\_\_\_\_\_ Microamps  
\_\_\_\_\_ Volts



**OIL BURNER**

Make \_\_\_\_\_ Model \_\_\_\_\_

Serial No. \_\_\_\_\_

CO<sub>2</sub>

Smoke Bacharach Scale

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Net Stack Temperature

Oil Burning Rate

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Nozzle Pressure

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Microamp or Voltage Reading  
for flame supervision

Microamps \_\_\_\_\_ Volts

END OF SECTION

## SECTION 15624

### STEEL BOILERS AND BURNERS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

Provide a complete low pressure packaged three-pass steel firetube water boiler arranged for operation with combination natural gas and No. 2 light oil forced draft power burner.

##### 1.03 QUALITY ASSURANCE

- A. Each boiler shall be designed, constructed and pressure tested in accordance with the provisions of the ASME Boiler and Pressure Vessel Code for Heating Boilers and shall be stamped with the required official ASME symbol.
- B. Each boiler shall be rated to standards developed by the American Boiler Manufacturers Association.
- C. Each boiler shall be tested, certified and listed in accordance with the requirements of the American Gas Association and GE Global Asset Protection (GE GAP).
- D. Each boiler's burner unit shall be approved and listed by the Underwriters Laboratory and shall include the official U/L Label. Burner shall be factory fire tested prior to shipment. A copy of this report shall be furnished to the Owner.
- E. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

## 2.01 BOILER/BURNER UNIT

The boiler assembly shall consist of a packaged steel firetube boiler, a natural gas and light oil fired combination burner, fuel train, water control connections, controls and an insulated jacket. Capacity shall be as shown on the drawings. Boiler shall be as manufactured by BURNHAM. Boilers by HURST BOILER (series 100) are acceptable providing capacities and arrangement can be furnished. Burners shall be as manufactured by WEBSTER ENGINEERING. Burners by POWER FLAME are acceptable providing capacities and arrangements can be furnished.

## A. Boiler

1. The boiler shall be a packaged three-pass forced draft steel firetube type constructed in conformity with ASME Code requirements and tested hydrostatically for a 30 psi working pressure. Boiler shall be sealed for forced draft firing, with skid base and floor insulation, factory installed and insulated jacket, rear vertical smoke outlet, rear access door with observation port, lifting lugs, and flue brush and handle.
2. Boiler shall be equipped with a minimum of six (6) handholes for cleaning purposes and at least two corner blowdowns for chemical/sludge blowdown purposes.
3. Boiler to have a hinged front flue access cover with access to all fire tubes, and a rear access door for fire box access.
4. The boiler insulation shall consist of a 2 inch fiber glass blanket under a sectional performed sheet metal lagging. Smoke box and front flue access shall have a minimum of 2" inside or outside insulation.
5. Trim - Provide all water trim, including a combination pressure altitude gauge and thermometer, ASME rated water relief valves, high limit aquastat, and two low water cutoffs (one float type and one probe type).

## B. Pressure Atomizing Burners

1. Furnish and install UL labeled combination gas-oil mechanical pressure atomizing type oil burners. Oil burners shall be capable of burning No. 2 fuel oil and shall be capable of burning natural gas. Burner shall have rated capacity as specified.
2. The oil burners shall burn the specified quantity of fuel without objectionable vibration, noise, or pulsation with not more than 20% excess air and a maximum of No. 2 smoke as measured on the Bacharach Scale.
3. The burners shall incorporate a stainless steel flame retention type combustion head for long life and efficient operation. Burners that have

refractory or cast iron type combustion heads will not be approved.

4. A permanent observation port shall be provided in the burner to allow observation of both the pilot and main flame.
5. Supply voltage will be \_\_\_ volts, \_\_ phase, 60 hertz. All motors shall be suitable for use on this voltage. All burner controls are to be for use on 120 volts, 1 phase, 60 hertz. The 120 volt control voltage shall be supplied through an isolating step-down control transformer from the supply voltage. Transformer shall be supplied as part of the burner controls and mounted in the control cabinet.

C. Burner Accessories:

1. A two-stage oil pump shall be provided for each burner. This shall be supplied as an integral or remote part of the burner.
2. Two approved automatically operated safety shut-off valves shall be provided in the oil supply to the burner, valves are to be piped in series but wired in parallel.
3. Supply an oil pressure gauge (liquid filled with 1 1/2" diameter face) to indicate the discharge oil pump pressure. Provide ¼ turn gauge cock.
4. Install a manual gate valve, fuel oil filter or strainer and vacuum gauge on the suction side of the oil pump.
5. Install a fusible link actuated safety cut-off valve in the oil supply line between the oil tank and the manual gate valve at the oil pump.
6. Oil pressure supervision shall be provided by an approved pressure switch interlocked to accomplish a non-recycling safety shutdown in the event of low oil pressure.
7. Oil piping connections to the burners shall consist of, on the inlet side: shut-off valve, filter, union, and pressure gauge; and on the outlet side: check valve, shut-off valve, pressure gauge and union. Relief valve or pressure regulators shall be installed per burner manufacturer's recommendations.

## 2.02 BURNER CONTROLS

- A. The on/off operation of the burner(s) shall be controlled by water temperature by means of a temperature control.
- B. An additional high-limit safety temperature control of the manual reset type shall be provided to control each burner.

- C. Pre- and post-purge operation of the burner fan shall be provided.
- D. A manual restart of the burner shall be necessary in the event of shutdown due to flame failure.
- E. All conduit for controls and motors shall be liquid-tight. See specification Section 16110.
- F. All three phase motors shall be controlled and protected by a burner mounted fuse block with fuses sized per NEC and an automatic starter with thermal overload protection. Starter shall be interlocked to prevent burner operation when overloaded relays are tripped out.
- G. Supply a burner mounted airflow switch to prevent the energization of the main fuel valves in the event of insufficient combustion air.
- H. Manual reset of system shall be required to restart burner after airflow failure has occurred.
- I. A factory pre-wired control cabinet shall be supplied with each burner. Cabinet shall be mounted on burner. Cabinet shall house the flame safeguard control, programming purge timer, burner motor starter, fuses, control switches, alarm bell with automatic reset silencing switch to ring on low water and flame failure, control transformer, indicating lamps as specified hereinafter and relays that may be required. The control cabinet door shall be hinged to allow access to the controls. Alarm bell shall be EDWARD's 4" diameter AC adaptable. Provide an engraved nameplate permanently affixed to the front of the cabinet with the following information.

Installer Contractor: \_\_\_\_\_

Contractor Phone No.: \_\_\_\_\_

Date Warranty - FROM: \_\_\_\_\_ TO: \_\_\_\_\_

- J. Provide on each control cabinet six (6) individual lights with nameplates to indicate "POWER ON", "CALL FOR HEAT", "IGNITION", "FUEL ON", "LOW WATER" AND "FLAME FAILURE".
- K. Furnish and install on the control cabinet for each boiler an electrical non-resettable elapsed time indicator, minimum of 99,999.9 hours, minimum 2 1/2" round face, UL listed, with NEMA standard round and square detachable bezels. Units by Cramer-Grainger's model no. 6X137.
- L. The changing from one fuel to the other shall be manual by means of fuel selector switch. No burner adjustments shall be required to switch from one fuel to the other.

- M. The burners shall be equipped with suitable fuel and air controls to assure smooth main flame ignition.
- N. Fuel-air control must be synchronized. The fuel-air drive unit shall be provided with a position-indicating switch, which shall be interlocked with the flame safeguard system to assure starting with low fire position. The flame safeguard system shall further program this drive unit to provide a full open louver purge of sufficient time to provide a four air change pre-ignition purge of the combustion chamber, heat exchanger, and flue passages. Duration of purge shall not be less than 30 seconds.
- O. Pre-ignition purge air flow rate shall be no less than 60% maximum firing rate air flow. Interlocks shall be provided to monitor and prove 60% airflow purge when air inlet louvers are opened automatically to obtain this purge rate.
- P. Modulation of fuel input shall be provided. A modulation temperature control shall be supplied to modulate a burner mounted damper motor controlling both fuel and air supply by means of mechanical linkage. Provide on the control cabinet a manual-auto switch and a potentiometer for manual control of the firing rate. Characterized cams shall be provided for both oil and gas operation.
- Q. Provide an aquastat in the boiler water to maintain low-fire until the aquastat setting of 120°F is reached.
- R. Provide and install emergency shut-off switch of burners at each entrance/exit to boiler room. Switch shall be push button type by Square "D" type TR with type TM contact and type KA contact block.

### 2.03 BOILER SEQUENCING CONTROLS

- A. Provide and install as a part of the burner control systems a Lead-Lag Boiler Sequencing Control System for two-boiler system. It shall respond to variations in the main header temperature. The system operating temperature is 180 degrees F. Two lead-lag aquastats shall be installed in the header and wired to the boiler #1 burner panel lead-lag terminals. Install a boiler #1/boiler #2 switch in the boiler #1 burner panel.
- B. In the event of power failure, the Lead-Lag system shall bring the boilers on the line in sequence after power is restored.
- C. The two boiler mounted temperature controls on each boiler, previously specified, one of which shall be the manual reset type, shall be in addition to the Lead-Lag System and shall both function as high limit controls.

### 2.04 BURNER MANAGEMENT CONTROL SYSTEM

Each burner will be equipped with a Microprocessor Based Burner Management Safeguard Control system that shall be UL listed.

A. Components

1. Each burner will be equipped with UL/FM approved microprocessor based Burner Management Safeguard Control System that incorporates a plug-in design, with the programmer, amplifier and display module to be in separate components. A self-diagnostic circuit within the control will identify module failures and an appropriate message will be displayed for servicing. This circuit will cause a safety shutdown should any component in the control fail. For example, if the amplifier module is malfunctioning, the message center will display the message, "LOCKOUT REPLACE AMPLIFIER".
2. Each component will plug into the Master Chassis and be keyed to insure that the components may be installed only into the proper location.
3. The control mounting screw will secure all components in the chassis. This will prevent tampering while the control is installed in the base. The control must be removed from the base to replace any of the components.
4. The amplifier shall be the auto-check ultraviolet type.
5. The control shall be the FIREYE YB110UV Flame-Monitor with the BLL510 display module, YP100 Programmer.
6. The ultraviolet scanner shall be the FIREYE UV1A.
7. Provide the FIREYE YZ300 Expansion Module which shall annunciate the following messages: "LOW GAS PRESSURE", "HIGH GAS PRESSURE", "LOW OIL PRESSURE", "AIRFLOW", AND "LOW WATER".

B. Control System Functions

1. The control will have a non-volatile memory, which allows it to remember burner history and present position, even after a power interruption. A minimum of 42 different messages will be displayed on the message center of the control (in English words and phrases) which indicates system function and diagnostic information.
2. The messages shall provide clear, concise information concerning system timing, present burner sequence position, lockout causes including wiring base terminal designations and historical data.
3. The control shall provide for direct connection of limit and operating

controls, fuel valve interlock, damper position interlocks, running interlocks (such as airflow, fuel pressure and temperature), burner motor, ignition, pilot valves, firing rate motor and alarm.

4. During the firing cycle, a constant read-out of the flame signal will be displayed on the message center.
5. At the end of each firing cycle, the control will display main fuel operating hours and complete firing history.
6. The control shall accomplish a safe start component check during each start. This will prevent the burner from firing under any condition, which causes the flame to assume and hold its energized position due the presence of an actual flame, a flame simulating component failure or mechanical failure.
7. Control shall provide a purge period of not less than 30 seconds with a damper driven to the open position and an interlock circuit provided to prove airflow rate during the purge period. A starting interlock circuit is required to prove that the burner equipment is in the low fire position at the same time of ignition, plus an interlock to prove airflow during the purge and firing cycle.
8. Control shall provide limited trial-for-ignition of pilot flame restricted to 10 seconds, trial-for-main flame restricted to 10 or 15 seconds (selectable) for oil or gas.
9. Control shall provide a safety shutdown following flame failure, with fuel and ignition circuits de-energized in not more than four seconds.
10. Control shall provide a post purge period of 15 seconds following a shutdown.
11. The system shall remain automatically under control of the operating control and when power is restored following power failure. Manual reset shall be required following any safety lockout. When in a lockout condition, power interruptions will not recycle the control.
12. The control shall provide a check-run switch will allow the service technician to stop the burner sequence in any of four different positions.
  - High Fire Purge
  - Low Fire Purge
  - Pilot Trail for Ignition
  - Low Fire (Burner On)
13. Interconnection with either a computer terminal or modem communications shall be possible. When connected, such equipment will



access both present control/burner status and historical information through a serial data port on the display module.

14. The message center display shall be designed to accept first out indication of an additional 16 limit condition from a separate future expansion module.

## 2.05 GAS VALVE TRAIN

- A. The gas train piping shall include a 1/4" NPT pressure tapping with 1/4" pipe plug upstream and downstream of each valve and regulator in the gas train.
- B. Provide a gas pressure gauge to indicate the gas burner manifold pressure.
- C. Furnish and install one manually operated lubricated plug cock upstream of all valves.
- D. Provide one gas pressure regulator (of tight shut-off type) with vent to outside atmosphere, in accordance with local gas company and GE GAP requirements.
- E. Provide one automatically operated motorized safety gas valve. Safety valve shall be proven closed during pre-ignition by proof of valve closure interlock switch on valve.
- F. Provide a second automatically motor operated gas safety shut-off valve to operate simultaneously with the above gas valve.
- G. A normally open, fully ported, electrically with proven closed operated valve shall be provided in a vent line connected between the two safety shut-off valves. The vent pipe shall be run independent of other vents to the outside atmosphere and provided with union to check vent valve operation. The proven closed switch shall interlock with its burner controls. Acceptable manufacturer: MAXON. No substitutes.
- H. A separate pilot gas cock, gas pressure regulator and pilot safety shut-off valve shall be provided for the ignition gas supply.
- I. A manually operated lubricated plug-type gas valve shall be located downstream of both automatic gas valves to permit leakage testing of the valves. A leak test gauge and gauge cock shall be provided.
- J. Gas pressure supervision shall be provided by approved pressure switches interlocked to accomplish a non-recycling safety shutdown in the event of either high or low gas pressure.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The boiler shall be assembled as recommended by the boiler manufacturer and set above the boiler room floor on a 4" high concrete pad where shown on the drawing. The installation shall meet all GE GAP and ASME requirements. Provide gas ignition when required.
- B. Burners shall have 4" deep, sealed galvanized sheet metal oil drip pans. Pans shall be 6" larger than burner assembly (all sides).
- C. The boiler main drain, low water cutoff and pressure relief valve shall be piped separately to the nearest floor drain.

### 3.02 VENTING

Boilers shall be vented as shown on the drawings and described in Section 15616.

### 3.03 GAS PIPING

Gas piping shall be installed as shown on the drawings and described in Section 15350.

### 3.04 OIL PIPING

Oil piping shall be installed as shown on the drawings and described in Section 15604.

### 3.05 START-UP

Service shall be provided by the equipment manufacturer's authorized representative and shall complete testing of all controls, burner adjustment and overall boiler operation. The Contractor is responsible for a monitored start-up. The monitoring agency (Washington Gas Light Company or Owner approved company) shall record the main gas supply pressure at inlet of gas line control assembly, gas manifold pressure, control settings and chimney draft-inches water column. Copies of this data shall be supplied to the Owner.

### 3.06 COMBUSTION TESTS

The Contractor, upon completion of the fuel burning system, shall submit a written report on the operation of each burner to the engineer and will include the following information.

**GAS BURNER**

Make \_\_\_\_\_ Model \_\_\_\_\_

Serial No. \_\_\_\_\_

CO<sub>2</sub>

CO

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Net Stack Temperature

Gas Burning Rate

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Gas Pressure at Orifices

Gas Pressure Upstream of All Valves

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Microamp or Voltage Reading  
for flame supervision

Microamps \_\_\_\_\_ Volts

**OIL BURNER**

Make \_\_\_\_\_ Model \_\_\_\_\_

Serial No. \_\_\_\_\_

CO<sub>2</sub>

CO

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Net Stack Temperature

Smoke Bacharach Scale

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Nozzle Pressure

Oil Burning Rate

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Microamp or Voltage Reading  
for flame supervision

Microamps \_\_\_\_\_ Volts

END OF SECTION

## SECTION 15625

### BOILER BURNER REPLACEMENT AND BOILER CONVERSION

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

- A. Boiler Room – Replace the burners on the (select)\_\_\_\_ existing boilers with new combination natural gas and no. 2 light oil forced draft power burners. The (select)\_\_\_\_ existing boilers are (select)\_\_\_\_\_ model (select)\_\_\_\_\_. Provide new gas valve trains for these two boilers.
- B. Boiler Room – Convert the\_\_\_\_ steam boilers and burners to hot water heating. Remove all existing steam trim. The (select) \_\_\_\_ existing boilers are (select) \_\_\_\_\_ model(select) \_\_\_\_\_ with (select)\_\_\_\_\_ model(select) \_\_\_\_\_ burners.

##### 1.03 QUALITY ASSURANCE

The burner shall comply with the requirements of the Underwriters Laboratories. The complete fuel burning system shall further be in full accordance with Industrial Risk Insurers (IRI).

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 BOILER UNIT (Burner Replacement Only)

Burner shall be manufactured by WEBSTER ENGINEERING. Burners manufactured by POWER FLAME are acceptable providing capacities and arrangements can be furnished.

##### A. Pressure Atomizing Burners

- 1. Furnish and install U/L labeled combination gas-oil mechanical pressure atomizing type oil burners. Oil burners shall be capable of burning No. 2 fuel oil and shall be capable of burning natural gas. Burner shall have

- rated capacity as specified. Burners shall have necessary accessories for mounting onto existing boilers.
2. The oil burners shall burn the specified quantity of fuel without objectionable vibration, noise, or pulsation with not more than 20% excess air and a maximum of No. 2 smoke as measured on the Bacharach Scale.
  3. The burners shall incorporate a stainless steel flame retention type combustion head for long life and efficient operation. Burners, which have refractory or cast iron type combustion heads, will not be approved.
  4. A permanent observation port shall be provided in the burner to allow observation of both the pilot and main flame.
  5. Supply voltage will be (select)\_\_\_\_ volts,(select) \_\_\_\_ phase, 60 hertz. All motors shall be suitable for use on this voltage. All burner controls are to be for use on 120 volts, 1 phase, 60 hertz. The 120 volt control voltage shall be supplied through an isolating stepdown control transformer from the supply voltage. Transformer shall be supplied as part of the burner controls and mounted in the control cabinet.

**B. Burner Accessories**

1. A two-stage oil pump shall be provided for each burner. This shall be supplied as an integral or remote part of the burner.
2. Two approved automatically operated safety shut-off valves shall be provided in the oil supply to the burner, valves are to be piped in series but wired in parallel.
3. Supply an oil pressure gauge (liquid filled with 1 1/2" diameter face) to indicate the discharge oil pump pressure.
4. Install a manual gate valve, fuel oil filter or strainer and vacuum gauge on the suction side of the oil pump.
5. Install a fusible link actuated safety cut-off valve in the oil supply line between the oil tank and the manual gate valve at the oil pump.
6. Oil pressure supervision shall be provided by an approved pressure switch interlocked to accomplish a non-recycling safety shutdown in the event of low oil pressure.
7. Oil piping connections to the burners shall consist of, on the inlet side: shut-off valve, filter, union, and pressure gauge; and on the outlet side: check valve, shut-off valve, pressure gauge and union. Relief valve or pressure regulators shall be installed per burner manufacturer's

recommendations.

8. All conduit for controls and motors shall be liquid-tight. See specification section 16110.
9. All three phase motors shall be controlled and protected by a burner mounted fuse block with fuses sized per NEC and an automatic starter with thermal overload protection. Starter shall be interlocked to prevent burner operation when overloaded relays are tripped out.
10. Supply a burner mounted airflow switch to prevent energizing the main fuel valves in event of insufficient combustion air.
11. Manual reset of system shall be required to restart burner after airflow failure has occurred.
12. A factory pre-wired control cabinet shall be supplied with each burner. Cabinet shall be mounted on burner. Cabinet shall house the flame safeguard switches, alarm bell with automatic reset silencing switch to ring on low water or flame failure, control transformer, indicating lamps as specified hereinafter and relays that may be required. The control cabinet door shall be hinged to allow access to the controls. Alarm bell shall be EDWARD's 4" diameter AC adaptable. Provide an engraved nameplate permanently affixed to the front of the cabinet with the following information.

Installing Contractor: \_\_\_\_\_

Contractor Phone No.: \_\_\_\_\_

Date Warranty – FROM: \_\_\_\_\_ TO: \_\_\_\_\_

13. Provide on each control cabinet six (6) individual lights with nameplates to indicate "POWER ON", "CALL FOR HEAT", "IGNITION", "FUEL ON", "LOW WATER" AND "FLAME FAILURE".
14. Furnish and install on the control cabinet for each boiler an electrical non-resettable elapsed time indicator, minimum of 99,999.9 hours, minimum 2 1/2" round face, UL listed, with NEMA standard round and square detachable bezels. Units by Cramer-Grainger's model no. 6X137.
15. The changing from one fuel to the other shall be manual by means of fuel selector switch. No burner adjustments shall be required to switch from one fuel to the other.
16. The burners shall be equipped with suitable fuel and air controls to assure smooth main flame ignition.

17. Fuel-air control must be synchronized. The fuel-air drive unit shall be provided with a position-indicating switch, which shall be interlocked with the flame safeguard system to assure starting with low fire position. The flame safeguard system shall further program this drive unit to provide a full open louver purge of sufficient time to provide a four air change pre-ignition purge of the combustion chamber, heat exchanger, and flue passages. Duration of purge shall not be less than 30 seconds.
18. Pre-ignition purge airflow rate shall be no less than 60% maximum firing rate airflow. Interlocks shall be provided to monitor and prove 60% airflow purge when air inlet louvers are opened automatically to obtain this purge rate.
19. Modulation of fuel input shall be provided. A modulation temperature control shall be supplied to modulate a burner mounted damper motor controlling both fuel and air supply by means of mechanical linkage. Provide on the control cabinet a manual-auto switch and a potentiometer for manual control of the firing rate.
20. Provide an aquastat in the boiler water to maintain low-fire until the aquastat setting of 120° F is reached.
21. Provide and install emergency shut-off switch of burners at each entrance/exit to boiler room. Switch shall be push button type by Square "D" type TR with type TM contact and type KA contact block.

## 2.02 BURNER MANAGEMENT CONTROL SYSTEM (Burner Replacement Only)

Each burner will be equipped with a Microprocessor Based Burner Management Safeguard Control system, which shall be U/L, listed.

### A. Components

1. Each burner will be equipped with UL/FM approved microprocessor based Burner Management Safeguard Control System that incorporates a plug-in design, with the programmer, amplifier and display module to be in separate components. A self-diagnostic circuit within the control will identify module failures and an appropriate message will be displayed for servicing. This circuit will cause a safety shutdown should any component in the control fail. For example, if the amplifier module is malfunctioning, the message center will display the message, "LOCKOUT REPLACE AMPLIFIER".
2. Each component will plug into the Master Chassis and be keyed to insure that the components may be installed only into the proper location.



3. The control mounting screw will secure all components in the chassis. This will prevent tampering while the control is installed in the base. The control must be removed from the base to replace any of the components.
4. The amplifier shall be the auto-check ultraviolet type.
5. The control shall be the FIREYE YB110UV Flame-Monitor with the BLL510 display module, YP100 Programmer.
6. The ultraviolet scanner shall be the FIREYE UV1A.

B. Control System Functions

1. The control will have a non-volatile memory, which allows it to remember burner history and present position, even after a power interruption. A minimum of 42 different messages will be displayed on the message center of the control (in English words and phrases) which indicates system function and diagnostic information.
2. The messages shall provide clear, concise information concerning system timing, present burner sequence position, lockout causes including wiring base terminal designations and historical data.
3. The control shall provide for direct connection of limit and operating controls, fuel valve interlock, damper position interlocks, running interlocks (such as airflow, fuel pressure and temperature), burner motor, ignition, pilot valves, firing rate motor and alarm.
4. During the firing cycle, a constant read-out of the flame signal will be displayed on the message center.
5. At the end of each firing cycle, the control will display main fuel operating hours and complete firing history.
6. The control shall accomplish a safe start component check during each start. This will prevent the burner from firing under any condition, which causes the flame to assume and hold its energized position due the presence of an actual flame, a flame simulating component failure or mechanical failure.
7. Control shall provide a purge period of not less than 30 seconds with a damper driven to the open position and an interlock circuit provided to prove airflow rate during the purge period. A starting interlock circuit is required to prove that the burner equipment is in the low fire position at the same time of ignition, plus an interlock to prove airflow during the purge and firing cycle.

8. Control shall provide limited trial-for-ignition of pilot flame restricted to 10 seconds, trial-for-main flame restricted to 10 or 15 seconds (selectable) for oil or gas.
9. Control shall provide a safety shutdown following flame failure, with fuel and ignition circuits de-energized in not more than four seconds.
10. Control shall provide a post purge period of 15 seconds following a shutdown.
11. The system shall remain automatically under control of the operating control and when power is restored following power failure. Manual reset shall be required following any safety lockout. When in a lockout condition, power interruptions will not recycle the control.
12. The control shall provide a check-run switch will allow the service technician to stop the burner sequence in any of four different positions.
  - High Fire Purge
  - Low Fire Purge
  - Pilot Trail for Ignition
  - Low Fire (Burner On)
13. Interconnection with either a computer terminal or modem communications shall be possible. When connected, such equipment will access both present control/burner status and historical information through a serial data port on the display module.
14. The message center display shall be designed to accept first out indication of an additional 16 limit condition from a separate future expansion module.

2.03 GAS VALVE TRAIN (Burner Replacements Only)

- A. The gas train piping shall include a 1/4" NPT pressure tapping with 1/4" pipe plug upstream and downstream of each valve and regulator in the gas train.
- B. Provide a gas pressure gauge to indicate the gas burner manifold pressure.
- C. Furnish and install one manually operated lubricated plug cock upstream of all valves.
- D. Provide one gas pressure regulator (of tight shut-off type) with vent to outside atmosphere, in accordance with local Gas Company and GE GAP requirements.
- E. Provide one automatically operated motorized safety gas valve. Safety valve

- shall be proven closed during pre-ignition by proof of valve closure interlock switch on valve.
- F. Provide a second automatically motor operated gas safety shut-off valve to operated simultaneously with the above gas valve.
  - G. A normally open, fully ported, electrically with proven closed operated valve shall be provided in a vent line connected between the two safety shut-off valves. The vent pipe shall be run independent of other vents to the outside atmosphere and provided with union to check vent valve operation. The proven closed switch shall interlock with its burner controls. Acceptable manufacturer: MAXON. No substitutions
  - H. A separate pilot gas cock, gas pressure regulator and pilot safety shut-off valve shall be provided for the ignition gas supply.
  - I. A manually operated lubricated plug-type gas valve shall be located downstream of both automatic gas valves to permit leakage testing of the valves. A leak test gauge and gauge cock shall be provided.
  - J. Gas pressure supervision shall be provided by approved pressure switches interlocked to accomplish a non-recycling safety shutdown in the event of either high or low gas pressure.

#### 2.04 STEAM TO HOT WATER BOILER CONVERSION

- A. Trim – Provide all water trim, including a combination pressure altitude gauge and thermometer, ASME rated water relief valves, high limit aquastat, and two low water cutoffs. one probe type and one float type. The boiler water jacket shall be acid washed prior to water being circulated through the hot water heating system.
- B. Burner Controls
  1. The on/off operation of the burner(s) shall be controlled by water temperature by means of a temperature control.
  2. An additional high limit safety temperature control of the manual reset type shall be provided to control each burner.
  3. Pre- and post-purge operation of the burner fan shall be provided.
  4. A manual restart of the burner shall be necessary in the event of shutdown due to flame failure.
  5. Provide an aquastat in the boiler water to maintain low-fire until the aquastat's setting of 120° F is reached.

- C. Boiler conversions shall comply with the following:
1. Virginia Department of Labor and Industry, Office of Compliance Management, Boiler Safety.
  2. ASME
  3. The Boiler Manufacturer
  4. Boiler nameplate information shall be updated by the boiler manufacturer or approved testing agency to reflect the conversion.

## 2.05 BOILER SEQUENCING CONTROLS

- A. Provide and install as a part of the burner control systems a Lead-Lag Boiler Sequencing Control System for two boiler system. It shall respond to variations in the main header temperature. The system operating temperature is 180°F. Two lead-lag aquastats shall be installed in the header and wired to the boiler #1 burner panel lead-lag terminals. Install a boiler #1/boiler #2 switch in the boiler #1 burner panel.
- B. In the event of power failure, the Lead-Lag system shall bring the boilers on the line in sequence after power is restored.
- C. The two boiler mounted temperature controls on each boiler, previously specified, one of which shall be the manual reset type, shall be in addition to the Lead-Lag System and shall both function as high limit controls.

## **PART 3 - EXECUTION**

### 3.01 INSTALLATION

The new burners shall be mounted on the existing boilers. The installation shall meet all GE GAP and ASME requirements.

### 3.02 GAS PIPING

Gas piping shall be installed as shown on the drawings and described in Section 15350.

### 3.03 OIL PIPING

Oil piping shall be installed as shown on the drawings and described in Section 15604.

3.04 COMBUSTION TESTS

The Contractor, upon completion of the fuel burning system, shall submit a written report on the operation of each burner to the engineer and will include the following information.

**GAS BURNER**

Make \_\_\_\_\_ Model \_\_\_\_\_

Serial No. \_\_\_\_\_

CO<sub>2</sub>

CO

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Net Stack Temperature

Gas Burning Rate

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Gas Pressure at Orifices

Gas Pressure Upstream of All Valves

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

High Fire \_\_\_\_\_  
Low Fire \_\_\_\_\_

Microamp or Voltage Reading  
for flame supervision

Microamps \_\_\_\_\_ Volts

**OIL BURNER**

Make \_\_\_\_\_ Model \_\_\_\_\_

Serial No. \_\_\_\_\_

CO<sub>2</sub>

CO

High Fire \_\_\_\_\_

High Fire \_\_\_\_\_

Low Fire \_\_\_\_\_

Low Fire \_\_\_\_\_

Net Stack Temperature

Smoke Bacharach Scale

High Fire \_\_\_\_\_

High Fire \_\_\_\_\_

Low Fire \_\_\_\_\_

Low Fire \_\_\_\_\_

Nozzle Pressure

Oil Burning Rate

High Fire \_\_\_\_\_

High Fire

Low Fire \_\_\_\_\_

Low Fire

Microamp or Voltage Reading  
for flame supervision

Microamps  
\_\_\_\_\_ Volts

END OF SECTION

## SECTION 15651

### REFRIGERATION PIPING SYSTEMS

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract Requirements, Division 1 - General Requirements, section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

- A. The refrigeration piping system shall be provided, installed, tested, evacuated and charged.

##### 1.03 QUALITY CONTROL

- A. The refrigeration piping system shall be provided, installed, tested, evacuated and charged in accordance with the manufacturer's recommendations, ANSI, ASHRAE, and ARI's Safety Code for Mechanical Refrigeration, state and local codes.

##### 1.04 SUBMITTALS

Provide shop drawings on the proposed system as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 GENERAL

The refrigerant piping system shall be provided complete and installed in accordance with the manufacturer's recommendations and as specified herein. The size of the refrigerant pipes shall be obtained from the equipment manufacturer unless otherwise shown on the drawings.

- A. Pipe, Fittings and Accessories - The pipe shall be type ACR 'L' copper refrigerant tubing with hard wrought copper fittings. Pipe sized ½ inch and larger shall be hard drawn. Pipe size 3/8 inch and smaller can either be hard or soft drawn. All of the joints shall be brazed with a filler material that complies with AWS classification BCuP-5. A sight glass with moisture indicator shall be provided if not provided with equipment, and installed in the liquid line in close proximity to the expansion device (not required on VRF systems). A removable SPORLAN cartridge type drier-strainer shall be installed in the liquid line with a three-way valve by-pass if it is not provided on the equipment (not required on



- VRF systems). Use type 'L' copper tubing to pipe the relief valve discharge to the outside.
- B. Condensate Drain Piping - Shall be type 'L' copper tubing.
  - C. Pipe Hangers and Supports - Shall be as required in section 15050.
  - D. The piping shall be insulated as shown in section 15250.
  - E. For VRF systems, the use of GelCopper per-insulated copper tubing, or approved equal, is acceptable for use from the refrigerant mains, typically located in corridors, to the terminal devices in sizes listed for soft copper.

### **PART 3 - EXECUTION**

#### **3.01 GENERAL**

The Refrigeration Piping System shall be installed in accordance with the manufacturer's recommendations as shown on the drawings and as specified herein.

- A. Installation- During brazing an inert gas (such as nitrogen) shall be continuously passed through the system at a rate sufficient to maintain an oxygen free environment to prevent the formation of copper oxide scale. After piping has been completed, the refrigerant piping system shall be pressure tested at a pressure of 300 psi on the high side and 150 psi on the low side. The pressure shall be maintained on the system for a minimum of 12 hours. The system shall be evacuated when the surrounding ambient air is not less than 60°F. If the temperature is less, auxiliary heat must be provided to insure proper evacuating conditions. A minimum vacuum of 500 Microns of Hg. shall be pulled on the system and maintained for 12 hours. The vacuum pump displacement shall be not less than 2 cfm for up to 15 tons. Owner/Engineer shall be notified to witness both the pressure and vacuum tests.
- B. The system shall be charged as recommended by the equipment manufacturer.

END OF SECTION

## SECTION 15655

### COMBINATION SPLIT SYSTEM AIR HANDLER/REMOTE AIR COOLED CONDENSING UNITS

#### PART I - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 -Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

- A. Provide and install complete the Combination Air Handling/Remote Air Cooled Condensing Units as shown on the drawing and specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The combined systems shall comply with ARI Standard 210.
- B. Both the air handling unit and the air cooled condensing unit shall be Underwriters Laboratories listed and bear the UL label.
- C. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

- A. Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 COMBINATION AIR HANDLER/REMOTE AIR COOLED CONDENSING UNIT

The combination air handling/remote air cooled condensing unit systems shall be provided and installed of the type and capacities as shown on the drawings and specified herein. The matching systems shall be manufactured by the manufacturer shown on the drawings. Combination systems fully equal to the specified manufacturer and manufactured by TRANE, CARRIER or DAIKIN are acceptable.

- A. Air Handling Units

1. Type - Shall have horizontally or vertically arranged insulated cabinet, direct expansion cooling coil, non-corrosive, positively sloped, cleanable, insulated IAQ type drain pan, centrifugal fan, adjustable belt drive and integral filter rack with throwaway filters. An accessory heating coil shall be provided when indicated on the drawings.
2. Cabinet - Heavy gauge steel, phosphatized and finished with baked-on acrylic enamel and insulated with foil faced permanent fireproof glass fiber. Provide removable access panels for the filter, fan and damper sections. Install isolators as recommended by manufacturer.
3. Cooling Coil - Shall be aluminum fin secondary surface mechanically bonded to primary surface of 1/2" seamless copper tubing and shall be leak tested to 300 psi. Refrigerant holding charge and matched capacity expansion valves shall be provided. Coil rows and circuiting to be as recommended by manufacturer to match condensing unit to meet job requirements.
4. Heating Coil Electric - Shall be enclosed nickel-chromium wire heating element. Heating section shall contain built-in contactors, thermal cutouts, interlock relays and box, and line voltage terminal blocks with lugs.  
  
Heating Coil Hot Water-Shall be constructed of aluminum fins mechanically bonded to seamless copper tubes, with continuous fin collars and sleeved coil and supports. Coils shall be factory tested at 300 psi. Hot water coils shall be placed downstream of the Dx coil.
5. Drain Pan – Insulated non-corrosive, positively sloped, cleanable IAQ type with threaded pipe connection.
6. Fan - Forward curved centrifugal with adjustable belt drive. Motor shall be overload protected.
7. Filters – Shall be throwaway type, 2" thick, 35% efficient. Filters shall have a minimum MERV rating of 13.
8. Starter - Provided magnetic starter with red running light. See Electric Motor Starters, Section 15050 - 2.07.

B. Air Cooled Condensing Unit

1. Type - The air-cooled condensing unit shall have all operating components assembled on one common base. These shall include: compressor, condenser coil, condenser fans and motors, charging valves, moisture indicating sight glass, shut-off valves, all controls and a

- holding charge of R-410A. The unit shall be designed for outdoor installation.
2. Casing - Shall be of 14-gauge zinc coated steel with all exterior surfaces painted with enamel for weather protection. Drain holes shall be provided for elimination of rain. Provide removable panels for access to components.
  3. Condenser Fans and Motors - Shall be furnished with direct driven, propeller type fans arranged for vertical discharge. Condenser fan motors shall have Class B motor insulation, inherent protection, and shall be of the permanently lubricated type, resiliently mounted. Each fan shall have a safety guard. Controls shall be included for low ambient operation down to 0° F.
  4. Condenser Coil - Shall have copper tubing with heavy-duty aluminum fins. The coil shall be factory tested at 425 psi and dehydrated. A factory or field installed sub-cooling circuit shall be provided to sub-cool refrigerant a minimum of 20° below saturation temperatures.
  5. Compressor - Shall be of hermetic design with spring isolators and shall have crankcase heaters. Compressor shall be located in a section separated from condenser fans and coils. Compressor shall have across-the-line start.
  6. Controls - Shall be factory wired and located in a separate enclosure. Safety devices shall consist of high and low pressure stats compressor overload devices and evaporator defrost control. Unit shall have electronic defrost controls and capabilities. Controls shall include a transformer for the control circuit.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The combination system shall be installed and tested in accordance with the manufacturer's recommendations, start-up and service instructions and as shown on the drawings.
- B. The refrigeration piping system shall be installed in accordance with section 15651.
- C. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.

- D. Provide one spare fan belt for each air handling unit.
- E. Provide a typed list of all the different units, their filter sizes, and belt sizes to be included in the O & M manuals. The list shall include the unit designation, filter size, belt size and the number of filters and belts required for each unit. In addition to this submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Falls Church VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032.

END OF SECTION

## SECTION 15674

### WATER COOLED CHILLER

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

A complete factory assembled package water-cooled hermetic centrifugal water chiller shall be installed.

##### 1.03 QUALITY ASSURANCE

- A. Unit shall be run tested at the factory and start-up and checkout shall be done by a factory certified technician. Pressurized components shall comply with the ASME code for unfired pressure vessels.
- B. Manufacturer shall provide a certification that the equipment has been performance tested at the factory. Certification shall record the unit capacity in BTU/hour and kilowatts.
- C. Chiller performance shall be rated in accordance with Air Conditioning and Refrigeration Institute (ARI) Standard 550, latest edition.
- D. Equipment and installation shall be in compliance with Safety Code for Mechanical Refrigeration, ANSI/ASHRAE 15-2004.
- E. Factory start-up- The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- F. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

## PART 2 – PRODUCTS

### 2.01 CHILLER

The chiller shall be of the type and capacity shown on the equipment schedule on the drawings. The unit shall be manufactured by TRANE. A unit fully equal to that specified and manufactured by CARRIER or DAIKIN are acceptable. Centrifugal, helical-rotary or screw-type compressors are acceptable.

- A. Unit Description - The chiller shall be a factory assembled, piped, wired and tested unit consisting of an evaporator, condenser, compressor, control panel, refrigerant piping and purge system all assembled on one base with accessories as required in this specification or as shown on the drawings. A matching motor starter shall be located as shown on the drawings.
- B. Refrigerant – The chiller shall use refrigerant R-134a or R-410a.
- C. Evaporator and Condenser - Shall be of shell and tube type. Test pressures shall be 45 psig minimum for the refrigerant side and 225 psig for the water side of the shells. Provide refrigerant circuit safety rupture disc. Condensing circuit marine type water box with taps for vents and drains shall be hydrostatically tested at 1.5 times working pressure. Provide fixed orifice return liquid refrigerant flow control.
- D. Compressor - Shall be direct drive, single or multiple stage design with high strength aluminum alloy, proof tested statically and dynamically balanced impellers keyed directly to motor shaft. Hermetic compressor motor shall be liquid refrigerant cooled with inherent low voltage protection, each phase motor winding temperature sensing for stopping by any phase sensing excessive temperature. Inherent single-phase protection shall operate in the same manner. Capacity control shall be variable inlet guide vanes capable of modulating performance from 100 to 10 percent of rated unit capacity at design conditions. Provide submerged oil pump for lubrication.
- E. Refrigerant Isolation Valves- Factory-installed condenser inlet and outlet refrigerant valves shall allow isolation of the full refrigerant charge in the condenser while servicing the chiller.
- F. Control Panel - Shall be electronic with microprocessor, current limiter, temperature control system with dead band range, indicator lights and gauges, low refrigerant temperature override, unloaded start, anti-recycle timer to limit starts to two per hour, oil pump operation, purge system operation, safety controls, and integral fused control circuits. Provide Expanded Service Panel located in the chiller control panel for reset of chilled water temperature based on return water temperature. Purge System - Shall be provided to remove non-

condensable gasses and return refrigerant to the machine. Provide a communication interface between the chiller and the building energy management system. Provide all necessary protocol documentation and gateway hardware and software (if required) such that the section 15900 system supplier may successfully create a communication interface between the control system furnished in this section of the specification and the 15900 control system. Provide an adequate level of technical support to guide the section 15900 personal towards completion of subject communication interface. Protocol must support reading/writing status and analog and digital point information from this section of the specification.. All documentation, gateway hardware and software, and required technical support are understood to be included in the bid. The points listed in section 15900 input/output summaries as well as those below shall be the minimum acceptable.

1. Chilled water pump request.
2. Chilled water setpoint.
3. Chiller enable/disable.
4. Chiller current draw.
5. Entering water temperature.
6. Leaving water temperature.
7. Compressor starts.
8. Compressor run time.
9. Alarm.
10. Present operating mode

- G. Integral Compressor Motor Starter - Shall be closed transition Wye-Delta type enclosed in a NEMA-1 enclosure with hinged door. Wires, busbars, and fittings shall be copper. Anti-recycling timer shall be included. Provide lugs for connection of specified conductors.

## 2.02 REFRIGERANT LEAKAGE SENSOR

A sensor mounted within the chiller room shall monitor refrigerant levels in the room. The sensor shall measure and indicate refrigerant levels ranging from 0-1000 parts per million. The sensor shall have an alarm setting of 1000 PPM which will activate audible and visual alarms located in the chiller room, outdoors at the chiller room entrance, and in the building outside of the chiller room. Exceeding the alarm setting of the sensor shall also activate the chiller room emergency exhaust fan (and de-energize the boilers and water heaters if located in the chiller room). Interlock wiring to be provided by the mechanical contractor.

## 2.03 SIGNAGE

- A. Provide signage outdoors on the exterior door to the chiller room, and indoors on the outside of the chiller room door, which states "DO NOT ENTER WHEN



ALARM IS ACTIVE. CALL THE OFFICE OF SAFETY AND SECURITY " 571-423-2000.

- B. Provide hazard signage outdoors on the exterior door to the chiller room, and indoors on the outside of the chiller room door, to comply with the NFPA 704 requirements for use of refrigerants R-134a R-410a. Signs shall be a minimum of 6" x6" and shall display the hazard ratings.

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

- A. Factory start-up- The manufacturer shall supply a complete factory start-up by a factory approved start-up agent.
- B. Insulation - Insulate the evaporator shell, exposed refrigerant circuit piping and auxiliary water piping as required. Insulation shall comply with the requirements of Section 15250.
- C. Installation - The chiller shall be installed in accordance with the manufacturer's recommendations. Provide auxiliary water supply to purge unit and oil cooler.
- D. Isolation - The chiller shall be mounted on spring vibration isolators.
- E. Pipe Connections - The chiller shall have a marine water box on the condenser water piping connections to the machine and either a marine water box or flanged pipe connections on the chilled water piping connections to the machine to allow removal of headers for inspection, cleaning, or removal of tubes. Two 1/2" valved connections shall be provided in tower water lines at machine inside the condenser shut off valves for future chemical cleaning.
- F. Refrigerant Leakage Sensor Installation - Sensor and alarms shall be installed in accordance with manufacturer's recommendations.
- G. Refrigerant Vent - Provide vent piping from rupture disc to outside of building. Piping shall be sized as recommended by ARI.
- H. Provide an engraved nameplate permanently affixed to the front of the control cabinet with the following information.

INSTALLING CONTRACTOR: \_\_\_\_\_

CONTRACTOR PHONE # : \_\_\_\_\_

WATER COOLED CHILLER  
15674

SECTION

WARRANTY DATE FROM: \_\_\_\_\_ TO: \_\_\_\_\_

END OF SECTION

## SECTION 15676

### AIR COOLED CHILLER

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract requirements, Division 1 - General Requirements, section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

- A. A complete factory assembled package air-cooled water chiller shall be installed.

##### 1.03 QUALITY ASSURANCE

- A. Unit shall be run tested at the factory and start-up and check out shall be done by a factory certified technician. Pressurized components shall comply with the ASME code for unfired pressure vessels. Rating and construction shall be in accordance with ARI Standard 59086, ANSI B9.1 safety code and the National Electrical Code.
- B. Manufacturer shall provide a certification that the equipment has been performance tested at the factory. Certification shall record the unit capacity in BTU/hour and kilowatts.
- C. Factory start-up- The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- D. Equipment installer shall attend a controls coordination meeting with the section15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

- A. Provide shop drawings on this equipment as described in section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 AIR COOLED CHILLER

The air-cooled chiller shall be of the type and capacity shown in the equipment schedule on the drawings. The unit shall be manufactured by TRANE. A unit fully equal to that specified and manufactured by CARRIER or DAIKIN is acceptable.

- A. Unit Description - The Air Cooled chiller shall be a factory assembled, piped, wired and tested unit consisting of a corrosion protected steel casing, an evaporator, condensers, multiple scroll or screw compressors, control panel, refrigerant piping and dual refrigeration system all assembled on one base with accessories as required in this specification or as shown on the drawings. Motor starters shall be unit mounted. The refrigerant used shall have an ozone depletion potential of less than .05 and a global warming potential of less than 0.37, (R-134A, R-410A).
- B. Unit Casing - Unit shall be enclosed in a galvanized steel casing, zinc phosphatized, with an electrostatically applied baked enamel finish, capable of withstanding Federal Test Method Standard No. 141, Method 6061, 500 hour salt spray test.
- C. Evaporator/Cooler - Shall be shell and tube type with removable heads and shall have two independent direct-expansion refrigerant circuits. Cooler shall be tested and stamped in accordance with ASME code for refrigerant side working pressure of 235 psig and a minimum waterside working pressure of 150 psig. Copper tubes shall be rolled into the tube sheets. Shell shall be covered with 3/4" layer of closed-cell foam plastic, vapor insulated.
- D. Condenser
  - 1. Air cooled condenser coils shall have aluminum fins mechanically bonded to seamless copper tubes, cleaned, dehydrated, sealed, leak tested at 150 psig and pressure tested at 450 psig.
  - 2. Condenser fans shall be propeller type with PVC coated steel wire safety guards, balanced statically and dynamically, and shall discharge vertically.
  - 3. Condenser fan motors shall have inherent overcurrent protection.
  - 4. Provide metal hail guards to protect the condenser coil from damage.
- E. Compressors - Shall be scroll hermetic type with a maximum speed of 3500 rpm, or rotary screw, serviceable and shall have an automatically reversible oil pump and operating oil charge. Compressors shall be equipped with suction and discharge shutoff valves and shall be mounted on individual spring vibration isolators. Each compressor motor shall be cooled by suction gas passing around the motor windings and shall be thermally protected with manual restart after thermal or pressure overload stoppage. Each compressor shall be equipped with an insert type crankcase heater to control oil dilution during shutdown. Cycles per hour per compressor shall not exceed six.

- F. Refrigeration Circuit - Each refrigeration circuit shall include: hot gas muffler, combination moisture indicator and sight glass, replaceable core refrigerant filter drier, liquid line solenoid valve, expansion valve, suction and discharge pressure gauges with manual shutoff valves, high side pressure relief device, and charging valve.
- G. Controls
1. Unit controls, including microprocessor, shall be factory mounted and wired in a weatherproof enclosure with hinged access doors for easy access. The controls shall include automatic lead-lag except where noted, pumpdown at beginning and end of every circuit cycle, loss-of-charge protection, inherent low water flow protection, low chilled water temperature safety, low- and high-suction superheat protection, low oil pressure protection for each circuit, ground current protection for each compressor, low control voltage to unit, current limit, field power and control circuit terminal blocks, compressor and fan motor circuit breakers, ON/OFF switch, replaceable relay board, individual solid-state compressor protection board, leaving chilled water set point board, diagnostic digital display module, a microprocessor board and a temperature reset board. The chiller shall be capable of sending a chill water pump run request to the building automation system.
  2. Unit control capacity is based upon leaving water temperature and will be compensated by return water temperature.
  3. Minimum number of capacity control steps shall be as shown in the equipment schedule.
  4. Provide a definite purpose magnetic contactor for each compressor.
  5. Calibrated circuit breakers shall be factory installed for each compressor, shall be manual reset and ambient insensitive, and shall open all three phases should an overload occur on any phase.
  6. Unit primary electrical power supply shall be connected to a single point with lugs sized for specified conductors.
  7. Control voltage shall be provided by a factory installed integral control transformer.
  8. Heat tracing for exterior piping shall be provided by a separate 120 volt, single phase power supply.
  9. Provide a barrel freeze alarm output for connection to the BAS.

- H. Chiller shall be capable of operating at ambient air temperatures down to 0 deg F without the use of glycol or any other type of antifreeze. Chillers that do not meet this requirement are not acceptable.
- I. Flow switches- switches for flow conformation shall be provided. Switches shall be paddle type with stainless steel bellows and paddle. Switches shall be suitable for outdoor installation.

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

- A. Factory Start-up- The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- B. Installation - The chiller shall be installed in accordance with the manufacturer's recommendations.
- C. Install isolation valves on evaporator water inlet and outlet at chiller.
- D. Install thermometers on evaporator water inlet and outlet at chiller.
- E. Isolation - Provide spring isolators as recommended by chiller manufacturer.
- F. Pipe Connections - The machine shall have water boxes or the contractor shall provide flanged pipe connections in the piping adjacent to the machine to allow removal of headers for inspection, cleaning or removal of tubes.
- G. Provide an engraved nameplate permanently affixed to the front of the control cabinet (inside of cabinet for outdoor locations) with the following information.

INSTALLING CONTRACTOR: \_\_\_\_\_

CONTRACTOR PHONE # : \_\_\_\_\_

WARRANTY DATE FROM: \_\_\_\_\_ TO: \_\_\_\_\_

END OF SECTION

## SECTION 15680

### PROPELLER FAN COOLING TOWER

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Building and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

A complete factory assembled propeller fan type cross flow induced draft design cooling tower shall be installed.

##### 1.03 QUALITY ASSURANCE

- A. Capacity shall be in accordance with published ratings; wet deck ASTM standard E-84 flame spread rated and finish corrosion protection tested per ASTM B117-64. Towers thermal performance shall be in accordance with CTI standard 201.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 PROPELLER FAN COOLING TOWER

The propeller fan-cooling tower shall be of the type and capacity shown on the drawings. The cooling tower shall be manufactured by BALTIMORE AIRCOIL. A unit fully equal to the specified manufacturer and manufactured by MARLEY or EVAPCO is acceptable.

- A. Unit Description - The cooling tower shall be a factory assembled, piped, wired and tested unit consisting of a stainless steel housing, distribution basins, wet deck, drift eliminator, propeller fan and fan motor and drive, all assembled on one base with accessories using series 300 stainless steel nuts and bolts, as required in this specification or as shown on the drawings.

- B. Casing and Basins - Shall be constructed of heavy gauge, stainless steel including all angles or channels. All casing exterior panels shall be fiberglass reinforced polyester (FRP) panels or stainless steel panels. Piping connections shall be flanged.
- C. Hot water Distribution Basins - Shall be type 304 stainless steel and open gravity type with distribution weirs and plastic metering orifices. Basin shall include integral balancing valves and removable basin covers. Each cell shall have a single water inlet with pre-strainer assembly, or external factory mounted strainer. PVC distribution system with plastic or brass nozzles are acceptable.
- D. Cold Water Basin - Shall be type 304 stainless steel and include circular access doors; large area strainers type 304 stainless steel with perforated openings sized smaller than water distribution metering orifices; and an integral anti-vortexing hood to prevent air entrainment.
- E. Wet Deck and Drift Eliminator - Shall be manufactured and performance tested by the manufacturer and shall be 15 mils thick polyvinyl chloride. It shall have a flame spread rate of 5 per ASTM E84-77a.
- F. Air Inlet Louvers - Shall be waveform, fiberglass-reinforced polyester or stainless steel, spaced to minimize air resistance and prevent splash out.
- G. Fan - Shall be fixed pitch cast aluminum propeller type mounted on a solid steel fan shaft supported by heavy duty, self-aligning relubricatable 40,000-hour life bearings with cast iron housings. Extended lube lines shall be provided for ease of maintenance. Provide galvanized steel fan guard.
- H. Fan Motor and Drive
  1. Motor - Shall be 1750 rpm drip-proof ball-bearing type with 1.15 service factor. High efficiency motor shall be rated for VFD duty and suitable for outdoor service and operation on indicated electrical service. Motor shall be mounted on easily adjusted heavy-duty motor base located so that drive and motor are in a protected position.
  2. The V-belt fan drive shall be designed for not less than 150% of motor nameplate horsepower. Drive and all moving parts shall be completely enclosed by removable stainless steel screens.
  3. Install VFD Variable Frequency Drive per specification section 15905.
  4. Provide a vibration cutout switch to de-energize fan motors in case of excessive vibration.
- I. Electronic Water Level Control Package - Consists of a weather protected unit mounted to the sump out of air stream and a slow acting solenoid valve installed in the makeup water line.



- J. Starter - Shall be magnetic with HAND-OFF-AUTOMATIC switch and red running light. See 15050, 2.07.
- K. Basin Sump Heater Package – Provide heaters, contactors for each heater element, control transformer, basin thermostat, and low water cut out. Provide and wire one heater package for each tower cell. Provide a 1” threaded outlet in each cells sump for the purposes of temperature monitoring via the ATC.
- L. Internal/External Working/Service Platforms - provide complete internal/external working/service platforms and ladder systems for the maintenance and service of all drive components and motor assemblies, at access doors for plenum sections and at the louver face. Towers which require service/maintenance from the top (fan deck) shall be provided with a perimeter handrail system with a ladder from grade to the fan deck. Ladders for external platforms shall extend to grade.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The cooling tower shall be installed as shown on the drawings and in accordance with the manufacturer's recommendations. Coordinate required elevation with supporting structure. Provide vibration isolation as shown on drawings.

- A. Install OSHA approved ladders to all internal and external working/service platforms.
- B. Install manufacturer's handrail system around the perimeter of the top of the unit.

#### **3.02 WARRANTY**

See Section 15010 for warranty information.

END OF SECTION

## SECTION 15681

### CENTRIFUGAL FAN COOLING TOWER

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

A complete factory assembled centrifugal fan type sectional counterflow blow-through design-cooling tower shall be installed.

##### 1.03 QUALITY ASSURANCE

- A. Capacity shall be in accordance with published ratings, wet deck ASTM standard E-84 flame spread rated and finish corrosion protection tested per ASTM B117-64. Towers thermal performance shall be in accordance with CTI standard 201.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 CENTRIFUGAL FAN COOLING TOWER

The centrifugal fan-cooling tower shall be of the type and capacity shown on the drawings. The cooling tower shall be manufactured by BALTIMORE AIRCOIL. A unit fully equal to the specified manufacturer and manufactured by EVAPCO is acceptable.

- A. Unit Description - The cooling tower shall be a factory assembled and tested unit consisting of a type 304 stainless steel pan and fan section with access openings, centrifugal fan, fan motor and drive, heat transfer surface, water distribution system and eliminator section, all prepared for piping and wiring and assembled on one base with accessories series 300 stainless nuts and bolts as required in this specification or as shown on the plans.

- B. Casing and Basins - Shall be constructed of heavy gauge, stainless steel, including all casing and basin interior and exterior surfaces.
- C. Pan-Fan Section
1. The combination pan-fan section shall consist of heavy gauge stainless steel framework, stainless steel type 304 V-shaped self-cleaning pan and centrifugal fans mounted beneath the sloping undersides of the pan.
  2. Standard pan accessories shall include circular access doors; large area lift-out stainless steel type 304 strainer with perforated openings sized smaller than spray nozzle orifices, and mounted in an assembly baffled to prevent circulation; and waste water bleed line with valve.
  3. The forwardly curved centrifugal fans shall be constructed totally of 304 stainless steel statically and dynamically balanced. Fan housings shall have compound curve inlet rings for efficient air entry, and discharge cowls within the pan for increased fan efficiency and to prevent water from entering the fans. Fan bearings shall be spherical self-aligning sleeve type with two piece cast iron body, deep well reservoir, and oil cup.
  4. Electronic Water Level Control Package - Consists of a weather protected unit mounted to the sump out of air stream and a slow acting solenoid valve installed in the makeup water line.
- D. Fan Motor Drive
1. A 1750-rpm drip-proof ball-bearing fan motor with 1.15 service factor shall be furnished. High efficiency motor shall be rated for VFD duty and suitable for outdoor service and operation on indicated electrical service. Motor shall be mounted on easily adjusted heavy-duty motor base located so that drive and motor are in a weather-protected position.
  2. The V-belt fan drive shall be designed for not less than 150% of motor nameplate horsepower. Drive and all moving parts shall be completely enclosed including the bottom by removable stainless steel screens.
  3. Provide and install VFD variable frequency drive per specification Section 15905.
  4. Provide a vibration cutout switch to de-energize fan motors in case of excessive vibration.
- E. Surface Section
1. The heat transfer sections of the tower shall be removable from the pan.

Each shall be a composite assembly containing wet deck surface fill and water distribution system in channel-formed casing layers, and shall have sectional eliminators on top.

2. Fill - the wet deck surface of the tower shall consist of wave-formed or cross-fluted sheets of polyvinyl chloride. The wet deck shall be designed for protection against vermin, rot, fire, fungus attack, or warpage.
  3. Water Distribution - Shall be distributed evenly over the tower fill area through a spray tree consisting of a header and removable branches constructed of schedule 40 PVC pipe. The branches and closely spaced molded ABS plastic spray nozzles shall be threaded or held in place with snap-on rubber grommets providing quick removal of individual nozzles or complete branches for cleaning or flushing. The header shall include provision for measuring spray pressure externally.
  4. Eliminators - Shall be constructed of ultra violet light resistive polyvinyl chloride. Eliminators shall be removable in easily handled sections. They shall have a minimum of three breaks with a hooked leaving edge and shall direct discharge air away from the fans at a 45-degree angle.
- F. Starter - Shall be magnetic with HAND-OFF-AUTOMATIC switch and red running lights. See 15050, 2.07.
- G. Basin Sump Heater Package – Provide heaters, contactors for each heater element, control transformer, basin thermostat and low water cut out. Provide and wire one heater package for each tower cell. Provide a 1” threaded outlet in each cells sump for the purpose of temperature monitoring via the automatic temperature system.
- H. Internal/External Working/Service Platforms- provide complete internal/external working/service platforms and ladder systems for the maintenance and service of all drive components and motor assemblies, at access doors for plenum sections and at the louver face. Towers which require service/maintenance from the top (fan deck) shall be provided with a perimeter handrail system with a ladder from grade to the fan deck. Ladders for external platforms shall extend to grade.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

The cooling tower shall be installed as shown on the drawings and in accordance with the manufacturer's recommendations. Coordinate required elevation with supporting structure. Provide vibration isolation as shown on drawings.

- A. Install OSHA approved ladders to all internal and external working/service platforms.

3.02 WARRANTY

See Section 15010 for warranty information.

END OF SECTION

## SECTION 15682

### CLOSED CELL COOLING TOWER

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

A complete factory-assembled closed circuit cooling tower of induced draft design with vertical air discharge shall be installed.

##### 1.03 QUALITY ASSURANCE

- A. Capacity shall be in accordance with published ratings, wet deck ASTM standard E-84 flame spread rated and finish corrosion protection tested per ASTM B117-64. Towers thermal performance shall be in accordance with CTI standard 201.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 COOLING TOWER

The cooling tower shall be of the type and capacity shown on the drawings. The cooling tower shall be manufactured by BALTIMORE AIRCOIL. A unit fully equal to the specified manufacturer and manufactured by MARLEY or EVAPCO is acceptable.

- A. Unit Description - The cooling tower shall be a factory assembled, piped, wired and tested unit consisting of a stainless steel housing, distribution basins, wet deck, drift eliminator, propeller fan and fan motor and drive, recirculating spray water pump and piping, positive closure damper hood and actuator, all assembled on one base with accessories using series 300 stainless steel nuts and bolts, as required in this specification or as shown on the drawings.

- B. Casing and Basins - Shall be constructed of heavy gauge, stainless steel including all angles or channels. All casing exterior panels shall be fiberglass reinforced polyester (FRP) panels or stainless steel panels. Piping connections shall be flanged.
- C. Stainless Steel Coil - Coil shall be constructed of Type 304 stainless steel serpentine tube. Tubes shall be sloped for free drainage and coil assembly shall be pneumatically tested at 375 psig (2,685 kPa). Coil shall be ASME B31.5 compliant.
- D. Hot Water Distribution Basins - Shall be type 304 stainless steel and open gravity type with distribution weirs and plastic metering orifices. Basin shall include integral balancing valves and removable basin covers. Each cell shall have a single water inlet with pre-strainer assembly, or external factory mounted strainer. PVC distribution system with plastic or brass nozzles are acceptable.
- E. Cold Water Basin - Shall be type 304 stainless steel and include circular access doors; large area strainers type 304 stainless steel with perforated openings sized smaller than water distribution metering orifices; and an integral anti-vortexing hood to prevent air entrainment.
- F. Wet Deck and Drift Eliminator - Shall be manufactured and performance tested by the manufacturer and shall be 15 mils thick polyvinyl chloride. It shall have a flame spread rate of 5 per ASTM E84-77a.
- G. Air Inlet Louvers - Shall be wave form, fiberglass reinforced polyester or stainless steel, spaced to minimize air resistance and prevent splash-out.
- H. Positive Closure Damper Hood - Provide coil air intake hoods with factory mounted positive closure dampers with stainless steel linkages and damper actuators. The hood shall be factory insulated.
- I. Fan - Shall be fixed pitch cast aluminum propeller type mounted on a solid steel fan shaft supported by heavy duty, self-aligning relubricatable 40,000 hour life bearings with cast iron housings. Extended lube lines shall be provided for ease of maintenance. Provide galvanized steel fan guard. To maintain the quality of the local environment, the closed circuit cooling tower shall be furnished with a low sound fan.
- J. Fan Motor and Drive
  - 1. Motor - Shall be 1750 rpm drip-proof ball-bearing type with 1.15 service factor. High efficiency motor shall be rated for VFD duty and suitable for outdoor service and operation on indicated electrical service. Motor shall be mounted on easily adjusted heavy duty motor base located so that drive and motor are in a protected position.

2. The V-belt fan drive shall be designed for not less than 150% of motor nameplate horsepower. Drive and all moving parts shall be completely enclosed by removable stainless steel screens.
  3. Install VFD Variable Frequency Drive per specification Section 15905.
  4. Provide a vibration cutout switch to de-energize fan motors in case of excessive vibration.
- K. Recirculating Spray Water Pump
1. Pump shall be close coupled, bronze fitted centrifugal pump.
  2. Motor shall be totally enclosed fan cooled (TEFC) motor.
  3. Provide bleed line with metering valve from pump discharge to overflow.
- L. Electronic Water Level Control Package - Consists of a weather protected unit mounted to the sump out of air stream and a slow acting solenoid valve installed in the makeup water line. Provide a level control package for each tower cell.
- M. Basin Sump Heater Package - Provide heaters, contactors for each heater element, control transformer, basin thermostat, and low water cut out. Provide and wire one heater package for each tower cell. Provide a 1" threaded outlet in each cells sump for the purposes of temperature monitoring via the ATC.
- N. Pump Starter - Shall be magnetic with HAND-OFF-AUTOMATIC switch and red running light. See 15050, 2.07.
- O. Internal/External Working/Service Platforms- provide complete internal/external working/service platforms and ladder systems for the maintenance and service of all drive components and motor assemblies, at access doors for plenum sections and at the louver face. Towers which require service/maintenance from the top (fan deck) shall be provided with a perimeter handrail system with a ladder from grade to the fan deck. Ladders for external platforms shall extend to grade.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The cooling tower shall be installed as shown on the drawings and in accordance with the manufacturer's recommendations. Coordinate required elevation with supporting structure. Provide vibration isolation as shown on drawings.
- B. Install OSHA approved ladders to all internal and external working/service platforms.



- C. Install manufacturer's handrail system around the perimeter of the top of the unit.

### 3.02 WARRANTY

See Section 15010 for warranty information.

END OF SECTION

## SECTION 15691

### SPECIAL SYSTEM ROOM AIR CONDITIONING UNIT (SELF CONTAINED UNIT)

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Furnish and install a ceiling mounted self contained air conditioning unit for the room as described below and shown on plans.

##### 1.03 QUALITY ASSURANCE

The air conditioning units shall have published ratings and shall be listed as acceptable by an approved testing agency.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04.

#### PART 2 - PRODUCTS

##### 2.01 SELF CONTAINED ROOM AIR CONDITIONING UNIT

The air conditioning unit shall be furnished and installed of the type and capacity as shown on the drawings and herein specified. The air conditioning unit shall be manufactured by LIEBERT. Units fully equal to the specified manufacturer and manufactured by SPACE COOLER, DATAIRE, or SKIL-AIRE are acceptable.

A. Package Indoor Unit - Shall be completely assembled, piped, wired, and factory tested. Unit configuration shall be horizontal, designed for ceiling mounting and fit the 2' X 4' opening of the T-bar ceiling.

1. Cabinet - Shall be constructed of heavy gauge galvanized steel and designed for easy installation and service access. All service access shall be through the sides of the unit without removing the unit from the ceiling. Cabinet shall be insulated with 1 1/2 pound density insulation providing thermal and acoustical treatment. Mounting kit shall include vibration isolators.

2. Air Distribution System - Shall include a direct drive forward curved centrifugal fan arranged to draw air through the evaporator. The blower motor shall be mounted on vibration isolators and shall have three speeds to allow airflow to be adjusted to the specific requirements of the installation. The return/supply grille assembly shall include discharge grille and a hinged return grille for filter access. Filter shall be a 1" disposable type. Filters shall have a minimum MERV rating of 13.
  3. Compressor - Shall be of the hermetically sealed type, complete with a resilient suspension system, oil strainer, inherent motor protection, and anti-slug protection. Refrigerant shall be 410A.
  4. Evaporator Coils - Shall be direct expansion type. The prime surface shall be of seamless copper tubes with aluminum plates fins.
- B. Condenser - The built-in condenser section contains the compressor, filter drier, sightglass, suction line accumulator, and condenser coil. The coil shall be constructed with copper tubes and aluminum fins. Condenser air shall be ducted to the unit using a centrifugal condenser fan.
- C. Automatic Temperature Control - Unit shall operate through built-in controls and wall mounted microprocessor-based thermostat. Provide all control wiring between unit and thermostat.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The air conditioning units shall be installed and tested in accordance with the manufacturer's recommendations and as shown on the drawings.
- B. Unit shall be suspended from the structure using all-thread rods with vibration isolators.
- C. Units shall not be located directly above any electronic/electric equipment.
- D. New filters shall be installed after construction is over and before the final inspection.
- E. Provide a typed list of all the different units and their filter sizes to be included in the O & M manuals. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  1. Project Manager, Office of Design and Construction Services, Project Manager, Design & Construction Services, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.

2. Coordinator, Mechanical Maintenance Division, Maintenance Services,  
5025 Sideburn Road, Fairfax, Virginia, 22032

END OF SECTION

## SECTION 15692

### SPECIAL SYSTEM ROOM AIR CONDITIONING UNIT (SPLIT SYSTEM UNIT)

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, Section 15050 - Basic Materials and Methods, and Section 15651 Refrigeration Piping Systems shall apply to this section.

##### 1.02 SCOPE

Furnish and install a ceiling/wall mounted air conditioning unit for the room as described below and as shown on the plans.

##### 1.03 QUALITY ASSURANCE

The ductless air conditioning units shall have published ratings and shall be listed as acceptable by an approved testing agency.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in section 15010, 1.04.

#### PART 2 - PRODUCTS

##### 2.01 SPLIT SYSTEM ROOM AIR CONDITIONER

The ductless room air conditioning unit shall be furnished and installed of the type and capacity as shown on the drawings and herein specified. The ductless air conditioning unit shall be manufactured by PANASONIC. Units fully equal to the specified manufacturer and manufactured by MITSUBISHI, TRANE, DAIKIN, or CARRIER are acceptable.

- A. Air cooled split system air conditioning unit having the capability listed in the schedule on the drawings.
- B. Air conditioning unit to be factory assembled and pre-wired suitable for low pressure operation, consisting of an indoor and outdoor unit, controls, air filters (filters shall have a minimum MERV rating of 13), refrigerant cooling coil and refrigerant piping. Refrigerant shall be 410A.
- C. The ductless unit drain pan shall be provided with a float switch to automatically shutoff the unit should the drain pan fill a indicating a clogged condensate drain line.

- D. Outdoor unit shall be equipped with low ambient kit, wind baffle, and crankcase heater.
- E. Automatic Temperature Control- Unit shall operate through built in controls and wall mounted microprocessor based thermostat. Provide all control wiring between unit and thermostat.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. For areas containing ceilings, provide a ceiling recessed type unit. Should a wall unit be required, install unit as high as possible under provisions of the manufacturer's instruction.
- B. Identify unit with its tag showing the building number, unit number and area served. For example, label the Communication Room unit "AC-1-1/Communication Room".
- C. Coordinate installation with architectural and electrical work.
- D. During construction, keep unit inlet and outlet sealed with polyethylene sheet to prevent accumulation of construction dust in unit.
- E. Prior to startup, clean inside of unit thoroughly of all construction dust.
- F. Do not operate unit until area has been cleaned and filters are in place.
- G. Unit to be fully charged with refrigerant.
- H. Refrigerant piping shall be type ACR 'L' copper refrigerant tubing with hard wrought copper fittings. Pipe sized ½ inch and larger shall be hard drawn. Pipe sized 3/8 inch and smaller can either be hard or soft drawn. All of the joints shall be brazed with a filler material that complies with AWS classification BCuP-5. Use type 'L' copper tubing to pipe the relief valve discharge to the outside.
- I. Correct any deficiencies in unit operation.
- J. Do not locate unit directly overtop of electric or electronic equipment.
- K. Provide a typed list of all the different units and their filter sizes to be included in the O & M manuals. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Design & Construction Services, 8115 Gatehouse Road, Suite 3500, Falls Church Va 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032.

SPECIAL SYSTEM ROOM AIR  
CONDITIONING UNIT (DUCTLESS AIR CONDITIONER)  
15692

SECTION

END OF SECTION

## SECTION 15700

### VARIABLE REFRIGERANT FLOW SYSTEM

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include the following:

- A. Complete variable refrigerant flow system including equipment, piping, and controls. System shall be a VRF (variable refrigerant flow) multi split air conditioning system. The system will utilize an air cooled condensing unit supplying a maximum of forty indoor fan coil units with combinations of outdoor units 3 - 25 ton capacity with a maximum of 2 outdoor units connected at one time for 208-230V/ 3 Phase service.
- B. The VRF (Variable Refrigerant Flow) system shall be a simultaneous cooling and heating heat pump system. The VRF system shall consist of an outdoor unit, high efficiency heat recovery units designed for minimum piping and maximum design flexibility, indoor units, and controls by the equipment manufacturer. Each indoor unit shall be independently capable of operating in either heating or cooling mode regardless of the mode of other indoor units.
- C. The variable refrigerant flow system piping system shall be designed by a manufacturer's certified designer. If Basis-of-Design system is not used, contractor shall submit fully revised piping layout to engineer, complete with revised locations and quantities of heat recovery units. Revised piping layout shall be submitted with equipment submittal for review and approval by engineer. Revised piping layout shall not affect performance of indoor or outdoor units. The contractor is responsible for all costs associated with additional review required by engineer.
- D. The variable refrigerant flow system piping system shall be installed by a manufacturer's certified contractor.
- E. The installing contractor shall be trained and certified at the manufacturer's training facility prior to installation, start-up, and commissioning. Submit for review the installation contractor's certification from the manufacturer. This



certification shall include the company certification as well as certifications for each individual which will be working on this project.

- F. The refrigeration piping system shall be provided, installed, tested, evacuated, and charged.
- G. The installing contractor shall have at least one year experience installing variable refrigerant flow systems (VRF) similar in size to the individual mechanical systems on this project. Proof of experience and project work shall be provided with the submittals.

### 1.03 QUALITY ASSURANCE

- A. Manufacturers Field Service - Engage a factory-authorized service representative to inspect field assembled components and equipment installation, including connections, and to assist in field testing.
- B. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label. All wiring shall be in accordance with the National Electrical Code (NEC). The units shall be manufactured in a facility registered to ISO 9001 and ISO14001.
- C. The refrigeration piping system shall be provided, installed, tested, evacuated and charged in accordance with the manufacturer's recommendations, ANSI, ASHRAE, and ARI's Safety Code for Mechanical Refrigeration, state and local codes.
- D. Perform the following field tests and inspections and prepare test reports:
  - 1. Leak Test - After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test - After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Remove and replace malfunctioning units and retest as specified above.
- F. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

**PART 2 - PRODUCTS**

## 2.01 MANUFACTURERS

- A. Manufacturers - Provide products by one of the following:
  - 1. MITSUBISHI ELECTRIC/TRANE
  - 2. PANASONIC ECOi 3-way Variable Refrigerant Flow (VRF) Heat Recovery System.
  - 3. Daikin Industries.
  - 4. CARRIER
- B. Coordinate any changes from the basis of design with all associated trades. Any additional costs associated with the alternate equipment shall be covered by the equipment manufacturer. No additional costs shall be incurred by the Owner.

## 2.02 REFRIGERANT COMPONENTS

- A. The equipment specified in this section shall operate with refrigerant R410A - no exceptions or substitutions.
- B. The system shall utilize fully modulating electronic expansion valves.
- C. Refrigerant Piping
  - 1. The refrigerant piping system shall be provided complete and installed in accordance with the manufacturer's recommendations and as specified herein and the requirement of 15651. The size of the refrigerant pipes shall be obtained from the equipment manufacturer unless otherwise shown on the drawings.
  - 2. Pipe, Fittings, and Accessories - The pipe shall be type ACR 'L' copper refrigerant tubing with hard wrought copper fittings. Pipe sized ½ inch and larger shall be hard drawn. Pipe sized 3/8 inch and smaller can either be hard or soft drawn. All of the joints shall be brazed with a filler material that complies with AWS classification BCuP-5. Use type 'L' copper tubing to pipe the relief valve discharge to the outside.
  - 3. Condensate Drain Piping - Shall be type 'L' copper tubing.
  - 4. Pipe Hangers and Supports - Shall be as required in Section 15050.

5. All refrigerant lines shall be insulated from the outdoor unit to the indoor terminal units as shown in Section 15250.
6. The system shall be capable of operating with refrigerant piping up to 492 equivalent feet, a total combined length of 984 feet of piping between the condensing and fan coil units with 164 feet maximum vertical difference, without any oil traps or additional equipment. The vertical difference shall not exceed a maximum of 131 feet where the outdoor unit is located below the indoor unit.
7. The use of GelCopper pre-insulated copper tubing, or approved equal, is acceptable for use from the refrigerant mains, typically located in corridors, to the terminal devices in sizes listed for soft copper.

### 2.03 HEAT PUMP CONDENSING UNIT

- A. The outdoor unit will have air cooled heat exchange coils constructed from copper tubing with aluminum fins. The coils will be set in a vertical formation with air being drawn in through three sides of the unit and discharged out of the top of the unit. The systems will have a single fan mounted on top of the coils.
- B. The outdoor unit will have one inverter controlled hermetic compressor. Partial capacity cooling/heating capability must be available. The system shall use a control sequence to ensure that indoor loads are matched to compressor capacity control.
- C. The refrigeration process of the outdoor unit will be maintained by pressure and temperature sensors controlling solenoid valves check valves and bypass valves. The heating or cooling mode of the outdoor unit will be controlled using a combination of two- and three-way valves which will reverse the cycle of the refrigerant to change the mode of the outdoor unit.
- D. The variable capacity, heat pump air conditioning system shall be variable refrigerant flow split system. The system shall consist of multiple evaporators using PID control and inverter driven outdoor unit. The unit shall consist of direct expansion (DX), air-cooled heat pump air conditioning system, variable speed driven compressor multi zone split system. The outdoor unit may connect an indoor evaporator capacity of 50-130% to that of the outdoor condensing unit capacity. Each indoor unit shall be capable of operating separately with individual temperature control.
- E. The outdoor unit shall be interconnected to indoor unit types specified in this section. The indoor units shall be connected to the outdoor units utilizing the specialized piping joints and headers provided by the equipment manufacturer.
- F. General - The outdoor unit is designed specifically for use with manufacturers components:

1. Refrigerant: R410A.
  2. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of a compressor, motors, fans, condenser coil, electronic expansion valve, solenoid valves, four-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receivers and accumulators.
  3. Both liquid and suction lines shall be individually insulated between the outdoor and indoor units.
  4. The outdoor unit shall be wired and piped with outdoor unit access from left, right, rear, or bottom.
  5. The connection ratio of indoor units to outdoor unit shall be 50% to 130%.
  6. The outdoor unit shall have a sound rating no higher than 63 dB(A).
  7. The system shall automatically restart operation after a power failure and shall not cause any settings to be lost, thus eliminating the need for re-programming.
  8. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimal spacing.
  9. The following safety devices shall be included on the condensing unit: high pressure switch, crankcase heaters, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, and over current protection for the inverter. To ensure the liquid refrigerant does not flash when supplying to the various fan coil units, the circuit shall be provided with a sub-cooling feature. Oil recovery cycle shall be automatic, occurring one hour after system start up, every six hours of system operation or as required to maintain oil levels at the system condensing unit.
  10. The outdoor unit shall operate in heating mode to -4F dry bulb ambient temperature without additional ambient controls.
- G. Unit Cabinet - The outdoor unit model shall be completely weatherproof and corrosion resistant. The outdoor unit will be constructed from steel plate and treated with acrylic paint, or galvanized steel, bonderized and finished with a powder coated baked enamel.
- H. Fan

1. The condensing unit shall consist of a propeller type, direct-drive fan motor that has multiple speed operation via a DC inverter.
  2. The fan motors shall have inherent protection and permanently lubricated bearings and be mounted.
  3. The fan motors shall be provided with a fan guard to prevent contact with moving parts.
- I. Condenser Coil - The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond. Provide vandal/hail guards for condenser coils.
- J. Compressor
1. The compressor shall be variable speed control capable of changing the speed to follow the variations in total cooling load as determined by the suction gas pressure as measured in the condensing unit.
  2. The inverter driven compressor in each condensing unit shall be a high efficiency DC, hermetically sealed compressor.
  3. The capacity control range shall be a minimum of 20% to 100% of total capacity.
  4. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
  5. Oil separators shall be standard with the equipment together with an oil balancing circuit.
  6. The compressor shall be mounted to avoid the transmission of vibration.
- K. Electrical
1. The power supply to the outdoor unit shall be 208/230 volts, 3 phase, 60 hertz with a voltage range of 187 volts to 253 volts.
  2. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable shielded communications wire.
- 2.04 HEAT RECOVERY UNITS FOR SIMULTANEOUS HEATING AND COOLING SYSTEMS
- A. General - The Heat Recovery Unit shall be designed for use with VRF equipment of the same manufacturer. These units shall be equipped with a circuit board that

interfaces to the controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish. The heat recovery unit shall be completely factory assembled, piped, and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of rated capacity.

B. Unit Cabinet

1. The casing shall be fabricated of galvanized steel.
2. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
3. The unit shall house tube-in-tube heat exchangers.

C. Refrigerant - R410A refrigerant shall be required for Heat Recovery units in conjunction with outdoor unit systems.

D. Refrigerant Valves

1. The unit shall be furnished with multiple branch circuits which can individually accommodate up to 54,000 BTUH and/or three indoor units. Branches may be twinned to allow more than 54,000 BTUH.
2. Each branch shall have multiple two-position valves to control refrigerant flow for optimum efficiency.
3. Service shut-off valves shall be installed for each branch to allow service to any indoor unit without field interruption to overall system operation. Shut-off valves shall be full-port ball valves, rated at 700 PSIG, with a Schrader port.
4. Linear electronic expansion valves shall be used to control the variable refrigerant flow.

E. Integral Drain Pan - A integral condensate pan and drain, if required, shall be provided.

F. Electrical

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
2. The unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253V (230V/60Hz).
3. The Heat Recovery unit shall be controlled by integral microprocessors.

4. 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.

## 2.05 INDOOR AIR HANDLING UNITS

- A. It shall be possible for the total connected capacity of the indoor units to be between 50 and 130% of the capacity of the outdoor unit.
- B. Each indoor unit will have a heat exchanger which shall be constructed from copper tubing with aluminum fins. The flow of refrigerant through the heat exchanger will be controlled by an electronic proportional expansion valve. This valve will be controlled by two pipe thermistors, a return air and discharge air thermistor and shall be capable of controlling the variable capacity of the indoor unit between 25% and 100%.
- C. Each indoor unit shall have an operating voltage of 208-230V/1 phase/60Hz. The indoor unit shall supply demand capacity information to the outdoor unit via its control algorithm.
- D. Four (4) Way Ceiling Cassette Indoor Unit
  1. The indoor unit shall be a ceiling cassette fan coil unit for installation into the ceiling cavity equipped with an air panel grille to be connected to indoor unit as scheduled and specified in this section. The indoor unit shall have a four-way air distribution type, impact resistant and washable decoration panel. The supply air shall be distributed via motorized louvers which can be horizontally and vertically adjusted from 0 degree to 90 degree angle.
  2. Construction
    - a. The indoor unit shall be completely factory assembled and tested. The unit shall include factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
    - b. The 4-way supply airflow shall be field modifiable to 3-way and 2-way airflow to accommodate various installation configurations including corner installations.
    - c. Return air shall be through the concentric panel, which shall include a filter.
    - d. The indoor unit shall be equipped with a condensate pan.

- e. The indoor unit shall be equipped with a return air thermistor.
  - f. The indoor unit shall be separately powered with 208-230V/1 phase/60Hz.
  - g. The voltage range shall be 253 volts maximum and 187 volts minimum.
  - h. The indoor unit shall be equipped with a condensate pump capable of providing at least 19" of lift.
3. Unit Cabinet
- a. The cabinet shall be space saving and shall be located into the ceiling.
  - b. The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.
  - c. Provide fresh air intake kit where used and indicated on the drawings. A branch duct knockout shall exist for branch ducting supply air.
4. Fan
- a. The fan shall be direct-drive turbo fan type with statically and dynamically balanced impeller with high and low fan speeds available.
  - b. The indoor unit shall operate with a power supply of 208/230 volts, 1 phase, 60 hertz. The allowable voltage range shall be 187 to 253 volts.
  - c. The airflow rate shall be adjustable and have high, medium and low fan settings.
  - d. The fan motor shall be thermally protected.
5. Filter - The return air shall be filtered by means of a long-life filter.
6. Coil
- a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.



- b. A condensate pan shall be located under the coil. The condensate pan shall have a built in high level safety alarm to shut down the unit.
  - c. A thermistor shall be located on the liquid and gas line.
- E. One (1) Way Ceiling Cassette Indoor Unit
- 1. The indoor unit shall be a ceiling cassette fan coil unit for installation into the ceiling cavity equipped with an air panel grille to be connected to indoor unit as scheduled and specified in this section. The indoor unit shall have a one-way air distribution type, impact resistant and washable decoration panel. The supply air shall be distributed via motorized louvers which can be horizontally and vertically adjusted from 0 degree to 90 degree angle.
  - 2. Construction
    - a. The indoor unit shall be completely factory assembled and tested. The unit shall include factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
    - b. Return air shall be through the concentric panel, which shall include a filter.
    - c. The indoor units shall be equipped with a condensate pan.
    - d. The indoor units shall be equipped with a return air thermistor.
    - e. The indoor unit shall be separately powered with 208-230V/1 phase/60Hz.
    - f. The voltage range shall be 253 volts maximum and 187 volts minimum.
    - g. The indoor unit shall be equipped with a condensate pump capable of providing at least 23" of lift.
  - 3. Unit Cabinet
    - a. The cabinet shall be space saving and shall be located into the ceiling.

- b. Provide fresh air intake kit where used and indicated on the drawings. A branch duct knockout shall exist for branch ducting supply air.
4. Fan
- a. The fan shall be direct-drive fan type with statically and dynamically balanced impeller with high and low fan speeds available.
  - b. The indoor unit shall operate with a power supply of 208/230 volts, 1 phase, 60 hertz. The allowable voltage range shall be 187 to 253 volts.
  - c. The airflow rate shall be adjustable and have high, medium and low fan settings.
  - d. The fan motor shall be thermally protected.
5. Filter - The return air shall be filtered by means of a long-life filter.
6. Coil
- a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
  - b. A condensate pan shall be located under the coil. The coil in the condensate pan shall have a built in high level safety alarm to shut down the unit.
  - c. A thermistor shall be located on the liquid and gas line.

## 2.06 CONTROLS

- A. The units shall have controls provided with the unit by the manufacturer to perform input functions necessary to operate the system.
- B. Computerized PID control shall be used to maintain room temperature within 1F of setpoint.

## 2.07 CONTROLLERS

- A. Physical Characteristics - The control system shall be a neutral color plastic material with a Liquid Crystal Display (LCD).
- B. Electrical Characteristics
  - 1. General - From each circuit board to the controls, the electrical voltage shall be 16 - 24 volts DC.
  - 2. Wiring: Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit then to the outdoor unit. Control wiring shall run from the indoor unit terminal block to the specific controller for that unit.
  - 3. Wiring Size: The wire shall be a shielded, size AWG16-2 or AWG 18-2.
- C. Individual Zone Controller
  - 1. The simplified wired remote controller shall be able to control 1 group (maximum of 16 fan coil units).
  - 2. The simplified wired remote controller shall have the following features:
    - a. Operation - Start/Stop, Operation Mode, Temperature Setting, 60F - 90F Set Point Range, Fan Speed, Airflow Direction.
    - b. Monitoring - Status, malfunction flashing, malfunction content, filter sign, operation mode, temperature setting, permit/prohibit selection, fan speed, airflow direction.
    - c. Scheduling - ON/OFF Timer.
    - d. Control Management - Field Setting Mode, Group Setting, Auto Restart.
- D. Centralized Controller
  - 1. The Centralized Controller shall be capable of controlling a maximum of 50 indoor units across multiple outdoor units. Centralized controller shall have a color LCD touch-screen. The Centralized Controller shall support system configuration, daily/weekly scheduling, monitoring of operation status, night setback settings, free contact interlock configuration and malfunction monitoring. The Centralized Controller shall have five basic operation controls which can be applied to an individual indoor unit, a group of indoor units (up to 50 indoor units), or all indoor units (collective batch operation). This basic set of operation controls for the Centralized controller shall include on/off, operation mode selection (cool, heat, auto, dry, and fan), temperature setting, fan speed setting, and airflow direction setting. The Centralized

Controller shall allow the user to define both daily and weekly schedules with operations consisting of ON/OFF, mode selection, temperature setting, air flow (vane) direction, fan speed, and permit/prohibit of remote controllers.

2. The functions of the Centralized Controller shall be accessible through the Web via a Web gateway in the Operator Interface Software as described in 15900 2.05 I2. Any required hardware or software for this access shall be provided by the VRF manufacturer. The Centralized Controller shall be connected to the buildings Local Area Network (LAN).

E. BACnet Interface to Building Automation System

1. The cooling and heating BACnet7 interface shall be compliant with BACnet7 Protocol (ANSI/ASHRAE 135-2004) and be Certified by the (BTL) BACnet7 Testing Laboratories. The BACnet7 interface shall support BACnet Broadcast Management (BBMD). The BACnet7 interface shall support a maximum of 50 indoor units. Operation and monitoring points include, but are not limited to, space temperature, space temperature setpoint, on/off, operation mode, fan speed, prohibit remote controller, filter sign reset, alarm state, error code and error address.

F. Control Panel

1. This contractor shall deliver the components of the centralized controllers and the BACnet interface devices to the Division 15900 contractor. It is the responsibility of the Division 15900 contractor to construct the control panel, housing these components in compliance with 15900 specification 2.02F.

G. Indoor Unit Sequence of Operations

1. On/Off Control - the indoor units shall be commanded ON/OFF by the BAS. If all indoor units are off, the outdoor unit shall turn off. With the Night Setback Function/Mode, the system shall cycle on during unoccupied periods as needed to maintain unoccupied temperature setpoint of 55°F (adjustable).
2. Space Temperature Control - the indoor unit shall modulate its internal linear expansion valve (LEV) to maintain the temperature setpoint via the indoor unit's internal controls.
  - a. The setpoint is provided and adjustable through the BAS interface.
  - b. The temperature setpoint provided through the BAS interface shall additionally be adjustable to a maximum of  $\pm 2^{\circ}\text{F}$  from that setpoint using the room controller.
3. Mode Control
  - a. Auto Mode

- 1) The indoor unit shall determine whether it should be in auto-heat mode or auto-cool mode based on space temperature relative to temperature setpoint. If the indoor unit is in auto-heat mode, the indoor unit control board shall follow the heat mode sequence. If the indoor unit is in auto-cool mode, the indoor unit control board shall follow the cool mode sequence.
  - 2) The indoor unit shall switch from auto-heat to auto-cool when the space temperature rises above and remains above the temperature setpoint plus the dead band for 3 minutes.
  - 3) The indoor unit will switch from auto-cool to auto-heat when the space temperature drops below and remains below the temperature setpoint minus the dead band for 3 minutes.
- b. Heating Mode - the indoor unit shall modulate its linear expansion valve (LEV) to maintain temperature setpoint of 71°F (adjustable).
  - c. Cooling Mode - the indoor unit shall modulate its linear expansion valve (LEV) to maintain temperature setpoint of 74°F (adjustable).

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Install all piping, fittings, and insulation to meet manufacturers requirements. Install units level and plumb. Evaporator-fan components shall be installed using manufacturers standard mounting devices securely fastened to building structure. Install and connect refrigerant tubing and fittings.
- B. Installer shall supply isolation ball valves for zoned refrigerant isolation. Installer shall supply Isolation ball valves with Schrader connection for isolating refrigerant charge and evacuation at each connected air handling unit and condensing unit. Isolation ball valves, with Schrader connection, are required for instances of air handling unit isolation for troubleshooting, repair, or replacement without affecting the remainder of the system. Isolation ball valves with Schrader connection are also required at condensing unit connection to isolate unit for troubleshooting, repair or replacement and as required to provide partial capacity Heating/Cooling in the instance of a failure of one of the multiple outdoor unit (condensing unit) compressors.
- C. During brazing an inert gas (such as nitrogen) shall be continuously passed through the system at a rate sufficient to maintain an oxygen free environment to prevent the formation of copper oxide scale. After piping has been completed,

the refrigerant piping system shall be pressure tested at a pressure of 300 psi on the high side and 150 psi on the low side. The pressure shall be maintained on the system for a minimum of 12 hours. The system shall be evacuated when the surrounding ambient air is not less than 60 F. If the temperature is less, auxiliary heat must be provided to insure proper evacuating conditions. A minimum vacuum of 500 Microns of Hg. shall be pulled on the system and maintained for 12 hours. The vacuum pump displacement shall be not less than 2 cfm for up to 15 tons. The system shall be charged as recommended by the equipment manufacturer. Owner/Engineer shall be notified to witness both the pressure and vacuum tests.

- D. Electrical wiring required by this section, both high and low voltage, shall comply with the Division 16 requirements.
- E. Start Up - Engage manufacturer or factory-authorized service representative to perform startup service. Manufacturer shall provide on-site startup and commissioning assistance through job completion. Complete installation and startup checks according to manufacturers written instructions. This shall include a factory startup for factory provided control devices as well as configuring control points for other DO devices. Service representative shall completely configure all control devices and establish remote internet connectivity with the owner's energy management department web server.
- F. Demonstration - Engage manufacturer or factory-authorized service representative to demonstrate and instruct the owner's maintenance personnel of the operation and functionality of the system.
- G. Training - Engage manufacturer or factory authorized service representative to train owner's maintenance personnel for a period of 2 days, to adjust, operate and maintain individual units and complete system. This shall also include training of the owner's energy management department representatives as to establish control system programming, scheduling routines, alarm reporting, system topography, communication protocols and password level assignments.  
  
This training shall take place on-site and at the owner's maintenance facility at 5025 Sideburn Road, Fairfax VA 22032.
- H. The indoor air handling and outside condensing units shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings. The first unit installed will be considered the typical mock up and shall require notification, inspection and approval by the designated owner representative and/or architect and engineer before any additional installations will be allowed.
- I. Provide laminated as built drawings and manufacturer's refrigeration piping layout showing typical layout and refrigerant volume of the system. This shall

include the actual room numbers, not from construction documents, and addressing scheme. Laminate shall have minimum thickness of 10 mil. Drawing size shall be 11"x17". Provide multiple drawings should zones not fit into one page. These will be mounted in the water heater room unless otherwise shown.

- J. Refrigerant distribution (BC) controllers shall include a label affixed to the controllers which identifies the room or rooms served such as "VRF-A1, A125" for each line set on the controller. Use the actual room numbers and not room numbers from construction documents. Identification labels shall be BROTHER type "P-TOUCH", white tape with upper case letters, minimum ½ high block lettering, and black printing and shall be located on the bottom of the branch controller next to each pipe run.
  
- K. Provide a typed list of all the different units, their filter sizes, to be included in the O&M manuals. The list shall include the unit designation, filter size, and the number of filters required for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, Gatehouse Administrative Center, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia 22032.
  
- L. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each condensing unit. Tag is to be screwed or riveted to unit. Identification tag shall be black with engraved ½ " white letters which reads:

|                              |   |
|------------------------------|---|
| UNIT #                       | <i>(unit number)</i> _____                |
| INSTALLED BY:                | <i>(contracting company's name)</i> _____ |
| WARRANTY EXPIRES:            | <i>(month/day/year)</i> _____             |
| COMPRESSOR WARRANTY EXPIRES: | <i>(month/day/year)</i> _____             |

- M. This contractor is responsible for the completion and approval of documents required by the manufacturer to initiate the warranty. In any instance where the manufacturer's warranty is pulled due to the incorrect installation or workmanship, the terms of this warranty become this contractor's responsibility.

- N. Provide 2 spare individual room controllers (wired remote) turn over to owner on project completion.

END OF SECTION



## SECTION 15701

### VARIABLE REFRIGERANT FLOW SYSTEM (For Building Additions)

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include the following:

- A. Complete variable refrigerant flow system including equipment, piping, and controls. System shall be a VRF (variable refrigerant flow) multi split air conditioning system. The system will utilize an air cooled condensing unit supplying a maximum of forty indoor fan coil units with combinations of outdoor units 3 - 25 ton capacity with a maximum of 2 outdoor units connected at one time for 208-230V/ 3 Phase service.
- B. The VRF (Variable Refrigerant Flow) system shall be a simultaneous cooling and heating heat pump system. The VRF system shall consist of an outdoor unit, high efficiency heat recovery units designed for minimum piping and maximum design flexibility, indoor units, and controls by the equipment manufacturer. Each indoor unit shall be independently capable of operating in either heating or cooling mode regardless of the mode of other indoor units.
- C. The variable refrigerant flow system piping system shall be designed by a manufacturer's certified designer. If Basis-of-Design system is not used, contractor shall submit fully revised piping layout to engineer, complete with revised locations and quantities of heat recovery units. Revised piping layout shall be submitted with equipment submittal for review and approval by engineer. Revised piping layout shall not affect performance of indoor or outdoor units. The contractor is responsible for all costs associated with additional review required by engineer.
- D. The variable refrigerant flow system piping system shall be installed by a manufacturer's certified contractor.
- E. The installing contractor shall be trained and certified at the manufacturer's training facility prior to installation, start-up, and commissioning. Submit for review the installation contractor's certification from the manufacturer. This

certification shall include the company certification as well as individual certifications for each individual which will be working on this project.

- F. The refrigeration piping system shall be provided, installed, tested, evacuated, and charged.
- G. The installing contractor shall have at least one year experience installing variable refrigerant flow systems (VRF) similar in size to the individual mechanical systems on this project. Proof of experience and project work shall be provided with the submittals.

### 1.03 QUALITY ASSURANCE

- A. Manufacturers Field Service - Engage a factory-authorized service representative to inspect field assembled components and equipment installation, including connections, and to assist in field testing.
- B. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label. All wiring shall be in accordance with the National Electrical Code (NEC). The units shall be manufactured in a facility registered to ISO 9001 and ISO14001.
- C. The refrigeration piping system shall be provided, installed, tested, evacuated and charged in accordance with the manufacturer's recommendations, ANSI, ASHRAE, and ARI's Safety Code for Mechanical Refrigeration, state and local codes.
- D. Perform the following field tests and inspections and prepare test reports:
  - 1. Leak Test - After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - 2. Operational Test - After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Remove and replace malfunctioning units and retest as specified above.
- F. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

**PART 2 - PRODUCTS**

## 2.01 MANUFACTURERS

- A. Manufacturers - Provide products by one of the following:
  - 1. MITSUBISHI ELECTRIC/TRANE
  - 2. PANASONIC ECOi 3-way Variable Refrigerant Flow (VRF) Heat Recovery System.
  - 3. Daikin Industries.
  - 4. TOSHIBA
- B. Coordinate any changes from the basis of design with all associated trades. Any additional costs associated with the alternate equipment shall be covered by the equipment manufacturer. No additional costs shall be incurred by the Owner.

## 2.02 REFRIGERANT COMPONENTS

- A. The equipment specified in this section shall operate with refrigerant R410A - no exceptions or substitutions.
- B. The system shall utilize fully modulating electronic expansion valves.
- C. Refrigerant Piping
  - 1. The refrigerant piping system shall be provided complete and installed in accordance with the manufacturer's recommendations and as specified herein. The size of the refrigerant pipes shall be obtained from the equipment manufacturer unless otherwise shown on the drawings.
  - 2. Pipe, Fittings, and Accessories - The pipe shall be type ACR 'L' copper refrigerant tubing with hard wrought copper fittings. Pipe sized ½ inch and larger shall be hard drawn. Pipe sized 3/8 inch and smaller can either be hard or soft drawn. All of the joints shall be brazed with a filler material that complies with AWS classification BCuP-5. Use type 'L' copper tubing to pipe the relief valve discharge to the outside.

3. Condensate Drain Piping - Shall be type 'L' copper tubing.
4. Pipe Hangers and Supports - Shall be as required in Section 15050.
5. All refrigerant lines shall be insulated from the outdoor unit to the indoor terminal units as shown in Section 15250.
6. The system shall be capable of operating with refrigerant piping up to 492 equivalent feet, a total combined length of 984 feet of piping between the condensing and fan coil units with 164 feet maximum vertical difference, without any oil traps or additional equipment. The vertical difference shall not exceed a maximum of 131 feet where the outdoor unit is located below the indoor unit.
7. The use of GelCopper pre-insulated copper tubing, or approved equal, is acceptable for use from the refrigerant mains, typically located in corridors, to the terminal devices in sizes listed for soft copper.

### 2.03 HEAT PUMP CONDENSING UNIT

- A. The outdoor unit will have air cooled heat exchange coils constructed from copper tubing with aluminum fins. The coils will be set in a vertical formation with air being drawn in through three sides of the unit and discharged out of the top of the unit. The systems will have a single fan mounted on top of the coils.
- B. The outdoor unit will have one inverter controlled hermetic compressor. Partial capacity cooling/heating capability must be available. The system shall use a control sequence to ensure that indoor loads are matched to compressor capacity control.
- C. The refrigeration process of the outdoor unit will be maintained by pressure and temperature sensors controlling solenoid valves check valves and bypass valves. The heating or cooling mode of the outdoor unit will be controlled using a combination of two- and three-way valves which will reverse the cycle of the refrigerant to change the mode of the outdoor unit.
- D. The variable capacity, heat pump air conditioning system shall be variable refrigerant flow split system. The system shall consist of multiple evaporators using PID control and inverter driven outdoor unit. The unit shall consist of direct expansion (DX), air-cooled heat pump air conditioning system, variable speed driven compressor multi zone split system. The outdoor unit may connect an indoor evaporator capacity of 50-130% to that of the outdoor condensing unit capacity. Each indoor unit shall be capable of operating separately with individual temperature control.

- E. The outdoor unit shall be interconnected to indoor unit types specified in this section. The indoor units shall be connected to the outdoor units utilizing the specialized piping joints and headers provided by the equipment manufacturer.
- F. General - The outdoor unit is designed specifically for use with manufacturers components:
1. Refrigerant: R410A.
  2. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of a compressor, motors, fans, condenser coil, electronic expansion valve, solenoid valves, four-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receivers and accumulators.
  3. Both liquid and suction lines shall be individually insulated between the outdoor and indoor units.
  4. The outdoor unit shall be wired and piped with outdoor unit access from left, right, rear, or bottom.
  5. The connection ratio of indoor units to outdoor unit shall be 50% to 130%.
  6. The outdoor unit shall have a sound rating no higher than 63 dB(A).
  7. The system shall automatically restart operation after a power failure and shall not cause any settings to be lost, thus eliminating the need for re-programming.
  8. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimal spacing.
  9. The following safety devices shall be included on the condensing unit: high pressure switch, crankcase heaters, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, and over current protection for the inverter. To ensure the liquid refrigerant does not flash when supplying to the various fan coil units, the circuit shall be provided with a sub-cooling feature. Oil recovery cycle shall be automatic, occurring one hour after system start up, every six hours of system operation or as required to maintain oil levels at the system condensing unit.
  10. The outdoor unit shall operate in heating mode to -4F dry bulb ambient temperature without additional ambient controls.

- G. Unit Cabinet - The outdoor unit model shall be completely weatherproof and corrosion resistant. The outdoor unit will be constructed from steel plate and treated with acrylic paint, or galvanized steel, bonderized and finished with a powder coated baked enamel.
- H. Fan
1. The condensing unit shall consist of a propeller type, direct-drive fan motor that has multiple speed operation via a DC inverter.
  2. The fan motors shall have inherent protection and permanently lubricated bearings and be mounted.
  3. The fan motors shall be provided with a fan guard to prevent contact with moving parts.
- I. Condenser Coil - The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond. Provide vandal/hail guards for condenser coils.
- J. Compressor
1. The compressor shall be variable speed control capable of changing the speed to follow the variations in total cooling load as determined by the suction gas pressure as measured in the condensing unit.
  2. The inverter driven compressor in each condensing unit shall be a high efficiency DC, hermetically sealed compressor.
  3. The capacity control range shall be a minimum of 20% to 100% of total capacity.
  4. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
  5. Oil separators shall be standard with the equipment together with an oil balancing circuit.
  6. The compressor shall be mounted to avoid the transmission of vibration.
- K. Electrical
1. The power supply to the outdoor unit shall be 208/230 volts, 3 phase, 60 hertz with a voltage range of 187 volts to 253 volts.

2. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable shielded communications wire.

#### 2.04 HEAT RECOVERY UNITS FOR SIMULTANEOUS HEATING AND COOLING SYSTEMS

- A. General - The Heat Recovery Unit shall be designed for use with VRF equipment of the same manufacturer. These units shall be equipped with a circuit board that interfaces to the controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish. The heat recovery unit shall be completely factory assembled, piped, and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of rated capacity.
- B. Unit Cabinet
  1. The casing shall be fabricated of galvanized steel.
  2. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
  3. The unit shall house tube-in-tube heat exchangers.
- C. Refrigerant - R410A refrigerant shall be required for Heat Recovery units in conjunction with outdoor unit systems.
- D. Refrigerant Valves
  1. The unit shall be furnished with multiple branch circuits which can individually accommodate up to 54,000 BTUH and/or three indoor units. Branches may be twinned to allow more than 54,000 BTUH.
  2. Each branch shall have multiple two-position valves to control refrigerant flow for optimum efficiency.
  3. Service shut-off valves shall be installed for each branch to allow service to any indoor unit without field interruption to overall system operation. Shut-off valves shall be full-port ball valves, rated at 700 PSIG, with a Schrader port.
  4. Linear electronic expansion valves shall be used to control the variable refrigerant flow.
- E. Integral Drain Pan - A integral condensate pan and drain, if required, shall be provided.

## F. Electrical

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
2. The unit shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253V (230V/60Hz).
3. The Heat Recovery unit shall be controlled by integral microprocessors.
4. 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.

## 2.05 INDOOR AIR HANDLING UNITS

- A. It shall be possible for the total connected capacity of the indoor units to be between 50 and 130% of the capacity of the outdoor unit.
- B. Each indoor unit will have a heat exchanger which shall be constructed from copper tubing with aluminum fins. The flow of refrigerant through the heat exchanger will be controlled by an electronic proportional expansion valve. This valve will be controlled by two pipe thermistors, a return air and discharge air thermistor and shall be capable of controlling the variable capacity of the indoor unit between 25% and 100%.
- C. Each indoor unit shall have an operating voltage of 208-230V/1 phase/60Hz. The indoor unit shall supply demand capacity information to the outdoor unit via its control algorithm.
- D. Four (4) Way Ceiling Cassette Indoor Unit
  1. The indoor unit shall be a ceiling cassette fan coil unit for installation into the ceiling cavity equipped with an air panel grille to be connected to indoor unit as scheduled and specified in this section. The indoor unit shall have a four-way air distribution type, impact resistant and washable decoration panel. The supply air shall be distributed via motorized louvers which can be horizontally and vertically adjusted from 0 degree to 90 degree angle.
  2. Construction
    - a. The indoor unit shall be completely factory assembled and tested. The unit shall include factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.



- b. The 4-way supply airflow shall be field modifiable to 3-way and 2-way airflow to accommodate various installation configurations including corner installations.
- c. Return air shall be through the concentric panel, which shall include a filter. Filters shall have a minimum MERV rating of 13.
- d. The indoor unit shall be equipped with a condensate pan.
- e. The indoor unit shall be equipped with a return air thermistor.
- f. The indoor unit shall be separately powered with 208-230V/1 phase/60Hz.
- g. The voltage range shall be 253 volts maximum and 187 volts minimum.
- h. The indoor unit shall be equipped with a condensate pump capable of providing at least 19" of lift.

### 3. Unit Cabinet

- a. The cabinet shall be space saving and shall be located into the ceiling.
- b. The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.
- c. Provide fresh air intake kit where used and indicated on the drawings. A branch duct knockout shall exist for branch ducting supply air.

### 4. Fan

- a. The fan shall be direct-drive turbo fan type with statically and dynamically balanced impeller with high and low fan speeds available.
- b. The indoor unit shall operate with a power supply of 208/230 volts, 1 phase, 60 hertz. The allowable voltage range shall be 187 to 253 volts.
- c. The airflow rate shall be adjustable and have high, medium and low fan settings.
- d. The fan motor shall be thermally protected.

5. Filter - The return air shall be filtered by means of a long-life filter. Filters shall have a minimum MERV rating of 13.
  6. Coil
    - a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
    - b. A condensate pan shall be located under the coil. The condensate pan shall have a built in high level safety alarm to shut down the unit.
    - c. A thermistor shall be located on the liquid and gas line.
- E. One (1) Way Ceiling Cassette Indoor Unit
1. The indoor unit shall be a ceiling cassette fan coil unit for installation into the ceiling cavity equipped with an air panel grille to be connected to indoor unit as scheduled and specified in this section. The indoor unit shall have a one-way air distribution type, impact resistant and washable decoration panel. The supply air shall be distributed via motorized louvers which can be horizontally and vertically adjusted from 0 degree to 90 degree angle.
  2. Construction
    - a. The indoor unit shall be completely factory assembled and tested. The unit shall include factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
    - b. Return air shall be through the concentric panel, which shall include a filter. Filters shall have a minimum MERV rating of 13.
    - c. The indoor units shall be equipped with a condensate pan.
    - d. The indoor units shall be equipped with a return air thermistor.
    - e. The indoor unit shall be separately powered with 208-230V/1 phase/60Hz.
    - f. The voltage range shall be 253 volts maximum and 187 volts minimum.



- B. Computerized PID control shall be used to maintain room temperature within 1F of setpoint.

## 2.07 CONTROLLERS

- A. Physical Characteristics - The control system shall be a neutral color plastic material with a Liquid Crystal Display (LCD).

- B. Electrical Characteristics

- 1. General - From each circuit board to the controls, the electrical voltage shall be 16 - 24 volts DC.
- 2. Wiring: Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit then to the outdoor unit. Control wiring shall run from the indoor unit terminal block to the specific controller for that unit.
- 3. Wiring Size: The wire shall be a shielded, size AWG16-2 or AWG 18-2.

- C. Individual Zone Controller - Wired Remote Controller

- 1. The wired remote controller shall be able to control 1 group (maximum of 16 fan coil units) and shall be able to function as follows:
  - a. The controller shall have a self diagnosis function that constantly monitors the system for malfunctions (total of 80 components).
  - b. The controller shall be able to immediately display fault location and condition.
  - c. An LCD digital display shall allow the temperature to be set in 1F units.
  - d. The controller shall be equipped with a thermostat sensor in the remote controller making possible more comfortable room temperature control.
- 2. The wired remote controller shall have the following features:
  - a. Operation - Start/Stop, Operation Mode, Temperature Setting, 60F - 90F setpoint Range, Fan Speed, Airflow Direction.
  - b. Monitoring - Status, malfunction flashing, malfunction content, filter sign, operation mode, temperature setting, permit/prohibit selection, fan speed, airflow direction.
  - c. Scheduling - ON/OFF Timer

- d. Control Management - Field Setting Mode, Group Setting, Auto Restart
- D. Individual Zone Controller B Simplified Wired Remote Controller
- 1. The simplified wired remote controller shall be able to control 1 group (maximum of 16 fan coil units).
  - 2. The simplified wired remote controller shall have the following features:
    - a. Operation - Start/Stop, Operation Mode, Temperature Setting, 60F - 90F Set Point Range, Fan Speed, Airflow Direction.
    - b. Monitoring - Status, malfunction flashing, malfunction content, filter sign, operation mode, temperature setting, permit/prohibit selection, fan speed, airflow direction.
    - c. Scheduling - ON/OFF Timer.
    - d. Control Management - Field Setting Mode, Group Setting, Auto Restart.
- E. System Remote Controller - The controller shall control up to 50 units in 4 zones and shall be able to be used in conjunction with all room controller types. Collective and individual group commands are available with permit/prohibit individual remote controller function. The system controller shall use the following connections for power and remote monitoring:
- L1: Power supply (60 Hz, 208-230 VAC)
  - C1: Inter-unit control wiring (Low voltage)
  - C3: Auxiliary
  - C4: Ground for inter-unit control wiring
  - A1: Input for turning ON air conditioners concurrently
  - A2: Input for turning OFF air conditioners concurrently
  - A3: Common input for turning air conditioners ON or OFF
  - B1: On operation state indicator output
  - B2: Alarm indicator output
  - B3: Common indicator output
- F. Web Enabled Intelligent Controller
- 1. This controller shall be wall mounted and hard wired. It will be manufactured with an LCD display and will be the manufacturers standard color. The controller will be capable of individually controlling the following functions on at least 50 indoor fan coil units:

- a. On/off.
  - b. Operating mode.
  - c. Set point.
  - d. Fan speed.
  - e. Louver position.
  - f. Timer settings.
  - g. Test run.
2. The controller shall also be capable of displaying the following information individually for at least 50 indoor fan coil units:
- a. On/off.
  - b. Operating mode.
  - c. Set point.
  - d. Fan speed.
  - e. Louver position.
  - f. Timer settings.
  - g. Test run.
  - h. Fault diagnosis.
3. Each Intelligent controller unit shall be accessed both locally and remotely via standard Internet Explorer IE6 or IE7 software. The Intelligent controller will be able to indicate system alarms via volt free contacts as well as providing control points for other DO devices. Additionally, the intelligent controller shall be able to monitor individual usage of heating and cooling demands, report alarm and conditions to nominated email address, and enable remote alteration of systems setpoints and schedules..

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Install all piping, fittings, and insulation to meet manufacturers requirements. Install units level and plumb. Evaporator-fan components shall be installed using manufacturers standard mounting devices securely fastened to building structure. Install and connect refrigerant tubing and fittings.
- B. Installer shall supply isolation ball valves for zoned refrigerant isolation. Installer shall supply Isolation ball valves with Schrader connection for isolating refrigerant charge and evacuation at each connected air handling unit and condensing unit. Isolation ball valves, with Schrader connection, are required for instances of air handling unit isolation for troubleshooting, repair, or replacement without affecting the remainder of the system. Isolation ball valves with Schrader connection are also required at condensing unit connection to isolate unit for troubleshooting, repair or replacement and as required to provide partial capacity Heating/Cooling in the instance of a failure of one of the multiple outdoor unit (condensing unit) compressors.
- C. During brazing an inert gas (such as nitrogen) shall be continuously passed through the system at a rate sufficient to maintain an oxygen free environment to prevent the formation of copper oxide scale. After piping has been completed, the refrigerant piping system shall be pressure tested at a pressure of 300 psi on the high side and 150 psi on the low side. The pressure shall be maintained on the system for a minimum of 12 hours. The system shall be evacuated when the surrounding ambient air is not less than 60 F. If the temperature is less, auxiliary heat must be provided to insure proper evacuating conditions. A minimum vacuum of 500 Microns of Hg. shall be pulled on the system and maintained for 12 hours. The vacuum pump displacement shall be not less than 2 cfm for up to 15 tons. The system shall be charged as recommended by the equipment manufacturer. Owner/Engineer shall be notified to witness both the pressure and vacuum tests.
- D. Electrical wiring required by this section, both high and low voltage, shall comply with the Division 16 requirements.
- E. Start Up - Engage manufacturer or factory-authorized service representative to perform startup service. Manufacturer shall provide on-site startup and commissioning assistance through job completion. Complete installation and startup checks according to manufacturers written instructions. This shall include a factory startup for factory provided control devices as well as configuring control points for other DO devices. Service representative shall completely configure all control devices and establish remote internet connectivity with the owner's energy management department web server.
- F. Demonstration - Engage manufacturer or factory authorized service representative to demonstrate and instruct the owner's maintenance personnel of the operation and functionality of the system.

- G. Training - Engage manufacturer or factory authorized service representative to train owner's maintenance personnel for a period of 2 days, to adjust, operate and maintain individual units and complete system. This shall also include training of the owner's energy management department representatives as to establish control system programming, scheduling routines, alarm reporting, system topography, communication protocols and password level assignments.

This training shall take place on-site and at the owner's maintenance facility at 5025 Sideburn Road, Fairfax VA 22032.

- H. The indoor air handling and outside condensing units shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings. The first unit installed will be considered the typical mock up and shall require notification, inspection and approval by the designated owner representative and/or architect and engineer before any additional installations will be allowed.
- I. Provide laminated as built drawings and manufacturer's refrigeration piping layout showing typical layout of the system. This shall include the actual room numbers, not from construction documents, and addressing scheme. Laminate shall have minimum thickness of 10 mil. Drawing size shall be 11"x17". Provide multiple drawings should zones not fit into one page. These will be mounted in the water heater room unless otherwise shown.
- J. Refrigerant distribution (BC) controllers shall include a label affixed to the controllers which identifies the room or rooms served for each line set on the controller. Use the actual room numbers and not room numbers from construction documents.
- K. Provide a typed list of all the different units, their filter sizes, to be included in the O&M manuals. The list shall include the unit designation, filter size, and the number of filters required for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
1. Project Manager, Office of Design and Construction Services, Gatehouse Administrative Center, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.
  2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia 22032.
- L. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each condensing unit. Tag is to be screwed or riveted to unit. Identification tag shall be black with engraved ½ " white letters which reads:



|                              |                                     |
|------------------------------|-------------------------------------|
| UNIT #                       | <u>(unit number)</u>                |
| INSTALLED BY:                | <u>(contracting company's name)</u> |
| WARRANTY EXPIRES:            | <u>(month/day/year)</u>             |
| COMPRESSOR WARRANTY EXPIRES: | <u>(month/day/year)</u>             |

- M. This contractor is responsible for the completion and approval of documents required by the manufacturer to initiate the warranty. In any instance where the manufacturer's warranty is pulled due to the incorrect installation or workmanship, the terms of this warranty become this contractor's responsibility.
- N. Provide 2 spare individual room controllers (wired remote) to turn over to owner on project completion.

END OF SECTION

## SECTION 15702

### HOT WATER, CHILLED WATER SUPPLY AND RETURN PIPING SYSTEM AND SPECIALTIES

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include the following:

- A. Complete chilled water piping systems.
- B. Complete hot water piping systems.
- C. Complete condenser water piping systems.

##### 1.03 QUALITY ASSURANCE

The piping system shall be tested for leaks before the insulation is applied and before the piping system is covered up. The test shall be at least 100 psi of water pressure for a duration of 12 hours.

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

All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. Shop drawings shall include proposed uses of all items.

#### PART 2 - PRODUCTS

##### 2.01 PIPING AND FITTINGS

- A. Hot water supply and return: Shall be schedule 40 black steel pipe with 125 psi cast iron screwed fittings or 150 psi steel weld fittings.

1. Type "L" copper tubing with copper fittings is acceptable for piping 2" and under.
- B. Chilled water supply and return: Shall be schedule 40 black steel pipe with 125 psi cast iron screwed fittings or 150 psi steel weld fittings.
1. Type "L" copper tubing with copper fittings is acceptable for piping 2" and under.
- C. Cold water make-up - Shall be type 'L' copper tubing with copper fittings.
- D. Grooved mechanical pipe couplings, fittings, valves and other grooved components may be used as an option to welding, threading or flanged methods. All grooved components shall be of one manufacturer and conform to local code approval. Grooved end product manufacturer to be ISO-9001 certified. Grooved couplings shall meet the requirements of ASTM F-1476. Grooved components shall be manufactured by VICTAULIC. Grooved components manufactured by GRINNELL or ANVIL INT. are acceptable providing all aspects of the specification are met. No substitutions.
1. Carbon steel piping shall be roll grooved in accordance with manufacturers current listed standard.
  2. Mechanical couplings for grooved piping shall be cast of ductile iron conforming to ASTM A-395, grade 65-45-15, and ASTM A-536, grade 65-45-12. Couplings shall be rigid style and be of the angle patterned bolt pad type, and shall provide system support and hanging requirements in accordance with ANSI B31.1, ANSI B31.4 and NFPA 13. Coupling bolts and nuts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to physical properties of ASTM A-183. Mechanical couplings shall be coated with an alkyd enamel finish.
  3. Gaskets for grooved pipe and fittings shall be grade "E" EPDM compound conforming to ASTM D-2000 designation 2CA615A25B24F17Z.
  4. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, with Victaulic Style 107H/107N (Quick-Vic), Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM designed for operating temperatures from -30 deg F to +250 deg F.
  5. Grooved fittings shall be cast of ductile iron conforming to ASTM A-395, grade 65-45-15, and ASTM A-536, grade 65-45-12, wrought steel to ASTM A234, Grade WPB; or factory-fabricated from ASTM A53 steel

- pipe. Grooved fittings shall be coated with an alkyd enamel finish.  
Grooved fittings shall be full flow.
- E. Condensate drain piping: Shall be type 'L' copper tubing and fittings.
  - F. Runouts to terminal units with copper pipe connections: Type 'L' hard drawn copper tubing shall be used for runouts where required. A brass coupling shall be used between the steel pipe and copper tubing connection.
  - G. Hot water supply and return under slab - Each piece of equipment shall have separate runouts and shall be type 'K' continuous copper pipe with no joints allowed below slab. All joints above slab shall be made with copper brazing rods. The entire underground pipe system shall be inside a minimum 6" round schedule 40 plastic pipe sleeve. Pipe shall be insulated; see section 15250.
  - H. Condensing water supply and return piping - Shall be schedule 40 black steel pipe with 125 psi cast iron screwed fittings or 150 psi steel weld fittings inside of the building and schedule 80 PVC plastic pipe and fittings for outdoors.
  - I. The use of running or close nipples is prohibited.

## 2.02 VALVES

Valves shall be manufactured by VICTAULIC, STOCKHAM, JENKINS, HAMMOND, JOMAR, MILWAUKEE, FAIRBANKS, CRANE, CONBRACO INDUSTRIES, INC., APOLLO VALVES, LUNKENHEIMER, WALWORTH, NIBCO, JAMESBURY or ROCKWELL unless otherwise noted. STOCKHAM catalog numbers are listed to identify quality and style Valves shall be rated for the medium served.

- A. Gate valves 2 1/2" and smaller: Shall be cast bronze body, sweat type or screwed ends and solid wedge disc with rising stem, STOCKHAM #B108.
- B. Gate valves larger than 2 1/2" - Shall be iron body flanged ends and solid wedge disc with rising stem (O S & Y type), STOCKHAM #G623.
- C. Globe valves 2 1/2" and smaller: Shall be cast bronze body, sweat type or screwed ends and replaceable composition disc, STOCKHAM #B24T.
- D. Check valves 2 1/2" or smaller: Shall be cast bronze body swing check with either screwed ends or sweat type and with regrinding disc, STOCKHAM #B319 or B309.
- E. Check valves larger than 2 1/2" - Shall be flanged iron body with bronze disc and ring, STOCKHAM #G931.
- F. Non-Slam check valves - Shall be used for all vertical applications and on pump discharge piping and shall be flanged iron body with bronze disc, wafer check, NIBCO #F-910 for 2 1/2" and larger or W-910 for under 2" and smaller.

- G. Butterfly valves - 2" and larger may be used in lieu of gate or globe valves except at boiler supply and return pipe. These valves shall be rated at not less than 150 psi WOG Class and be suitable for use with 180°F water. Shall be lug type for pipe removal on either side of valve, shall have stainless steel shafts and shall have 4" extended stem lengths for all size valves. Stockham #LD611.
- H. Ball valves: 2" and smaller may be used in lieu of gate or globe valves. These valves shall be bronze, rated at not less than 150 psi WOG Class, full port, solid chrome plated ball design and stem, blow out proof stem. Be suitable for use with 180-degree water and provided with extended insulated handles. Stockham #S216. Extended insulated handles shall be APOLLO VALVES "Therma-Seal" or NIBCO "Nib-seal".
- I. Balancing valves: Valves manufactured by FLOWSET, GRISWOLD, GERAND, DANFOSS, FLOW-PAC, NUTECH, BARCO or PRESO with memory stop, positive shutoff, extended insulated handle and P/T type ports for balancing. Flowset model AS size 1/2" to 2" flow .25 GPM to 100 GPM. For all units with runouts 2" and smaller.
- J. Constant volume flow valves – VICTAULIC, GRISWOLD, AUTOFLOW or FLOWSET, automatic pressure-connecting spring and cartridge type valves with quick disconnect pressure taps. For all units with pipe size 2 1/2" and larger with GPM capacity shown.
- K. Valve Operating Chains: Valves installed six feet or more above finished floor in boiler rooms or mechanical rooms shall be chain operated. Provide chain and chain wheel with chain guide of size required, as manufactured by STOCKHAM.
- L. Balance valve for pump: Eccentric, combination shut-off and balancing with memory stop valve as manufactured by DEZURIK or ROCKWELL.
- M. Provide metering device in boiler room or in pump room for measuring pump flow rates, for systems piping a minimum of 20 feet (measured along pipe length) from pump discharge or just before pipe exits room, whichever is greater. Provide extended metering taps on metering devices. Flow metering devices and elements shall be as manufactured by FLOWSET, GERAND, GRISWOLD, PRESO or BARCO.
- N. Valves for flushing piping mains - Provide 1 1/2" full port ball valves on the supply and return mains of each piping system for the purpose of flushing debris and other foreign mater out of piping. Valves shall be rated at not less that 150 PSI WOG, shall be suitable for 180 degree water and provided with extended insulated handle. Provide adapter for valve to accept a fire hose and provide a removable cap. STOCKHAM # S207.

## 2.03 SPECIALTIES

- A. Pipe Hangers and Supports: See section 15050.
- B. Unions: Shall be provided for the assembly, dismantling or service to any portion of the piping system.
1. Unions 2" and Smaller: Shall be malleable iron ground joint unions with brass to iron seals. Stockham Fig. #694.
  2. Unions 2-1/2" and Larger: Shall be of the companion flange type with ring type gasket painted with graphite before installation. Stockham Fig. #799.
  3. Brass Couplings: Shall be used for connecting steel pipe to copper tubing.
- C. Thermometers: Shall be provided and installed in the supply and return piping of the system. Thermometers mounted at heights other than 5 feet from the floor shall be the adjustable angle type and located so they may be read from the floor.
- The body of the thermometer shall be brass or die-cast aluminum and at least 9" long. The thermometer shall be blue organic fill type with an appropriate scale for the medium being measured. The thermometer shall be mounted in the pipe in a separate well. Manufacturer – TRERICE BX 91406 or equivalent by WEKSLER, TAYLOR, or WEISS.
- D. Pressure Gauges: Shall be installed in the piping system at the pumps. Connect the gauge to the piping system with 1/4" iron pipe. Provide 1/4" rough brass cock between the gauge and piping system.
- The pressure gauge shall be of the liquid filled, bourdon-tube type with at least a 4" diameter dial with an appropriate scale. The gauge shall be the dust, corrosion and moisture resistance type with a cast aluminum case. Manufacturers – ASHCROFT, WEKSLER, TAYLOR, or TRERICE.
- E. Expansion Tank: Shall be ASME labeled and the size listed on the drawings. Provide the tank with the required tappings and a prime coat of paint. The expansion tank shall be BELL & GOSSETT, TACO, JOHN WOOD, WESSELS, or ARMSTRONG.
- F. Tank Fitting: Shall match the tank to maintain the proper amount of air. The tank fitting shall be BELL & GOSSETT or TACO.
- G. Air Separator: Shall be ASME labeled and the same size as connecting pipe. Provide separator with strainer. The air separator shall be BELL & GOSSETT, TACO, THRUSH, AMTROL, JOHN WOOD, or ARMSTRONG.

- H. Pressure Reducing Valve: Shall be set at 12 psi unless otherwise noted on drawings and shall be the size of the cold water make up piping. The pressure-reducing valve shall be CONBRACO INDUSTRIES INC., APOLLO VALVES, WATTS, BELL & GOSSETT, or TACO.
- I. Flexible Connection: Flexible pipe connection shall be installed on all pipes connecting to equipment where indicated on the drawings. The isolated equipment shall be provided with flexible connections for all piping connections immediately adjacent to the equipment. The hose shall be flexible, braid-reinforced, seamless metal hose within the pressure and temperature range applicable. Hose lengths shall be a minimum of ten inches and as recommended by the manufacturer, whichever is greater. Short style will not be acceptable. Provide control rods for stabilization. Flexible connections shall be as manufactured by TWIN CITY HOSE, METRAFLEX, SSI, KEFLEX, or METRASPHERE.
- J. Air Vents: Provide at high points of systems, on trapped sections of piping with automatic air vents or other locations as required for air removal from the system. Manual air vents shall be used on piping above ceilings in all finished spaces. Each air vent shall be accessible. Provide Hoffman No. 77 manual air vents for unit heaters, fan coil units, unit ventilators, piping mains above ceilings, etc. Provide Hoffman No. 79 automatic air vents for all exposed piping mains, air handling units, etc. Air vents as manufactured by SPIROTHERM shall also be acceptable.
- K. Strainers: Shall be VICTAULIC, CONBRACO INDUSTRIES, INC., APOLLO VALVES, ARMSTRONG, TACO, or SARCO. Iron or brass body 'Y' pattern sediment strainers shall be installed. These strainers shall be provided with stainless steel or non-ferrous straining elements with heads for removal of the elements.
  - 1. Iron body 'Y' pattern sediment strainers shall be installed with steel pipe.
  - 2. Brass body 'Y' pattern sediment strainers shall be installed with copper or brass pipe.
  - 3. Area of strainer openings shall not be less than four (4) times the pipe area. All strainers shall have blow-off valves with hose ends.
  - 4. Strainer elements shall be No. 10 (ten), mesh screen or perforated stainless steel.
  - 5. Each strainer body shall be cast with the manufacturer's name, an arrow indicating the direction of flow, strainer size, and pressure classification.
  - 6. Each strainer shall be of the operating pressure, temperature and service rating of the respective systems.

- L. Check valves (condensate drains): See Section 15420.
- M. Condensate overflow protection. Provide float control safety switches in condensate drain pans (or secondary drain pans), for all equipment with cooling coils. Switches shall be as manufactured by BECKETT or LITTLE GIANT. Equipment located outside of plenum spaces may use safety switches as manufactured by EZ-TRAP (1-877-439-8727), where the switch is integral to a PVC trap.
- N. Low point drains shall be provided for sections of trapped piping. Low point drains shall be a  $\frac{3}{4}$  ball valve with a hose end connection and cap.

#### 2.04 WATER PIPING ELECTRICAL HEAT TRACING:

- A. Provide and install for all exterior piping Raychem Corporation, XL-Trace, U/L Listed, braided, self regulating heating cable with inherent temperature control and a 5 foot cold lead inside the building. Electrical characteristics 120/1/60. All piping shall have Model 5XL-CR heat tracing. Nominal watts per foot rating at 40 degree pipe temperature is 5.9 for Model 5XL-CR. Provide Models XLK-PC and XLK-SET components for power connection, tees, end seals kits and splices and GT-66 glass cloth adhesive tape. Heat tracing cable equal to the item specified as manufactured by THERMON shall be acceptable.

### **PART 3 - EXECUTION**

#### 3.01 INSTALLATION

- A. The piping systems shall be installed as described in section 15050 - Basic Materials and Methods.
- B. Heat tracing cable shall be installed linearly along the piping, not spiraled. Secure heat tracing to piping using glass cloth adhesive tape. Provide manufacturer's recommended pattern coverage for valves, flanges and pipe supports. Heat tracing shall be installed on all exterior piping to five feet inside the building beyond the pipe sleeve. Heat tracing shall be tested, after installation, per manufacturer's recommendations. Heat traced piping shall have manufacturers warning labels installed stating that the piping is electrically heat traced. This contractor shall install heat trace in such a manner that the termination points are coordinated with the electrical drawings.
- C. Float control safety switches shall be interlocked with the fan to turn off the unit when a high water level is detected.

#### 3.02 PIPING SYSTEM CLEANING



- A. The piping systems shall be cleaned and flushed with chemicals in accordance with the following sequences:
1. Initial Flush - The initial flush shall be performed on the piping mains, with pumps running and before any branch piping or equipment has been connected. This initial flush is to remove debris and other foreign objects out of the piping systems. Flush systems until all matter has been removed from piping. After this flushing, the strainers shall be opened, screens removed and the entire unit cleaned and re-installed.
  2. Pre-Cleaning - After the initial flush, the piping mains shall then be pre-cleaned for a minimum of eight hours with the pumps running and before any branch piping or equipment has been connected with cleaning chemicals provided by the water treatment contractor. After the pre-cleaning, the strainers shall be opened, screens removed and the entire unit cleaned and re-installed.
  3. Cleaning - After equipment and branch piping has been installed, the entire piping systems shall then be cleaned out for a minimum of eight hours with the pumps running, all 3-way valves open to equipment coils and all valves open in the systems to allow complete circulation of cleaning chemicals. The water treatment contractor shall provide the cleaning chemicals required to perform this cleaning. After piping system cleaning, all strainers shall be opened, screens removed and the entire unit cleaned and re-installed.
  4. Flushing - After the piping systems cleaning, the systems shall then be re-filled with water and circulated for a minimum of two hours, followed by draining the entire systems. The hot water system shall be brought up to operating temperature for this procedure. After systems draining, the air control tank strainer shall be removed and cleaned.
  5. pH Balance and Treatment - After the two hour flush but before the water balance, the piping systems shall be flushed until the total alkalinity of the rinse water is equal to that of the make-up water. Once this has been completed, the systems shall be refilled with clean water and shall be treated per Section 15705. The treatment shall be performed by the water treatment contractor.
- B. The piping systems cleaning and flushing shall be witnessed and verified by the owners representative. The contractor shall verify in writing that the cleaning and flushing of the piping systems has been performed and shall have the signature of the owner's representative.
- C. The mechanical contractor shall provide the water treatment contractor the capacities of the systems so that proper dosages of products will be used.

- D. Valves for flushing piping mains shall be located at the low points in the mains. Mains shall be flushed before any branch piping or equipment is connected. Renewal projects, which must have piping mains installed in phases, shall have separate valves installed for each phase.

3.03 GROOVED PIPING

- A. Pipe Ends shall be clean and free from indentations, projections and roll marks in the area from the pipe end to groove for proper gasket sealing.
- B. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service.
- C. The use of bolted branch outlets is not permitted.
- D. Outlets for wells and gauges etc. shall be made using welded "thread-o-lets".
- E. All grooved components shall be of one manufacturer.
- F. Grooved connections shall not be installed in inaccessible concealed locations.
- G. Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions.

END OF SECTION

## SECTION 15703

### HOT WATER, HEAT PUMP LOOP SUPPLY AND RETURN PIPING SYSTEM AND SPECIALTIES

#### PART 1 – GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, section 15010 - General Provisions, and section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include the following:

- A. Complete hot water piping systems.
- B. Complete hydronic heat pump loop water piping systems.

##### 1.03 QUALITY ASSURANCE

The piping system shall be tested for leaks before the insulation is applied and before the piping system is covered up. The test shall be at least 100 psi of water pressure for a duration of 12 hours.

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

All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in section 15010, 1.04. Shop drawings shall include proposed uses of all items.

#### PART 2 - PRODUCTS

##### 2.01 PIPING AND FITTINGS

- A. Heat Pump Loop Supply and Return - Shall be schedule 40 black steel pipe with 125 psi cast iron screwed fittings or 150 psi steel weld fittings.
  - 1. Type "L" copper tubing with copper fittings is acceptable for piping 2" and under.

- B. Hot Water Supply and Return - Shall be schedule 40 black steel pipe with 125 psi cast iron screwed fittings or 150 psi steel weld fittings.
1. Type "L" copper tubing with copper fittings is acceptable for piping 2" and under.
- C. Cooling Tower Water Supply and Return – Shall be scheduled 40 black steel pipe with 125 psi cast iron screwed fittings or 150 psi steel weld fittings inside of the building and schedule 80 PVC plastic pipe and fittings for outdoors.
- D. Cold water make up - Shall be type 'L' copper tubing with copper fittings.
- E. Grooved mechanical pipe couplings, fittings, valves and other grooved components may be used as an option to welding, threading or flanged methods. All grooved components shall be of one manufacturer and conform to local code approval. Grooved end product manufacturer to be ISO-9001 certified. Grooved couplings shall meet the requirements of ASTM F-1476. Grooved components shall be manufactured by VICTAULIC. Grooved components manufactured by GRINNELL or ANVIL INT. are acceptable providing all aspects of the specification are met. No substitutions.
1. Carbon steel piping shall be roll grooved in accordance with manufacturer's current listed standard.
  2. Mechanical couplings for grooved piping shall be cast of ductile iron conforming to ASTM A-395, grade 65-45-15, and ASTM A-536, grade 65-45-12. Couplings shall be rigid style and be of the angle patterned bolt pad type, and shall provide system support and hanging requirements in accordance with ANSI 831.1, ANSI B31.4 and NFPA 13. Coupling bolts and nuts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to physical properties of ASTM A-183. Mechanical couplings shall be coated with an alkyd enamel finish.
  3. Gaskets for grooved pipe and fittings shall be grade "E" EPDM compound conforming to ASTM D-2000 designation 2CA615A25B24F17Z.
  4. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, with Victaulic Style 107H/107N (Quick-Vic), Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM designed for operating temperatures from -30 deg F to +250 deg F.
  5. Grooved fittings shall be cast of ductile iron conforming to ASTM A-395, grade 65-45-15, and ASTM A-536, grade 65-45-12, wrought steel to ASTM A234, Grade WPB; or factory-fabricated from ASTM A53 steel pipe.

Grooved fittings shall be coated with an alkyd enamel finish. Grooved fittings shall be full flow.

- F. Condensate drain piping - Shall be type 'L' copper tubing and fittings.
- G. Runouts to terminal units with copper pipe connections - Type 'L' hard drawn copper tubing shall be used for runouts where required. A brass coupling shall be used between the steel pipe and copper tubing connection.
- H. Hot water supply and return under slab - Each piece of equipment shall have separate runouts and shall be type 'K' continuous copper pipe with no joints allowed below slab. All joints above slab shall be made with copper brazing rods. The entire underground pipe system shall be inside a minimum 6" round schedule 40 plastic pipe sleeve. Pipe shall be insulated; see section 15250.
- I. The use of running or close nipples is prohibited.

## 2.02 VALVES

Valves shall be manufactured by VICTAULIC, STOCKHAM, JENKINS, HAMMOND, JOMAR, MILWAUKEE, FAIRBANKS, CRANE, CONBRACO INDUSTRIES, INC., APOLLO VALVES, LUNKENHEIMER, WALWORTH, NIBCO, JAMESBURY, or ROCKWELL unless otherwise shall be rated for the medium served.

- A. Gate valves 2-1/2" and smaller - Shall be cast bronze body, sweat type or screwed ends and solid wedge disc with rising stem, STOCKHAM #B108.
- B. Gate valves larger than 2-1/2" - Shall be iron body flanged ends and solid wedge disc with rising stem (OS & Y type), STOCKHAM #G623.
- C. Globe valves 2-11/2" and smaller - Shall be cast bronze body, sweat type or screwed ends and replaceable composition disc, STOCKHAM #B24T.
- D. Check valves 2-1/2" or smaller - Shall be cast bronze body swing check with either screwed ends or sweat type and with regrinding disc, STOCKHAM #B319 or B309.
- E. Check valves larger than 2-1/2" - Shall be flanged iron body with bronze disc and ring, STOCKHAM #G931.
- F. Non-Slam check valves - Shall be used for all vertical applications and on pump discharge piping and shall be flanged iron body with bronze disc, wafer check, NIBCO #F910 for 2W and larger or W910 for 2" and smaller.
- G. Butterfly valves - 2" and larger may be used in lieu of gate or globe valves except at boiler supply and return pipe. These valves shall be rated at not less than 150 psi WOG Class and be suitable for use with 180°F water. Shall be lug type for pipe

removal on either side of valve, shall have stainless steel shafts and shall have 4" extended stem lengths for all size valves. STOCKHAM #LD611.

- H. Ball valves - 2" and smaller may be used in lieu of gate or globe valves. These valves shall be bronze, rated at not less than 150 psi WOG Class, full port, solid chrome plated ball design and stem, blow out proof stem. Be suitable for use with 180-degree water and provided with extended insulated handles. STOCKHAM #5216. Extended insulated handles shall be APOLLO VALVES "Therma-Seal" or NIBCO "Nib-seal".
- I. Balancing valves - Valves manufactured by FLOWSET, GRISWOLD, GERAND, DANFOSS, BARCO, PRESO, FLO-PAC, or NUTECH with memory stop, positive shutoff, extended insulated handle and PIT type ports for balancing. Flowset model AS size "A" to 2" flow 0.25 GPM to 100 GPM. For all units with runouts 2" and smaller.
- J. Constant volume flow valves – VICTAULIC, GRISWOLD, AUTOFLOW, or FLOWSET, automatic pressure-connecting spring and cartridge type valves with quick disconnect pressure taps. For all units with pipe size 2-1/2" and larger with GPM capacity shown.
- K. Valve operating chains - Valves installed six feet or more above finished floor in boiler rooms or mechanical rooms shall be chain operated. Provide chain and chain wheel with chain guide of size required, as manufactured by STOCKHAM.
- L. Balance valve for pump - Eccentric, combination shut-off and balancing with memory stop valve as manufactured by DEZURIK or ROCKWELL.
- M. Provide metering device in boiler room or in pump room for measuring pump flow rates, for systems piping a minimum of 20 feet (measured along pipe length) from pump discharge or just before pipe exits room, whichever is greater. Provide extended metering taps on metering devices. Flow metering devices and elements shall be as manufactured by FLOWSET, PRESO, GERAND, GRISWOLD, or BARCO.
- N. Valves for flushing piping mains - Provide 1 1/2" full port ball valves on the supply and return mains of each piping system for the purpose of flushing debris and other foreign matter out of piping. Valves shall be rated at not less than 150 PSI WOG, shall be suitable for 180°F water and provided with extended insulated handle. Provide adapter for valve to accept a fire hose and provide a removable cap. STOCKHAM #S207.

## 2.03 SPECIALTIES

- A. Pipe Hangers and Supports - See section 15050.

- B. Unions - Shall be provided for the assembly, dismantling or service to any portion of the piping system.
  - 1. Unions 2" and Smaller - Shall be malleable iron ground joint unions with brass to iron seals. Stockham Fig. #694.
  - 2. Unions 2-1/2" and Larger - Shall be of the companion flange type with ring type gasket painted with graphite before installation. Stockham Fig. #799.
  - 3. Brass Couplings - Shall be used for connecting steel pipe to copper tubing.
- C. Thermometers - Shall be provided and installed in the supply and return piping of the system. Thermometers mounted at heights other than 5 feet from the floor shall be the adjustable angle type and located so they may be read from the floor. The body of the thermometer shall be brass or die-cast aluminum and at least 9" long. The thermometer shall be blue organic filled type with an appropriate scale for the medium being measured. The thermometer shall be mounted in the pipe in a separate well. Manufacturer - TRERICE BX 91406 or equivalent by WEKSLER, TAYLOR, or WEISS.
- D. Pressure Gauges - Shall be installed in the piping system at the pumps, Connect the gauge to the piping system with 1/4" iron pipe. Provide 1/4" rough brass cock between the gauge and piping system. The pressure gauge shall be of the liquid filled, bourdon-tube type with at least a 4" diameter dial with an appropriate scale. The gauge shall be the dust, corrosion and moisture resistance type with a cast aluminum case. Manufacturers ASHCROFT, WEKSLER, TAYLOR, or TRERICE.
- E. Expansion Tank - Shall be ASME labeled and the size listed on the drawings. Provide the tank with the required tappings and a prime coat of paint. The expansion tank shall be BELL & GOSSETT, TACO, JOHN WOOD, WESSELS, or ARMSTRONG.
- F. Tank Fitting - Shall match the tank to maintain the proper amount of air. The tank fitting shall be BELL & GOSSETT or TACO.
- G. Air Separator: Shall be ASME labeled and the same size as connecting pipe. Provide separator with strainer. The air separator shall be BELL & GOSSETT, TACO, THRUSH, AMTROL, JOHN WOOD, or ARMSTRONG.
- H. Pressure Reducing Valve - Shall be set at 12 psi unless otherwise noted on drawings and shall be the size of the cold water make up piping. The pressure-reducing valve shall be CONBRACO INDUSTRIES INC., APOLLO VALVES, WATTS, BELL & GOSSETT, or TACO.
- I. Flexible Connection - Flexible pipe connection shall be installed on all pipes connecting to equipment where indicated on the drawings. The isolated equipment shall be provided with flexible connections for all piping connections immediately

adjacent to the equipment. The hose shall be flexible, braid-reinforced, seamless metal hose within the pressure and temperature range applicable. Hose lengths shall be a minimum of ten inches and as recommended by the manufacturer, whichever is greater. Short style will not be acceptable. Provide control rods for stabilization. Flexible connections shall be as manufactured by METRAFLEX, KEFLEX, SSI, or METRASPHERE.

- J. Air Vents - Provide at high points of systems, on trapped sections of piping with automatic air vents or other locations as required for air removal from the system. Manual air vents shall be used on piping above ceilings in all finished spaces. Each air vent shall be accessible. Provide Hoffman No. 77 manual air vents for unit heaters, fan coil units, unit ventilators, piping mains above ceilings, etc. Provide Hoffman No. 79 automatic air vents for all exposed piping mains, air handling units, etc. Air vents as manufactured by SPIROTHERM shall also be acceptable.
  
- K. Strainers - Shall be VICTAULIC, CONBRACO INDUSTRIES, INC., APOLLO VALVES, ARMSTRONG, TACO, or SARCO. iron or brass body 'Y' pattern sediment strainers shall be installed. These strainers shall be provided with stainless steel or non-ferrous straining elements with heads for removal of the elements.
  - 1. Iron body 'Y' pattern sediment strainers shall be installed with steel pipe.
  - 2. Brass body Y pattern sediment strainers shall be installed with copper or brass pipe.
  - 3. Area of strainer openings shall not be less than four (4) times the pipe area. All strainers shall have blow-off valves with hose ends.
  - 4. Strainer elements shall be No. 10 (ten) mesh screen or perforated stainless steel.
  - 5. Each strainer body shall be cast with the manufacturer's name, an arrow indicating the direction of flow, strainer size and pressure classification.
  - 6. Each strainer shall be of the operating pressure, temperature and service rating of the respective systems.
  
- L. Check valves (condensate drains): See Section 15420.
  
- M. Condensate Overflow Protection - Provide float control safety switches in condensate drain pans (or secondary drain pans), for all equipment with cooling coils. Switches shall be as manufactured by BECKETT or LITTLE GIANT. Equipment located outside of plenum spaces may use safety switches as manufactured by EZ-TRAP (1-877-439-8727), where the switch is integral to a PVC trap.



- N. Low point drains shall be provided for sections of trapped piping. Low point drains shall be a  $\frac{3}{4}$ " ball valve with a hose end connection and cap.

#### 2.04 WATER PIPING ELECTRICAL HEAT TRACING:

- A. Provide and install for all exterior piping RAYCHEM Corporation, XL-Trace, U/L Listed, braided self regulating heating cable with inherent temperature control and a 5 foot cold lead inside the building. Electrical characteristics 208/1/60. All piping shall have Model 5XL-CR heat tracing. Nominal watts per foot rating at 40 degree pipe temperature is 5.9 for Model 5XL-CR. Provide Models XLK-PC and XLK-SET components for power connection, tees, end seals kits and splices and GT-66 glass cloth adhesive tape. Heat tracing cable equal to the item specified as manufactured by THERMON shall be acceptable.
- B. Cooling Tower heat tracing shall include supply and return piping, makeup water piping, water treatment piping, drain and overflow piping, electronic water level piping, spray pump suction piping, spray pump body (excluding motor), and spray pump discharge piping.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. The piping systems shall be installed as described in section 15050 - Basic Materials and Methods.
- B. Heat tracing cable shall be installed linearly along the piping, not spiraled. Secure heat tracing to piping using glass cloth adhesive tape. Provide manufacturer's recommended pattern coverage for valves, flanges and pipe supports. Heat tracing shall be installed on all exterior piping to five feet inside the building beyond the pipe sleeve. Heat tracing shall be tested, after installation, per manufacturer's recommendations. Heat traced piping shall have manufacturer's warning labels installed stating that the piping is electrically heat traced. This contractor shall install heat trace in such a manner that the termination points are coordinated with the electrical drawings.
- C. Float control safety switches shall be interlocked with the fan to turn off the unit when a high water level is detected.

#### 3.02 PIPING SYSTEM CLEANING

- A. The piping systems shall be cleaned and flushed with chemicals in accordance with the following sequences:
  - 1. Initial Flush - The initial flush shall be performed on the piping mains, with pumps running and before any branch piping or equipment has been

- connected. This initial flush is to remove debris and other foreign objects out of the piping systems. Flush systems until all matter has been removed from piping. After this flushing, the strainers shall be opened, screens removed and the entire unit cleaned and re-installed.
2. Pre-Cleaning - After the initial flush, the piping mains shall then be pre-cleaned for a minimum of eight hours with the pumps running and before any branch piping or equipment has been connected with cleaning chemicals provided by the water treatment contractor. After the pre-cleaning, the strainers shall be opened, screens removed and the entire unit cleaned and re-installed.
  3. Cleaning - After equipment and branch piping has been installed, the entire piping systems shall then be cleaned out for a minimum of eight hours with the pumps running, all 3-way valves open to equipment coils and all valves open in the systems to allow complete circulation of cleaning chemicals. The water treatment contractor shall provide the cleaning chemicals required to perform this cleaning. After piping system cleaning, all strainers shall be opened, screens removed and the entire unit cleaned and re-installed.
  4. Flushing - After the piping systems cleaning, the systems shall then be refilled with water and circulated for a minimum of two hours, followed by draining the entire systems. The hot water system shall be brought up to operating temperature for this procedure. After systems draining, the air control tank strainer shall be removed and cleaned.
  5. pH Balance and Treatment - After the two hour flush but before the water balance, the piping systems shall be flushed until the total alkalinity of the rinse water is equal to that of the make-up water. Once this has been completed, the systems shall be refilled with clean water and shall be treated per Section 15705. The treatment shall be performed by the water treatment contractor.
- B. The piping systems cleaning and flushing shall be witnessed and verified by the Owner's representative. The contractor shall verify in writing that the cleaning and flushing of the piping systems has been performed and shall have the signature of the Owner's representative.
  - C. The mechanical contractor shall provide the water treatment contractor the capacities of the systems so that proper dosages of products will be used.
  - D. Valves for flushing piping mains shall be located at the low points in the mains. Mains shall be flushed before any branch piping or equipment is connected. Renewal projects which must have piping mains installed in phases shall have separate valves installed for each phase.

3.03 GROOVED PIPING

- A. Pipe ends shall be clean and free from indentations, projections and roll marks in the area from the pipe end to groove for proper gasket sealing.
- B. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service.
- C. The use of bolted branch outlets is not permitted.
- D. Outlets for wells and gauges etc. shall be made using welded "thread-o-lets".
- E. All grooved components shall be of one manufacturer.
- F. Grooved connections shall not be installed in inaccessible concealed locations.
- G. Grooved joints shall be installed in accordance with the manufacturer's latest published installation instructions.

END OF SECTION

## **SECTION 15705**

### **WATER TREATMENT**

#### **PART 1 - GENERAL**

##### **1.01 GENERAL**

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### **1.02 SCOPE**

The work covered under this section shall include the furnishing of all labor, piping, valves, gauges, control panels, water meter wiring, chemicals and all other equipment required for a complete water treatment service as indicated on the drawings or herein specified.

##### **1.03 QUALITY ASSURANCE**

The water treatment chemical equipment and service supplier shall be a recognized specialist, active in the field of industrial water treatment for the last ten years, whose major business is in the field of water treatment and shall have regional water analysis laboratories, development facilities and service department, plus full time service personnel located within the trading area of the job site.

##### **1.04 SUBMITTALS**

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### **PART 2 - PRODUCTS**

##### **2.01 WATER TREATMENT SYSTEM**

Provide, install and service a water treatment system for the water systems. The water treatment system shall be as manufactured by MOGUL CORPORATION. Other manufacturers fully equal to the specified manufacturer as manufactured by HYDAC, MORR, ARC, or AQUATOMIC are acceptable.

- A. Piping, valves, and accessories shall be furnished and installed as required by the water treatment manufacturer.
- B. Provide all chemicals required at system start-up and throughout the service period. Chemical formulations shall not exceed the allowable EPA or local effluent limits.

- C. The water treatment chemical and service supplier shall furnish basic water test equipment including carrying case and reagents for use with suppliers' products. This shall include apparatus for determination of pH, P and M alkalinity, treatment residual, and conductivity. Where specialized or supplementary equipment is required, it shall be furnished as part of the contract.
- D. Condenser System Feeding and Control Equipment - Contractor shall install the following apparatus including all external piping and wiring for each condenser water system.
  - 1. One MOGUL AUTO CHEM Model 16712 as manufactured by the MOGUL CORPORATION, for controlling Total Dissolved Solids (TDS), biological growth, inhibitor feed and chemical treatment in the cooling water system. Controller shall be U.L. Listed. Control panel shall be a single, NEMA 1 steel enclosure, primed and fully painted, and shall have the following basic features, fully pre-wired:
    - a. Internal wiring harnessed, color-coded, clearly identified, and brought to master terminal board.
    - b. Grounded AC receptacles for chemical treatment pump and utility use.
    - c. Main power switch and indicating lamps, with legend plate, for power, bleed control, biocide pump, inhibitor pump and system flow.
    - d. Line voltage safety switch - Interlock with door to shut off line voltage to control when adjustment or maintenance is required.
    - e. Manual-Off-Auto selector switches and indicating lamps for bleed off control, chemical feed and acid feed, with legend plates.
    - f. Manual-Off-Auto selector switch for inhibitor feed and a push button to simulate a water meter pulse in the makeup water supply line for test purposes.
    - g. A selector switch for control of chemical feed from metered makeup.
    - h. Conductivity controller accurate to 5% full scale with an analog-indicating meter.
    - i. Front panel fuses.

- j. Dual biocide feed program modules to automatically alternate between two biocides with a seven-day timer.
  - k. A temperature compensated conductivity electrode and flow switch mounted on the side of the controller enclosure.
  - l. Bleed lock-out timer to prevent bleed function after a biocide feed. Power and bleedoff status shall be displayed by indicating lights on the front panel. The controller shall be insensitive to phase angle shifts and be capable of operating with input line voltage of 95 to 130 volts AC without affecting accuracy. Conductivity level shall be recorded on an indicating meter. The chemical feed shall be controlled by a reset timer actuated by a make-up water meter with electric contractor. The chemical feed control module shall have a pump status indicating lamp, a Manual-Off-Auto switch and a 20 amp pump relay.
- 2. The chemical feed pumps shall be mounted in a NEMA 1 steel enclosure, primed and fully painted. They shall be pre-plumbed, pre-wired and include the following:
    - a. Sample stream piping assembly, including a conductivity flatee, sample cock, check valve and three chemical injection tees.
    - b. One Inhibitor feed pump, two biocide feed pumps of the positive displacement type, with ball type check valves, 120/1/60 fractional hp motor drive, discharge pressure relief valve, foot valve, suction tubing and discharge tubing. The feed rate shall be adjustable while the pump is running and the chemicals shall be pumped directly from the shipping container. Pump shall be U.L. Listed and shall be manufactured by PULSA FEEDER, LMI or CHEM-TECH.
  - 3. One sample stream injection assembly.
  - 4. One water meter, complete with electric contacting registers sized to meter the peak make-up rates.
  - 5. One bleedoff solenoid and throttling valve, sized for bleed off requirements of the system.
  - 6. One 50-gallon inhibitor tank and two 30-gallon biocide tanks. Tanks shall be polyethylene and shall include lids. Pump suction will be through the lid. Fittings in tanks are not allowed.
- E. Hot and Chilled Water Systems - Contractor shall install a One Shot Feeder for each system, minimum four quart capacity, designed to meet pressure requirements of the specific system.

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

The water treatment system shall be installed as recommended by the manufacturer.

**A. Pre-Cleaning and Cleaning**

1. Provide the chemicals used for the pre-cleaning and cleaning sequences listed in Section 15701. Chemicals shall be capable of removing deposits from construction, such as pipe dope, oils, most loose mill scale, and other extraneous materials. The products used shall inhibit corrosion of the various metals in the piping systems and shall be safe to handle and use. Effectiveness of the product shall be such that the water need only be at ambient temperatures. Add recommended dosages of products for corresponding system capacities.

**B. pH Balance and Treatment**

1. Piping systems shall be drained and flushed until the total alkalinity of the rinse water is equal to the makeup water, as described in Section 15701. Refill with clean water, which shall be properly treated to prevent scale and corrosion during operation of the water systems (See paragraph 3.01.C). This contractor shall assist in performing the pH balance of the systems.

**C. Maintain the following conditions in each system:**

1. Chilled
  - a. pH 7.0 to 9.0
  - b. Buffered Nitrite 500 PPM
2. Hot
  - a. pH 7.0 to 9.0
  - b. Buffered Nitrite 1000 PPM to 180 Deg. F  
2000 PPM above 180 Deg. F
3. Condenser
  - a. pH 7.0 to 8.0
  - b. Organic Inhibitor 15 to 25 PPM
  - c. Cycles 7 Maximum
  - d. Organic Growths None

3.02 SYSTEM SERVICE

- A. The water treatment service shall start after the initial cleaning, flushing, start-up and check out of the water systems and shall continue for a period of one year after the substantial completion date of the entire project.
- B. Prior to the substantial completion date and during the one year service period after this date, the water treatment contractor shall visit the site and thoroughly inspect the systems for proper operation, make necessary adjustments, test water and chemical conditions, and complete a written report on conditions. Service frequency shall be as a minimum as follows:
  - 1. Chiller/cooling tower condensers - every two weeks
  - 2. Closed loop hot and chilled water - once per month
- C. Prior to the substantial completion date and during the one year service period after this date, the water treatment contractor shall test water samples from cooling tower water for legionella pneumophila. Tests shall be made monthly when the cooling tower operates. The report shall give the result in bacteria per millimeter and include the result from the previous month.
- D. The water treatment contractor shall maintain complete records of the treatment program for each system and submit to the Owner three copies of each report distributed to:
  - 1. System Site
  - 2. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Falls Church VA 22042.
  - 3. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax Virginia 22032
- E. The initial fill of water treatment chemicals and water treatment service shall be witnessed and verified by the Owners representative. A signed service card must be obtained by the technician after each visit for service.

END OF SECTION



## SECTION 15725

### BASE MOUNTED PUMPS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

Provide and install the base mounted pumps as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

- A. Pumps must be selected from published test curves showing actual brake horsepower. The selection point shall be confined to the left of the center of the efficiency curve for the impeller being furnished.
- B. All pump motors shall meet NEMA Standards.
- C. All pumps shall be factory tested prior to shipment to the job site.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 BASE MOUNTED PUMPS

The base mounted pump shall be of the centrifugal base mounted type and of the size, capacity and voltage shown on the drawings. The pump shall be series 1510 as manufactured by BELL & GOSSETT. Pumps fully equal to the specified pump and manufactured by ARMSTRONG, PATTERSON or WEINMANN are acceptable.

- A. Pump - Shall be of the vertical split case design for servicing without disturbing piping connections or motor. Motor to pump connections shall be of the flexible spacer spring coupler type, to dampen noise transmission and protect pump and motor from stress and strain of high starting torque. The pump shall use a mechanical rotating type carbon seal and shall face against a ceramic insert. The pump shall have a seal flush line of copper and shall be equipped with

regreasable ball bearings. Extend grease fitting with permanently attached tube to extend through insulation. Provide variable speed drive coupler for variable speed drive pumps.

- B. Motor - Shall be drip-proof, 1750 rpm, and shall be especially selected for quiet operation, and shall be so stamped. The electrical characteristics of the motor shall be as shown on the drawings. The horsepower of the motor shall be of such a size as to insure non-overloading of the motor throughout the capacity range of the pump. The motor shall have sealed bearings.
- C. Base - Shall be of the size suitable for the pump, motor and shaft, and shall be constructed of cast iron or welded steel.
- D. Starters - Magnetic line voltage starter with HAND-OFF-AUTOMATIC switch and red running light. See section 15050, 2.07.

## 2.02 SUCTION DIFFUSER

- A. Provide suction diffuser at each pump. Units shall consist of an angle type body with inlet vanes and combination diffuser - strainer - orifice cylinder with 3/16" diameter openings for pump protection. A permanent magnet shall be located within the flow stream and shall be removable for cleaning. The orifice cylinder shall be equipped with a disposable fine mesh strainer that shall be removed after start-up. Orifice cylinder shall be designed to withstand a pressure differential equal to pump shutoff head and shall have a free area equal to five times the cross section area of the pump to suction opening. Vane length shall be not less than 2 1/2 times the pump connection diameter. Unit shall be provided with adjustable support foot to carry weight of suction piping. Manufacturer shall be Bell & Gossett. Suction diffusers manufactured by Patterson are acceptable provided they are fully equal to the suction diffuser specified.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The pumps shall be installed and serviced in accordance with the manufacturer's recommendations and as shown on the drawings.
- B. A concrete base a minimum of four (4) inches higher than the surrounding floor shall be provided. Foundation bolts in pipe sleeves shall be set in the base to allow movement for final positioning of the bolts. The pump base shall be set dead level by means of properly spaced metal blocks or wedges. After pump is

leveled, align pump and motor shaft and then pour grout between concrete base and pump base.

- C. Pump base shall be isolated as shown on the drawings.
- D. Coupling guards shall be installed per ANSI and OSHA standards.
- E. Pumps mounted in areas other than slab on grade shall be mounted on inertia bases with vibration isolators.

END OF SECTION

## **SECTION 15726**

### **INLINE PUMPS**

#### **PART 1 - GENERAL**

##### **1.01 GENERAL**

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### **1.02 SCOPE**

Provide and install the inline pump as shown on the drawings and specified herein.

##### **1.03 QUALITY ASSURANCE**

- A. Pump must be selected from published test curves showing actual brake horsepower. The selection point shall be confined to the left of center of the efficiency curve for the impeller being furnished.
- B. All pump motors shall meet NEMA Standards and shall be UL listed.
- C. All pumps shall be factory tested prior to shipment to the job site.

##### **1.04 SUBMITTALS**

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### **PART 2 - PRODUCTS**

##### **2.01 INLINE PUMP**

The inline pump shall be of the centrifugal inline mounted type and of the size, capacity and voltage shown on the drawings. The pump shall be booster series as manufactured by BELL & GOSSETT. Pumps fully equal to the specified pumps and manufactured by ARMSTRONG, WEINMANN, or PATTERSON are acceptable.

- A. Pump - Shall be quiet operating, horizontal, oil lubricated, inline, single stage, vertical split case design, in cast iron bronze fitted construction for heating or cooling applications and shall be all bronze construction for domestic water applications. The pump internals shall be capable of being serviced without disturbing piping connections. The pump shall have a dynamically balanced impeller keyed and locknuttetted to a ground and polished steel shaft with hardened integral thrust collar. Shaft shall be supported by oil lubricated bronze sleeve bearings. Watertight mechanical seal faces shall be carbon on cast iron or ceramic.

- B. Coupling - Shall be self-aligning, flexible type connecting the pump and motor.
- C. Motor - Shall be open drip proof, journal bearing, resilient mounted, 1750 rpm, and shall be especially selected for quiet operation. The electrical characteristics of the motor shall be as shown on the drawings. The horsepower of the motor shall be of such a size as to insure non-overloading of the motor throughout the capacity range of the pump. The motor shall have sealed bearings.
- D. Testing - The pump shall be factory tested, thoroughly cleaned, and painted with one (1) coat of machinery enamel prior to shipment. A set of installation instructions shall be included with the pump at the time of shipment.
- E. Starter - Provide a manual starter for single-phase units and magnetic across-the-line starter for three phase units. The starter shall have HAND-OFF-AUTOMATIC switch and red running light. See Section 15050 paragraph 2.07.

## 2.02 SPECIALTIES

- A. Specialties shall be provided for all inline pumps, which shall include, but not be limited to, isolation valves, unions, strainers, thermometers and check valves.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The pumps shall be installed and serviced in accordance with the manufacturer's recommendations and as shown on the drawings.
- B. Coupling guards shall be installed per ANSI and OSHA standards.

END OF SECTION

## SECTION 15727

### PLATE TYPE HEAT EXCHANGER

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install the plate type heat exchanger as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

The plate type heat exchanger shall be manufactured to meet ASME codes and shall be hydrostatically tested at the factory at pressures higher than the unit will be subjected to in the field.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04.

#### PART 2 - PRODUCTS

##### 2.01 PLATE TYPE HEAT EXCHANGER

The plate type heat exchanger shall be completely factory assembled and shall be of the type and capacity as shown on the drawings. The heat exchanger shall be manufactured by TRANTER. Units fully equal to the specified unit and manufactured by ALFA LAVAL, BELL & GOSSETT or MUELLER are acceptable.

- A. Construction - Frame shall be carbon steel with baked epoxy enamel paint. Guide bars shall be hard chrome plated carbon steel. Tie bolts shall be zinc-plated carbon steel.
- B. Plates - Shall be constructed with electro polished 304 stainless steel. All plates shall have identical patterns. Provide 10% additional heat transfer surface area to allow for fouling. Gasketing material shall be nitrile rubber with plate separation fixed by contact points, not by gaskets.
- C. Pipe Connections - Shall be 316 stainless steel flanged and sized for a maximum

for 20 fps water velocity. Connections on the stationary frame are straight nozzles and, when required, 90° elbow nozzles on the follower frame.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The plate type heat exchanger shall be installed as recommended by the manufacturer and set above the mechanical room floor on a 4" high concrete pad.
- B. Provide isolation valves on inlet and outlet piping for service purposes. Provide thermometers and gauges. Thermometers and gauges shall be located on the heat exchanger side of the service valves.

END OF SECTION

## SECTION 15728

### SHELL AND TUBE HEAT EXCHANGER

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, section 15010 - General Provisions, and section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install the shell and tube heat exchanger as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

The shell and tube heat exchanger shall be manufactured to meet ASME codes and shall be hydrostatically tested at the factory at pressures higher than the unit will be subjected to in the field. The ASME "U" symbol shall be stamped on the heat exchanger. Each unit shall be registered as required with the National Board of Boiler and Pressure Vessel Inspectors.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in section 15010, 1.04.

#### PART 2 - PRODUCTS

##### 2.01 SHELL AND TUBE HEAT EXCHANGER

The shell and tube heat exchanger shall be completely factory assembled and shall be of the type and capacity as shown on the drawings. The heat exchanger shall be manufactured by BELL & GOSSETT. Units fully equal to the specified unit and manufactured by ARMSTRONG or TACO are acceptable.

###### A. Materials

1. Shell - steel.
2. Tubes - copper.
3. Tube sheets - steel.
4. Tube supports - steel.



5. Heads - cast iron or steel.

**PART 3 - EXECUTION**

**3.01 INSTALLATION**

The heat exchanger shall be installed as recommended by the manufacturer and as detailed on the drawings.

END OF SECTION

## SECTION 15740

### WATER SOURCE HEAT PUMPS

#### PART 1 - GENERAL

##### 1.01 REQUIREMENTS

- A. The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

- A. The work covered under this Section shall include providing and installing complete heat pump unit as shown on the Drawings and herein specified.

##### 1.03 QUALITY ASSURANCE

- A. The heat pump unit shall have ARI certified ratings and shall be labeled as acceptable by an approved safety testing or inspection agency such as Underwriters Laboratories.
- B. The motor shall be manufactured under NEMA standards.
- C. The coils shall have ARI certified ratings.
- D. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

- A. Provide submittals on this equipment in accordance with Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

##### 1.05 EXTRA MATERIAL

- A. Contractor to provide extra heat pump to be turned over to the owner at close of project. (ENGINEER TO EDIT WHICH UNIT/S WILL BE PROVIDED)

#### PART 2 - PRODUCTS

##### 2.01 ACCEPTABLE MANUFACTURERS (No Substitutions)

- A. TRANE

- B. DAIKIN
- C. CARRIER
  
- D. FLORIDA HEAT PUMP

## 2.02 HEAT PUMP UNIT

- A. Provide indoor fan draw-thru type heat pump unit of unitary design. Provide and install the heat pump unit complete with the type, arrangement, capacities and accessories as shown on the drawings and specified herein. Units shall be designed to operate throughout the range of entering fluid temperature of 25 °F to 110 °F (Extended Range).
  - 1. Casing for Indoor Units - The housing shall be constructed of heavy sheet mill galvanized steel adequately reinforced with structural members and provided with sufficient access panels for proper lubrication and maintenance. Unit shall be of the arrangement shown on the drawings. Unit shall include plastic drain pan, positively sloped, with access for cleaning, and drain connections on both sides. Removable panels in fan and coil sections shall provide access to all internal parts. All unit panels shall be insulated. Unit casing may be chemically cleaned, spray painted, baked and coated with an additional exterior coat of enamel after final assembly in lieu of mill galvanizing.
  - 2. Blower Motor - The supply air motor shall be a multi-speed motor with internal thermal overload protection. Motor bearings shall be permanently lubricated and sealed. Motors shall be factory wired to the option selected. Provide a speed tap for field customizing high, medium or low speed.
  - 3. Motor and Drive - Provide belt or direct drive multi-speed motors. Motor nameplate horsepower shall exceed brake horsepower by a minimum of 5% with airfoil or BI fans and 20% with forward curved fans. Provide motor especially designed for quiet operation.
  - 4. Co-axial Water to Refrigerant Coil - Shall be copper seamless tubing, steel outer refrigerant gas tube, leak tested to assure there is no cross leakage between the water tube and the refrigerant gas (steel tube) coil. The completely drainable coil shall be tested under water at 250 psig. Provide one piece insulated drain pan.
  - 5. Sound Attenuation Package - Shall consist of:
    - a. 16 Gauge compressor enclosure
    - b. 16 Gauge single wall front panel
    - c. Lined compressor enclosure with ½ inch cabinet insulation

- d. Compressor discharge muffler
  - e. 12 Gauge compressor/water-to-refrigerant heat exchanger pan with second stage of vibration isolation
  - f. Compressor vibration isolation
  - g. Water-to-refrigerant heat exchanger vibration isolation
  - h. Lengthwise unit base stiffeners
  - i. 3/32-inch Foam gasket sealant placed around the compressor and end panel perimeter
- 6. Filter Section - Filters shall not be integral to the unit. Units shall have duct mounted filter racks. Filters shall be 2" pleated MERV 13.
  - 7. Isolation - Provide factory installed internal spring isolators or field installed external housed type spring isolators for fans and compressors. Install external isolators in accordance with manufacturer's recommendations.
  - 8. Provide control interface including contactor for Automatic Temperature Control interface, and unit disconnect. Disconnect shall meet the requirements of National Electrical Code Article 430.
  - 9. Temperature Controls - Automatic temperature controls shall be furnished under Section 15900.
  - 10. Expansion Valve - Water source systems shall include an expansion valve flow metering device. The thermal expansion valve shall allow the unit to operate with an entering fluid temperature from 25 to 110F, and entering air temperatures from 40 to 90F. The valve shall be designed to meter refrigerant flow through the circuitry to achieve desired heating or cooling.
  - 11. Refrigerant Piping - Copper tubing shall be seamless and conform to American Society of Testing (ASTM) B743.
  - 12. Refrigeration Circuits - All units shall contain a sealed R-410A refrigerant circuit including a hermetic scroll compressor, bi-directional thermal expansion valve metering device, finned tube air-to-refrigerant heat exchanger, refrigerant reversing valve, coaxial tube-in-tube water to refrigerant heat exchanger, liquid line filter drier and service ports. Compressor shall be mounted on rubber vibration isolators. Compressor motors shall be equipped with overload protection. Refrigerant reversing valves shall be pilot operated sliding piston type with replaceable

encapsulated magnetic coils energized only during cooling cycle.

13. Unit Controls - Controls and safety devices will be factory wired and mounted within the unit. Controls shall include fan relay, compressor contactor, 24V transformer, reversing valve coil and solid state lock-out controller. The controller shall include the following features: diagnostic LED's, low pressure bypass time delay (to prevent nuisance low pressure lock-outs during operation with low fluid temperatures), anti short cycle time delay, random start time delay and one time intelligent reset.
14. Unit shall be equipped with a condensate overflow switch. Upon activation, the unit shall turn off the compressor.
15. Provide with each heat pump one flexible hose assembly kit. Kit shall have stainless steel hoses automatic control valve, Y-strainer with PT port, drain valves, and supply and return shut-off ball valves.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Install the heat pump units as shown on the drawings and as recommended by the manufacturer.
  1. The first unit installed will be considered the typical mock up and shall require notification, inspection and approval by the designated owner representative and/or architect and engineer before any additional installations will be allowed.
  2. The heat pump unit fan speed shall be adjusted in the field to deliver the amount of air as stated on the drawings by adjusting the motor speed.
  3. The filters shall be changed after the construction dust has been eliminated and before final inspection. Provide two sets of spare filters.
  4. Provide grease fittings extensions where necessary to have the grease fitting accessible.
  5. Provide one complete set of belts for each water source heat pump.
  6. Piping to each unit to include ball valves, balance valve, balance fitting and flexible hose for supply and return.
  7. Provide a typed list of all the different units, their filter sizes, and fan belt size to be included in the O & M manuals. The list shall include the unit designation, filter/belt size and the number of filters/belts required for

each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:

- a. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Rd, Suite 3500, Falls Church, Virginia, 22042.
- b. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032.

END OF SECTION

## **SECTION 15745**

### **ELECTRIC DUCT HEATERS**

#### **PART I - GENERAL**

##### **1.01 GENERAL**

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### **1.02 SCOPE**

Provide and install electric duct heater as shown on the drawings and as specified herein.

##### **1.03 QUALITY ASSURANCE**

- A. The electric duct heater shall have published ratings and be listed by Underwriters Laboratories.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### **1.04 SUBMITTALS**

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### **PART 2 - PRODUCTS**

##### **2.01 ELECTRIC DUCT HEATER**

The electric duct heater shall be of the type, capacity and voltage shown on the drawings. The duct heater shall be manufactured by INDEECO or MARKEL. Duct heaters fully equal to the specified manufacturer and manufactured by BRASCH or TPI are acceptable.

- A. Type – Shall be of the open type using wire constructed of 80% nickel and 20% chromium supported in ceramic bushings. The heating wire for each step shall be strung across the entire face of the coil to prevent stratification when operating at less than full capacity. Maximum watts density shall not exceed 35 watts per 1 sq. in. of wire surface.

- B. Trim – All terminals and nuts shall be constructed of stainless steel, and terminal insulators and bracket bushings shall be constructed of ceramic and securely positioned.
- C. Test – Heating coils shall be tested for twice the rated voltage plus 1000 volts, or 2000 volts whichever is greater. After the heater is built, the manufacturer's quality control inspection shall test the heater for the following: Ohm reading to verify capacity, voltage, phase, control voltage and tightness of terminals.
- D. Casing – shall be constructed of not less than 22 gauge galvanized steel with vertical galvanized steel supports 4" on center gusseted and spot welded. A solid cover shall be provided on the terminal box to minimize dust in the terminal box. The terminal box shall be recessed when installed in air handling units. Mounting provisions shall be flanged or slip-type as shown in the equipment schedule.
- E. Safety Features – Shall include an automatic reset thermal cutout wired in series with the control circuit and heat timers (fusible links) wired in series with the power legs. All of the safety devices shall be serviceable through the terminal box without removing the heater from the duct.
- F. Built-in Features – Shall include contactors, transformers, interlock relay, fusing to meet NEC requirements and lugs sized to receive specified conductors. All built-in components shall be factory wired and mounted on the heating coil in an integral terminal box. The unit shall be complete with terminal strip for electrical connections.
- G. The duct heater shall be controlled as shown on the drawings or in the Automatic Temperature Control Section.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The electric duct heater shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings.

END OF SECTION



## SECTION 15746

### ELECTRIC WALL HEATERS

#### PART I - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install complete with all accessories the electric wall heater as shown on the drawings and as specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The electric wall heater shall have published ratings and be listed by Underwriters Laboratories.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 ELECTRIC WALL HEATER

The electric wall heater shall be of the type and capacity shown on the drawings. The wall heater shall be manufactured by MARKEL. Wall heaters fully equal to the specified manufacturer and manufactured by BERKO or QMARK are acceptable.

- A. Unit Casing - Casing shall be constructed of heavy gauge steel, phosphatized for rust resistance and finished with baked enamel. All hardware used in the casing shall be plated for rust resistance. Cabinets shall be equipped with a removable front access to the interior.
- B. Front Cover - Shall be of the louver type, 16 gauge steel. Discharge grille shall direct the air downward to floor.

- C. Motors - Shall be permanently lubricated for constant operation. All motors shall be provided with built-in, automatic reset thermal overload protection. All motors shall be rated for voltage indicated.
- D. Heating Elements - Elements shall be constructed of high quality, nickel chrome resistance coils embedded in a refractory material and enclosed within a steel sheath. The sheath shall have spirally wound, extended fins for high heat transfer and reduced operating temperature. The elements shall be housed in a heavy gauge, steel enclosure
- E. Wiring - All wiring in the heating element circuit shall consist of high temperature, heat resistant wire, fully enclosed within metal boxes or conduit for complete mechanical/electrical protection.
- F. Standard Controls - Provide low voltage controls (24volt) by the manufacturer to interface with the division15900 ATC system. Wall heater shall be controlled as outlined in the Automatic Temperature Control section 15900. Each unit shall be provided with: An automatic reset, and a built-in fan delay switch.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The electric wall heater shall be installed complete with all accessories in accordance with the manufacturer's recommendations and as shown on the drawings.

END OF SECTION

## SECTION 15747

### INDUCTION TERMINAL UNITS

#### PART 1 – GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install complete with all accessories the induction terminal units as shown on the drawings and as specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The induction terminal units shall have published ratings.
- B. All induction terminal units shall be tested by an independent Nationally recognized Testing Laboratory for performance and sound levels.
- C. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTAL

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 – PRODUCTS

##### 2.01 INDUCTION TERMINAL UNITS

The induction terminal units shall be of the type and capacity shown on the drawings. The units shall be manufactured by NUCLIMATE.

- A. General - Induction terminal unit shall be constant volume primary air flow unit designed to induce a secondary airflow within the conditioned space using the primary conditioned air supply. Units shall be designed for ceiling installation with factory supplied hanging brackets. The unit shall be capable of inducing the secondary airflow within the conditioned space using the velocity pressure of the primary airflow. This secondary air must flow directly from the room to the unit and shall not use the ceiling as a return air plenum. Induction units using the ceiling plenum as a return air path are not acceptable.

- B. Connections – Units shall be equipped with a round duct primary air intake, one air plenum, an air induction nozzle plate, a supply and return chilled water piping connection, one supply and return hot water piping connection, one 3/4" condensate drain connection, and one combination supply/return air grille for a full 360 degree coanda effect room air distribution. The grille shall have a removable center core to provide full access to the return air side of the coil
- C. Casing - The entire unit shall be constructed of 20 gauge galvanized sheet metal. The primary air plenum and nozzles shall be designed and configured to provide uniform air distribution to the nozzles with low noise operation.
- D. Induction Nozzles - Induction nozzles shall be aerodynamically designed and made of food grade plastic having a tapered discharge for low noise levels.
- E. Water Coil Assembly
  - 1. Coils shall be of the hot water type utilizing aluminum fins and copper tubes. Coils shall be factory leak tested at 350 psi water. Coil connections shall be as indicated on the drawings.
  - 2. The water coil assembly shall consist of a two row copper tube and aluminum fins coil for cooling and a one row coil for heating.
- F. Condensate Pan
  - 1. A piped condensate pan with a trap shall be provided by the induction unit manufacturer.
  - 2. Provide factory installed float control safety switch in condensate drain pans. Float shall close the chilled water coil control valve upon activation.
- G. Air Diffuser - The unit shall be matched up to a supply/return diffuser to evenly distribute the mixed primary air in a 360 degree coanda effect air distribution pattern. The diffuser shall fit into a standard ceiling grid. The center grille center portion of the diffuser for return air shall be removable for access to interior of unit without tools. The primary air connection is a single duct collar which directs the primary air to the nozzles.
- H. Filters shall be concealed and accessible. They shall be the throwaway type and 1" thick. Filters shall have a minimum MERV rating of 13.

## **PART 3 – EXECUTION**

### **3.01 INSTALLATION**

- A. The induction terminal units shall be installed complete with all accessories in accordance with the manufacturer's recommendations and as shown on the

drawings. The first unit installed will be considered the typical mock up and shall require notification, inspection and approval by designated owner representative and/or architect and engineer before any additional installations will be allowed.

- B. Install induction terminal units in ceiling in such a manner as to allow easy access to all control.
- C. Using the hanging brackets on each unit supplied by the manufacturer, support induction terminal units to supporting structure using field supplied threaded rod or other secure hanging system.
- D. Provide primary supply air connection and seal with duct sealer after installation.
- E. Filters - Shall be changed at the end of the construction period and before the final inspection.
- F. Provide a typed list of all the different units and their filter sizes to be included in the O&M manuals. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, Gatehouse Administrative Center, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia 22032.

END OF SECTION

## SECTION 15748

### ELECTRIC UNIT HEATERS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install complete with all accessories the electric unit heater as shown on the drawings and as specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The electric unit heater shall have published ratings and be listed by Underwriters Laboratories.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTAL

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 ELECTRIC UNIT HEATER

The electric unit heater shall be of the type and capacity shown on the drawings. The unit heater shall be manufactured by TRANE. Unit heaters fully equal to the specified manufacturer and manufactured by QMARK, SINGER, BERKO, ERINCRAFT, or MARKEL are acceptable.

- A. Unit Casing – Casing shall be constructed of heavy gauge steel, zinc coated for rust resistance and finished with baked enamel. All hardware used in the casing shall be plated for rust resistance. Enclosures shall be equipped with elements, contactor and built-in controls.
- B. Discharge – Shall be of the louver type. Discharge grille shall be adjustable to

- direct the air downward to floor.
- C. Elements – Shall consist of helically coiled nickel chromium alloy resistance wire embedded and completely surrounded in magnesium oxide, enclosed and swagged into corrosion resistant sheaths to which are permanently attached corrosion resistant steel fins.
  - D. Motors – Shall be totally enclosed industrial rated, single phase, permanently lubricated and equipped with thermal overload protection with automatic reset. Units rated 20 KW and less shall have shaded pole motors. Those over 20 KW shall have permanent split capacitor motors.
  - E. Fan Blade – Shall be of the axial flow type designed for high efficiency and quiet operation. Fan speed shall not exceed 1750 rpm.
  - F. Thermal Overload Protection – All heaters shall be equipped with a manual reset thermal cutout which disconnects elements and motors in the event normal operating temperatures are exceeded.
  - G. Wiring – Heaters shall be designed for a single supply circuit, with elements, motor and control circuits sub-divided and fused to conform to the current National Electrical Code, Occupational Safety and Health Act (OSHA) and Underwriters Laboratories, Inc. Standard. All three phase heaters shall have balanced phases.
  - H. Controls – The unit heater shall be provided with low voltage (24v) controls by the manufacturer to interface with Division 15900 ATC system.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The electric unit heater shall be installed complete with all accessories in accordance with the manufacturer's recommendations and as shown on the drawings.

END OF SECTION

## SECTION 15749

### ELECTRIC CABINET UNIT HEATERS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install cabinet unit heater as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The cabinet unit heater shall have published ratings and be UL listed and bear the UL label.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 CABINET UNIT HEATERS

The cabinet unit heater shall be completely factory assembled and of the type, capacity and voltage shown on the drawings. The cabinet unit heater shall be manufactured by MARKEL. Units fully equal to the specified manufacturer and manufactured by BERKO, QMARK, or INDEECO are acceptable.

- A. Cabinet: All cabinets shall be constructed of galvanized steel panels, acoustically and thermally insulated with glass fiber blanket material. The cabinet shall be constructed of a minimum of 16-gauge steel on top and sides with 18 gauge front panels. Front panels of horizontal cabinet unit heaters shall be provided with a restraining device or hinges which hold this front panel securely when servicing. The interior chassis shall be constructed of not less than 16 gauge galvanized steel and coated with rust inhibiting paint. Cabinet



- shall have baked enamel finish with color selected from manufacturer's selection chart by the Architect.
- B. Filters: Shall be one (1) inch thick throwaway type. Filters shall have a minimum MERV rating of 13.
  - C. Motor and Fan: Shall be direct driven, forward curved, centrifugal, double width type design for quiet operation. The motor shall be multi-speed, permanent split capacitor. Motor shall have built-in thermal overload protection. The electric input shall not exceed those listed on drawings.
  - D. Controls: Fan control shall be from multi-speed fan switch located in cabinet unless otherwise noted. The cabinet unit heater shall be provided with low voltage (24v) controls by the manufacturer to interface with Division 15900 ATC system.
  - E. Electric Heating Coil: The coil shall be finned tube metal sheated type with extended fins for high heat transfer and reduced operating temperature. The elements shall be enclosed in a heavy gauge steel enclosure.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The cabinet unit heaters shall be installed as shown on the drawings and in accordance with the manufacturer's recommendations.
- B. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- C. Provide a typed list of all the different units and their filter sizes to be included in the O & M manuals. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Rd., Suite 3500, Falls Church, VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032

END OF SECTION

**SECTION 15750**  
**VALANCE SYSTEM**

**PART 1 - GENERAL**

1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

1.02 SCOPE

Provide and install complete with all accessories the valance heating and cooling system as shown on the drawings and as specified herein.

1.03 QUALITY ASSURANCE

- A. The valance shall be certified by the manufacturer to provide the capacities scheduled on the drawings.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

1.04 SUBMITTAL

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

**PART 2 - PRODUCTS**

2.01 VALANCE

The valance shall be of the type and capacity shown on the drawings. The valance shall be manufactured by EDWARDS ENGINEERING or ENVIROTHERM. The valance unit shall include a heat transfer element, element support structure, support brackets, ceiling baffle, condensate drain pan, and drain connections.

- A. **HEAT TRANSFER ELEMENT** The heat transfer element shall be a plate fin coil with aluminum fins on copper tubes. Plastic slides shall be attached to the fins at 3'-0" spacing and be held in place by the element support structure. The heat transfer element circuiting shall be such that the total water side pressure drop will not exceed fifteen feet of water at flow rates specified on the valance schedule. The heat transfer element shall have supply and return connections in accordance with valance connection details.

- B. ELEMENT SUPPORT STRUCTURE The longitudinal support for the valance unit shall be provided by the element support structure. All components, including drain pan, ceiling baffle and heat transfer element, shall be supported from this structure. The support structure shall consist of two aluminum channels facing inward and enclosing the heat transfer element. Cross bracing shall be provided as required to offer lateral support. The support structure shall run the length of the valance and shall rest on the valance support brackets.
- C. SUPPORT BRACKETS Wall Brackets: The valance unit shall be supported by 14 gauge steel wall brackets located at each end of the unit. The brackets shall be self-positioning, fitting directly into the junction of the outside wall and the ceiling. The wall brackets shall provide support directly to the element support structure and be covered by sheet rock; alternative surface mounted bracket available but is not self-positioning. Intermediate Ceiling Brackets: Intermediate aluminum ceiling brackets shall be provided on all valance units when the length of the valance is greater than sixteen feet. The spacing of the intermediate ceiling brackets shall be maintained at about twelve feet center-to-center and shall not exceed sixteen feet. The intermediate ceiling brackets shall be located along the center line of the element support structure and shall be firmly supported to the ceiling or other substantial overhead structure. The intermediate bracket shall provide support directly to the element support structure.
- D. CEILING BAFFLE The aluminum ceiling baffle shall be pre-painted and shall be adjustable to fit tightly against the ceiling.
- E. CONDENSATE DRAIN PANS The streamline valance condensate drain pan shall be constructed of pre-painted 0.032 aluminum. The drain pan shall be lined with closed cell insulation having a solid waterproof surface, said surface facing the heat transfer element. OR The square valance condensate drain pan shall be constructed of pre-painted 0.032 aluminum outer pan and inner pan. The inner drain pan shall be lined with closed cell insulation having a solid waterproof surface, said surface facing the heat transfer element.
- F. DRAIN CONNECTION The exterior drain connection shall be of molded plastic and shall be affixed to the drain pan with a mechanical seal. The drain shall include a length of flexible tubing for connection to the drain risers. OR The interior drain connection shall be an integral part of the valance pan and shall be affixed to the drain pan with a mechanical seal and be properly caulked with a silicon type sealant. The drain shall include a length of flexible tubing for connection to the drain risers.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The valance shall be installed complete with all accessories in accordance with the manufacturer's recommendations and as shown on the drawings.
- B. The first unit installed will be considered the typical mock up and shall require notification, inspection and approval by the designated owner representative and/or architect and engineer before any additional installations will be allowed.

END OF SECTION

## SECTION 15751

### HOT WATER FINNED TUBE RADIATION

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install complete with all accessories the hot water finned tube radiation as shown on the drawings and as specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The hot water finned tube radiation shall have published ratings and be certified by IBR.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTAL

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 HOT WATER FINNED TUBE RADIATION

The hot water finned tube radiation shall be of the type and capacity shown on the drawings. The finned tube radiation shall be manufactured by STERLING. Finned tube radiation fully equal to the specified manufacturer and manufactured by VULCAN, or RITTLING are acceptable.

- A. Enclosure - shall be constructed of 14 gauge steel and shall mount into a continuous roll-formed captive channel mounting strip which permits hinge type mounting and access at the top and invisible fastening onto a rigid, 14 gauge steel enclosure brackets at the bottom. Enclosure brackets shall be spaced at not more than 4-foot intervals. Front panels shall be individually removable to facilitate cleaning, servicing or replacement. All accessories shall fasten to the enclosure assembly in a manner, which prevents contact with the back wall during installation. Cabinet air outlets of sheet metal shall be recessed and

framed. Enclosure shall have baked enamel finish with color selection by Architect.

- B. Heating Element - Copper tube aluminum fin element types, as indicated on plans, shall have integral fin collars which space the fins and provide fin-to-tube surface firmly bonded by mechanical expansion of the tube. Elements shall be positively positioned front-to-back, with provisions for silent horizontal expansion and contraction.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The hot water finned tube radiation shall be installed complete with all accessories in accordance with the manufacturer's recommendations and as shown on the drawings.

END OF SECTION

## SECTION 15752

### HORIZONTAL PIPE ENCLOSURE

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install complete with all accessories the radiation enclosure and horizontal enclosure as shown on the drawings and as specified herein.

##### 1.03 QUALITY ASSURANCE

The horizontal pipe enclosure shall be factory manufactured.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 HORIZONTAL PIPE ENCLOSURE

The horizontal enclosure shall be of the type and as detailed as shown on the drawings. The enclosures shall be manufactured by STERLING. Enclosures fully equal to the specified manufacturer and manufactured by CUSTOM ENCLOSURE, TRANE, VULCAN, RITTLING or MARK-HOT are acceptable.

- A. Enclosure - Shall be constructed of 14 gauge steel and shall mount into a continuous roll-formed captive channel mounting strip which permits hinge type mounting and access at the top and invisible fastening onto rigidized, 14 gauge steel enclosure brackets at the bottom. Enclosure brackets shall be spaced at not more than 4-foot intervals. Front panels shall be individually removable to facilitate cleaning, servicing or replacement. All accessories shall fasten to the enclosure assembly in a manner, which prevents contact with the back wall during installation. Cabinet air outlets of sheet metal shall be recessed and framed. Enclosure shall have baked enamel finish with color selection by Architect. Arrangement shall be as detailed on the drawings.

**PART 3 - EXECUTION**

3.01 INSTALLATION

The horizontal pipe enclosure shall be installed complete with all accessories in accordance with manufacturer's recommendations and as shown on the drawings.

END OF SECTION



## SECTION 15753

### HOT WATER CONVECTORS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install hot water convectors as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

The hot water convectors shall have published ratings.

##### 1.04 SUBMITTAL

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 – PRODUCTS

##### 2.01 HOT WATER CONVECTORS

The hot water convectors shall be of type and capacity shown on the drawings. The convectors shall be manufactured by STERLING. Convectors fully equal to the specified manufacturer and manufactured by VULCAN, RITTLING or TRANE are acceptable.

- A. Enclosure - Cabinet front and top panels shall be 14-gauge steel. End panels shall be reinforced 18 gauge. Front panel shall have horizontal stiffening channel. Cabinet backs shall be phosphatized, galvanized; front, top and sides shall be phosphatized and painted inside and out with one coat of gray primer. Provide baked enamel finish with color selection by architect. Fronts shall be secured in place by quick opening slide bolts or camlock fasteners. Convector styling shall match fin-tube enclosure styling. All cabinets shall have recessed framed air outlets. Provide damper blade with a vandal resistant, allen head external operator.
- B. Heating Element - Shall be constructed of aluminum fins, ribbed steel side plates, fin tube supports and copper tubes expanded and rolled into cast iron headers. Fins shall have integral fin collars, which space the fins and provide fin-to-tube surface firmly bonded to the tube by mechanical expansion of the

tube. All elements shall withstand 150-lb. air pressure factory tested under water.

**PART 3 - EXECUTION**

3.01 INSTALLATION

The hot water convectors shall be installed as shown on the drawings and in accordance with the manufacturer's recommendations.

END OF SECTION

**SECTION 15754**  
**CABINET UNIT HEATERS**

**PART 1 - GENERAL**

1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

1.02 SCOPE

Provide and install cabinet unit heater as shown on the drawings and specified herein.

1.03 QUALITY ASSURANCE

- A. The cabinet unit heater shall have published ratings and be UL listed and bear the UL label.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

**PART 2 - PRODUCTS**

2.01 CABINET UNIT HEATERS

The cabinet unit heater shall be completely factory assembled and of the type, capacity and voltage shown on the drawings. The cabinet unit heater shall be manufactured by TRANE. Units fully equal to the specified manufacturer and manufactured by STERLING, RITTLING or AIRTHERM are acceptable.

- A. Cabinet: All cabinets shall be constructed of galvanized steel panels, acoustically and thermally insulated with glass fiber blanket material. The cabinet shall be constructed of a minimum of 18-gauge steel on top and sides with 16 gauge front panels. Front panels of horizontal cabinet unit heaters shall be provided with a restraining device or hinges which hold this front panel securely when servicing. The interior chassis shall be constructed of not less than 16 gauge galvanized steel and coated with rust inhibiting paint. Cabinet shall

- have baked enamel finish with color selected from manufacturer's selection chart by the Architect.
- B. Filters: Shall be one (1) inch thick throwaway type. Two complete set of spare filters shall be supplied in addition to the set used during construction. Filters shall have a minimum MERV rating of 13.
  - C. Motor and Fan: Shall be direct driven, forward curved, centrifugal, double width type design for quiet operation. The motor shall be multi-speed, permanent split capacitor. Motor shall have built-in thermal overload protection. The electric input shall not exceed those listed on drawings.
  - D. Controls: Fan control shall be from multi-speed fan switch located in cabinet unless otherwise noted. The cabinet unit heater shall be provided with low voltage (24v) controls by the manufacturer to interface with Division 15900 ATC system. It shall have a strap on hot water aquastat located on the hot water supply to prevent the fan from running when hot water is not present.
  - E. Hot Water Heating Coil: The coil shall be factory tested and shall be suitable for working pressures up to 250 psig. Automatic air vents shall be provided. Coils shall be of copper tube/aluminum fin construction.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The cabinet unit heaters shall be installed as shown on the drawings and in accordance with the manufacturer's recommendations. The first unit installed will be considered the typical mock up and shall require notification, inspection and approval by designated owner representative and/or architect and engineer before any additional installations will be allowed.
- B. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection.
- C. Provide a typed list of all the different units and their filter sizes to be included in the O & M manuals. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road, Suite 3500, Falls Church VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032

END OF SECTION

## SECTION 15755

### HOT WATER DUCT COIL

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

Provide and install hot water duct coil as shown on the drawings and as specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The hot water duct coil shall have published ratings by an acceptable manufacturer.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 HOT WATER DUCT COILS

The hot water duct coils shall be of the type, and capacity shown on the drawings. The units shall be manufactured by TRANE. Units fully equal to the specified manufacturer and manufactured by CARRIER, AIRTHERM, OR DUNHAM BUSH are acceptable.

- A. Duct Flange - Shall be constructed of heavy gauge steel. Cast brass supply and return pipe tap connections shall be furnished for each coil.
- B. Coil - The coil shall be constructed on a single serpentine tube and shall be constructed of copper with at least .031" thick walls. Aluminum fins at least .015" thick shall be mechanically attached to the coil by expansion. All connections and U-bends shall be electrically induction-brazed to the tube. The coil shall be tested for 150 psi.

- C. The duct coils shall be controlled by a sensor. (See Div 15900)



**PART 3 - EXECUTION**

## 3.01 INSTALLATION

The hot water duct coil shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings. The unit shall be mounted at maximum height. The first unit installed will be considered the typical mock up and shall require notification, inspection and approval by designated owner representative and/or architect and engineer before any additional installations will be allowed.

END OF SECTION

## SECTION 15760

### HOT WATER UNIT HEATERS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

Provide and install hot water unit heater as shown on the drawings and as specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The hot water unit heater shall have published ratings by an acceptable manufacturer.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 HOT WATER UNIT HEATERS

The hot water unit heaters shall be of the type, capacity and voltage shown on the drawings. The unit heaters shall be manufactured by AIRTHERM. Unit heaters fully equal to the specified manufacturer and manufactured by TRANE, STERLING, RITTLING or TED REED THERMAL are acceptable.

- A. Casing - Shall be constructed of heavy gauge furniture steel. It shall be phosphatized and completely dip painted with heavy-duty baked enamel. Cast brass supply and return pipe tap connections shall be bolted to corners of the back.
- B. Coil - The coil shall be constructed on a single serpentine tube and shall be constructed of copper with at least .031" thick walls. Aluminum fins at least .015"

thick shall be mechanically attached to the coil by expansion. All connections and U-bends shall be electrically induction-brazed to the tube. The coil shall be tested for 100 psi.

- C. Fan and Motor - Shall be selected for quiet operation. The fan shall be factory balanced and the motor shall have permanent lubricated bearings and inherent protection.
- D. The unit shall have louvers or diffusers as shown on the drawings.
- E. The unit heater shall be provided with low voltage (24v) controls by the manufacturer to interface with Division 15900 ATC system. It shall have a strap on hot water aquastat located on the hot water return to prevent the fan from running when hot water is not present.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The hot water heater shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings. The unit shall be mounted for maximum headroom.

END OF SECTION

## **SECTION 15761**

### **FAN COIL UNITS**

#### **PART 1 - GENERAL**

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install complete the fan coil units as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The fan coil units shall be Underwriters Laboratories listed and be rated in accordance with ARI Standards 440-81.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

#### **PART 2 - PRODUCTS**

##### 2.01 GENERAL

Provide and install fan coil units of the type and capacity as shown on the drawings and specified herein. The fan coil units shall be manufactured by TRANE. Fan coil units fully equal to the specified manufacturer and manufactured by CARRIER, DAIKIN or INTERNATIONAL, are acceptable providing they meet connection limitations.

##### 2.02 FAN COIL UNITS

- A. Assembly Description - The unit shall consist of a finished room cabinet with configuration as shown, access openings, discharge and intake grilles, toe space base, connection pockets, noted coils, drain pan, fan and motor assembly, filter and control box.

- B. Cabinet
1. The cabinet shall be constructed of galvanized steel panels, acoustically and thermally insulated with glass fiber blanket material. The cabinet shall be constructed of a minimum of 18-gauge steel on top and sides with 16 gauge front panels. The interior chassis shall be constructed of not less than 16 gauge galvanized steel and shall be coated with rust inhibiting paint. Cabinet shall have baked enamel finish with color selected from manufacturer's selection chart by the Architect.
  2. The discharge grille shall be integral stamped metal unless noted otherwise.
- C. Coils - Shall be constructed of aluminum fins mechanically bonded to seamless copper tubes, with continuous fin collars and sleeved coil and supports. Coils shall be factory tested at 300 psi. Coil connections shall be at opposite ends. Hot water coils shall be placed in a pre-heat position in all units.
- D. Drain pan shall be an IAQ type non-corrosive, positively sloped, insulated and cleanable drain pan. It shall fit under the coil and control valves and be sized to collect the water from all component chilled surfaces. Pan insulation shall be selected to prevent condensation on pan surfaces.
- E. Motor and Fan - Shall be direct driven, forward curved, centrifugal, double width type, quiet operating design. The motor shall be multi-speed, permanent split capacitor, continuous duty, high efficiency type. Motor shall have built-in thermal overload protection. The electric inputs shall not exceed those listed on drawings.
- F. Filters shall be concealed and accessible without removing front panel. They shall be the throwaway type and 1" thick. Filters shall have a minimum MERV rating of 13.
- G. Controls - The fan shall be controlled with a multi-speed fan switch with auxiliary taps located in an accessible lockable end compartment. The temperature controls shall be as shown in Section 15900 - Automatic Temperature Controls.
- H. All floor mounted fan coil units shall be provided with a sub-base.
- I. All horizontal, semi-recessed fan coil units shall be provided with a telescoping ceiling panel with hinged access and intake grille.
- J. Provide factory installed float control safety switch in condensate drain pans. Float shall stop unit upon activation.

**PART 3 - EXECUTION**

3.01 INSTALLATION

- A. The fan coil units shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings. Install sub-bases on all floor-mounted units. The first unit installed will be considered the typical mock up and shall require notification, inspection and approval by the designated owner representative and/or architect and engineer before any additional installations will be allowed.
- B. Piping - Shall be as described in Section 15701. Provide supply and return ball valves, manual air vents and drain plugs.
- C. Filters - Shall be changed at the end of the construction period and before the final inspection.
- D. Provide a minimum 18" long section of removable horizontal pipe enclosure as described in Section 15752, for floor mounted units that can not be piped from opposite ends, to locate valves in. Provide end caps.
- E. Provide spare fuses for fan coil units for each size of fuse used in accordance with the following schedule:

| <u>Number of Fan Coil Units</u> | <u>Spares Required</u> |
|---------------------------------|------------------------|
| 1-10                            | 2                      |
| 11-20                           | 4                      |
| 21-30                           | 6                      |
| 31-40                           | 8                      |
| over 40                         | 10                     |

- F. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before the final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- G. Provide a typed list of all the different fan coil units and their filter sizes to be included in the O & M manuals. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.

2. Coordinator, Mechanical Maintenance Division, Maintenance Services,  
5025 Sideburn Road, Fairfax, Virginia, 22032

END OF SECTION

## SECTION 15765

### UNIT VENTILATOR

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install, complete, the unit ventilator as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The unit ventilator shall be Underwriters Laboratories listed or be tested by an accepted independent testing agency.
- B. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 UNIT VENTILATOR

Provide and install unit ventilator(s) of the type and capacity as shown on the drawings and specified herein. The unit ventilator shall be manufactured by TRANE. Unit ventilators fully equal to the specified manufacturer and manufactured by CARRIER or DAIKIN are acceptable providing they meet the specification requirements.

- A. Assembly Description - The unit shall consist of a finished room cabinet with configuration as shown, access openings, discharge and intake grilles, toe space base, connection pockets, noted coils, drain pan, fan and motor assembly, damper assembly, outside air inlet, filter and control box and factory supplied extension cabinet for housing shutoff and control valves.
- B. Cabinet



1. The cabinet shall be constructed of 14 gauge steel panels, acoustically and thermally insulated with glass fiber blanket material. All exposed edges shall be rounded. The interior chassis shall be constructed of not less than 16 gauge galvanized steel and shall be coated with rust inhibiting paint. Cabinet shall have baked enamel finish with color selected from manufacturer's selection chart by the Architect.
  2. Front panels shall be removable in sections. They shall be secured by allen wrench operated quick open fasteners. The cabinet shall have a separate space for piping and wiring crossover. Provide access opening for adjustment and service access.
  3. Return air intake grille shall be bottom front face located or recessed in toe space slotted kick plate type.
  4. Discharge air grille shall be top mounted, continuous; round edged steel bars with 10 degrees vertical deflection.
- C. The coils shall be constructed of aluminum fins mechanically bonded to seamless copper tubes, with continuous fin collars and sleeved coil and supports. Coils shall be factory tested at 300 psi. Coils connections shall be at opposite ends. Hot water coils shall be placed in a pre-heat position in all units. Chilled water coil connections shall be on the opposite end from the electrical connections. 2-pipe systems shall have coil connections on the opposite end from the electrical connections.
- D. The drain pan shall be an IAQ type non-corrosive positively sloped and cleanable drain pan. It shall fit under the coil and control valves and be sized to collect the water from all future component chilled surfaces. Pan insulation shall be selected to prevent condensation on pan surfaces.
- E. Motor and Fan - Shall be direct driven, forward curved, centrifugal, double width type, quiet operating design. The motor shall be multi-speed, permanent split capacitor, continuous duty, high efficiency type. Motor shall have built-in thermal overload protection. The electric inputs shall not exceed those listed on drawings.
- F. The filters shall be concealed and accessible without removing front panel. They shall be the throwaway type and 1" thick. Filters shall have a minimum MERV rating of 13.
- G. Controls - The fan shall be controlled with a multi-speed fan switch with auxiliary taps located in an accessible lockable end compartment. The temperature controls shall be as shown in Section 15900 - Automatic Temperature Controls.
- H. Provide factory installed float control safety switch in condensate drain pans. Float shall stop unit upon activation.

**PART 3 - EXECUTION**

## 3.01 INSTALLATION

- A. The unit ventilator shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings.
- B. Piping - Shall be as described in Section 15701. Provide supply and return gate valves, manual air vents and drain plugs.
- C. Filters - Shall be changed at the end of the construction period and before the final inspection.
- D. Provide spare fuses for unit ventilators for each size of fuse used in accordance with the following schedule:

| <u>NUMBER OF VENTILATORS</u> | <u>SPARES REQUIRED</u> |
|------------------------------|------------------------|
| 1-10                         | 2                      |
| 11-20                        | 4                      |
| 21-30                        | 6                      |
| 31-40                        | 8                      |
| Over 40                      | 10                     |

- E. Provide a typed list of all the different unit ventilators and their filter sizes to be included in the O & M manuals. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032.
- F. The unit ventilators shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings. The first unit installed will be considered the typical mock-up and shall require notification, inspection and approval by the designated owner representative and/or architect and engineer before any additional installations will be allowed.

END OF SECTION

## SECTION 15769

### PACKAGE ROOFTOP HEATING AND COOLING UNITS WITH ENTHALPHY WHEELS

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 QUALITY ASSURANCE

- A. The system shall deliver the specified air volume at the static pressure scheduled.
- B. The unit shall be constructed to provide smooth interior surfaces and to limit the casing leakage at less than 1% of the specified air volume at operating static.
- C. Unit shall be constructed in accordance with CSA C22.2 and UL 1812 and shall carry the ETL label of approval.
- D. Unit shall be constructed in accordance with industrial design practices.
- E. Insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.
- F. Airflow data shall comply with AMCA 210 method of testing.
- G. Cabinet and exterior components shall be tested and certified weatherproof.
- H. All units shall be 100% factory tested.
- I. All effectiveness data of heat and energy recovery components shall be certified by the ARI 1060 certification program directory.
- J. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### 1.03 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

The rooftop unit shall be manufactured by VALENT. Units fully equal to the specified manufacturer and manufactured by GREENHECK or AAON are acceptable.

### 2.02 EQUIPMENT

- A. General - Factory assembled, consisting of fan and motor assemblies (supply and exhaust), compressor section, heat wheel, all necessary dampers, hoods, plenums, filters, drain pans, wiring and controls. Unit shall be stand-alone controlled with all control devices provided by the unit manufacturer. Unit shall have single point power connection.
- B. Unit Cabinet
1. The rooftop unit is to be installed outdoors by the mechanical contractor. Indoor units weatherized for outdoor use are not acceptable.
  2. All unit panels are fixed with zinc plated hexagonal head type screws complete with a washer and rubber gasket for a weatherproof assembly. Self-drilling, self-tapping screws are used and therefore no tools are required from the unit interior for panel removal. These panels allow for fast service to all major components.
  3. All panel joints must be caulked with a weatherproof silicone. The silicone used must be clear to match any color surfaces. After application, the silicone must react with atmospheric moisture to produce a formed-in-place silicone rubber glazing and curtain wall seal.
  4. The unit base frame shall be constructed from a bolted, structural formed G90 galvanized steel with internal structural cross members properly sized to allow rigging and handling of the unit. All major components shall be supported by the base without sagging or pulsating. Lifting lugs shall be provided and strategically located to allow equilibrium during lifting.
  5. Unit construction consists of an insulated 14 gauge galvanized structural frame complete with die cast aluminum corners. The rigid frame provides stable construction allowing for panel removal without affecting the unit integrity. Panels shall be double wall construction using 2" thick mineral wool insulation 1.5 lbs/ft<sup>3</sup> density, 18 gauge galvanized steel exterior panels (satin coat finish) and 26 gauge G90 galvanized steel inner liner. The unit shall be designed to resist any snow, ice and wind loads, as well as seismic loads in compliance with the National Building Code. Single

wall construction with coated insulation will not be acceptable. Exposed insulation edges in the air stream will not be acceptable.

6. Internal partition wall shall be insulated and constructed the same as the unit cabinet.
7. Full size access door(s) to allow for periodic maintenance and inspections must be provided for all serviceable components. Serviceable components include but are not limited to coils, heat exchanger, damper sections, motor sections, compressor sections, and piping enclosures. Doors shall be double wall construction made of 18 gauge galvanized steel on both outer and inner liner for maximum rigidity. Door insulation is the same as the unit panels. Provide doors with heavy duty corrosion resistant aluminum hinges that allow the door to open at 180°. Compression type handles are operable from both sides of the unit access door(s) and neoprene resilient bubble gaskets for an enclosure that is sealed tight shall also be provided. Plastic latch hinges are not acceptable.
8. Outdoor constructed units shall have a pitched roof to dissipate water accumulation. Rain gutters must be provided above access doors. All roof joint seams are "T" shape construction, minimum height of 1.5", sealed and encapsulated by a metal strip.
9. All weather hoods for outdoor constructed units shall be provided with birdscreen and rain gutters. Hoods may ship loose for field assembly.
10. Recessed, double-sloped drain pans shall be made of formed sections of stainless steel. Drain pans are sloped with a threaded drain pipe connection of 1 1/2" in diameter ending outside through the structural base channel. All drain pan corners shall be welded.
11. Paint
  - a. Outdoor constructed units shall have one coat of primer and two coats of enamel paint.
  - b. All galvanized steel surfaces that require paint shall be made of satin coat-finished galvanized steel of the specified gauge(s).
  - c. All galvanized steel surfaces without any paint shall be made of G90 galvanized steel of the specified gauges.
  - d. All unit surfaces that require paint must be cleaned and free from all oil, dirt, and other contaminants before painting.

C. Energy Recovery Heat Wheel

1. Heat Wheels shall comply with UL standards.
2. Heat Wheel - Provide aluminum or polymer transfer media, flame spread rating of not more than 25, and smoke developed rating of not more than 50, and shall be independently tested in accordance with ASTM standard E-84. Rotor media shall be independently tested in accordance with ASHRAE Standards. It shall allow laminar flow (but not radial) at usual velocities and prevent leakage, bypassing and cross contamination by cross flow within wheel. Size the transfer media to allow passage of 300 micron particles without fouling or clogging. Treat media with non-degrading desiccant that is bacteriostatic, non-corroding, and non-toxic. No asbestos material will be allowed. Wheel shall not condense water directly or require a condensate drain for summer or winter operation. Performance rating shall be in accordance with ARI Standard 1060.
3. Provide casing seals on periphery of rotor as well as on duct divider and purge section. Seals are to be adjustable, of extended life materials, and effective in limiting air leakage.
4. Wheel shall be supported by ball or roller bearings and belt driven by a fractional horsepower, totally enclosed, NEMA Standard motor through a close coupled positively lubricated speed reducer, or gear/chain speed reduction. Wheel motor shall be controlled by a manufacturer provided variable frequency drive.
5. Unit shall be constructed of heavy gage steel to insure rigidity and stability. Casing side panels shall be removable to insure easy access to internal parts. Provide integral flanges for flanged duct connection and provide lifting holes or lugs.
6. Provide rotation sensor to monitor energy recovery wheel rotation.

D. Fans

1. Fan performance ratings for flow rate, pressure, power, air density, speed or rotation, and efficiency shall be factory tested and shall comply with the requirements of AMCA 210.
2. All fans shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 300.

3. Fans shall be of centrifugal type, rigidly braced and reinforced to help prevent vibration or pulsation. Wheel diameters and outlet areas shall be in accordance with the standard sizes adopted by AMCA.
4. Fan and motors shall be mounted inside the unit casing with 1" (minimum 90% efficiency) deflection spring vibration isolators and supplied with neoprene flexible connections.
5. Fans shall be selected for a stable operation, at least 20% under the fan's first critical speed.
6. Units shall be equipped with non-overloading, airfoil, SWSI plenum fan, Arrangement 3 (AMCA labeled) supply and exhaust fans to provide scheduled airflows against static pressures indicated.
7. Fan shaft shall be solid steel, turned, ground, polished, and completed with a corrosion resistant coating. Fan wheels shall be keyed to the shaft.
8. Bearings shall be heavy duty, grease-lubricated, self-aligning ball or pillow block type. Bearing shall be selected for a basic rating fatigue life (L-50) in excess of 200,000 hours at maximum operating speed in accordance with AFBMA 9 regulations.
9. Fan drives shall be designed for a 1.4 service factor. Drives are factory mounted with final alignment and belt adjustment made before unit start-up.
10. Belt drives with motor pulley shall be adjustable pitch for use with motors up to and including 10 HP. Fan pulleys shall be fixed pitch.

E. Motors

1. All motors are internal to the unit casing and are mounted on an adjustable base allowing for belt alignment and tensioning.
2. All motors with belt drives are internal to the unit casing and are mounted on an adjustable base allowing for belt alignment and tensioning.
3. Fan motors shall be heavy duty, 1800 rpm, high efficiency (E-pact Series), open drip proof (ODP), NEMA Design B Class F insulation and 1.15 service factor. Motors shall be constant speed operable at field voltage: 460 volts, 60 Hz, 3 phase.
4. Torque characteristics shall be sufficient to accelerate the drive loads satisfactorily.

5. Motor sizes shall be minimum size indicated in the equipment schedule. If not indicated, large enough so that the drive load will not require the motor to operate in the service factor range.
6. Temperature rating shall be 122°F (50°C) maximum temperature rise at 104°F (40°C) ambient for continuous duty at full load (Class B Insulation).
7. Motor construction shall be NEMA Standard MG 1, general purpose, continuous duty, Design B.
  - a. Bases shall be adjustable.
  - b. Bearings shall be:
    - 1) Ball or roller bearing with inner and outer shaft seals.
    - 2) Grease lubricated.
    - 3) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motors.
  - c. Energy efficient motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112-B. If efficiency is not specified, motors shall give a higher efficiency than "average standard industry motors" in accordance with IEEE Standard 112-B.

F. Filters

1. Filters shall be UL 900 Class II.
2. Outside and return air inlet shall be equipped with galvanized steel racks that permit slide out removal of filters (side access) for units equal or smaller than 78", and universal holding frames with upstream access for units taller than 78".
3. Filter banks shall be arranged for flat orientation. The air velocity shall not exceed 500 fpm through each filter bank.
4. Unit shall include 2" disposable type air filters, 25-30% DSE efficiency, consisting of viscous coated fibers with filtering media encased in fiberboard cell sides having perforated metal grids on each face to provide media support. Airflow resistance with clean media shall not exceed 0.28 inch w.g. at a face velocity of 500 fpm and filter arrestance efficiency of 90% based on ASHRAE Test Standard 52. Filters shall have a minimum MERV rating of 13.

G. Dampers



1. Air leakage through a 48" x 48" damper shall not exceed 10.3 cfm/sq.ft. against 4 in. wg. differential static pressure at standard air. Standard air leakage data to be certified under AMCA certified rating program.
2. Dampers are designed for operation in temperatures ranging between -40°F and 212°F.
3. Unit shall be equipped with all necessary dampers. Dampers for outside air intake, exhaust air and all other dampers required for the system including the dampers for defrost (if required).
4. Intake outside air dampers are opposed blade type and exhaust air dampers are parallel blade type. For other dampers, see manufacturer's recommendations.
5. Outside air dampers and bypass dampers shall be motorized. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
6. Exhaust air dampers shall be gravity backdraft type. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
7. Damper construction shall be as follows:
  - a. Damper frame shall be extruded aluminum.
  - b. Blades shall be extruded aluminum.
  - c. Dampers shall be opposed blade type or parallel blades where indicated
  - d. Damper blade ends shall be sealed with neoprene flexible edge seals complete with bottom and top blade wiper seals.
  - e. Frame and blades shall be non-insulated.

H. Direct Expansion Cooling Section

1. Compressors - Shall be quiet-running hermetic, scroll-type. They shall be mounted in an isolated compartment to be serviceable without affecting airflow, and mounted on neoprene isolators to minimize vibration transmission and noise. Unit shall be capable of full modulation to maintain space temperature.
2. Condenser and Evaporator Coils - Shall have copper tubes with permanently expanded aluminum fins. Evaporator coils shall be mounted

- on a stainless steel drain pan. Condenser coils shall be provided with hail/ vandal guards to protect the coils.
3. Provide factory mounted sensor between the evaporator coil and the hot gas reheat coil for connection to the ATC system.
  4. Thermal Expansion Valves - Shall provide refrigerant control.
  5. Standard features of the packaged direct expansion cooling include:
    - a. Liquid-Line Filter Drier
    - b. High Pressure Manual Reset Cutout
    - c. Low Pressure Auto-Reset Cutout
    - d. Time Delay Relay for Compressor Protection
    - e. Service/Charging Valves
    - f. Moisture Indicating Sight Glass
  - I. Indirect Gas Fired Heating Section - Shall be 80% efficient, ETL Listed for outdoor installation to ANSI Standard Z83.8 - 2002, CGA approved per 2.6 - 2002 and have a blow through fan design. Furnace shall operate with natural gas and have a power venting system. The burner and heat exchanger shall be constructed of aluminized steel. Standard furnace features shall include main gas pressure regulator, main gas valve, fully modulating electronic controls to maintain discharge temperature, direct spark ignition system, high limit, and a 24-volt control transformer.
  - J. Hot Gas Reheat for Dehumidification - Hot gas reheat coils, piping, and modulating controls shall be factory installed for humidity control.
  - K. Roof curb: Roof curb shall be supplied by the unit manufacturer for field assembly. Curb shall consist of formed 18 gauge galvanized steel sections. Manufacturer's curb is standard double wall, 14" in height, un-insulated. Unit base design is made for recessed curb installation. Stiffeners will be provided for field assembly when required. Pitch roof curb to match building roof. Provide wood nailer. Curb shall be one piece. Two piece curbs are not acceptable.
  - L. Temperature Controls shall be provided by the unit manufacturer.
    1. Shall be provided to accomplish control sequence as outlined in the automatic temperature control section of specifications. All temperature controls shall be factory installed, wired, and programmed by the manufacturer or see item 3 below.
    2. Manufacturer shall provide an interface which will allow the Owner's energy management system to access the control points shown on the

points list. This interface shall be in complete compliance with the current ANSI/ASHRAE Standard #135. Provide any coordination as required to facilitate this interface into the Owner's EMS. Provide all necessary protocol documentation and gateway hardware and software (if required) such that the section 15900 system suppliers may successfully create a communication interface between the control system furnished in this section of the specification and the 15900 control system. Provide an adequate level of technical support to guide the section 15900 personnel towards completion of subject communication interface. Protocol must support reading/writing status and analog and digital point information from this section of the specification. All documentation, gateway hardware and software, and required technical support are understood to be included in the bid.

3. Temperature Controls shall be accomplished by either of the following methods:
  - a. Factory built-in controls shall be provided to interface with the ATC to accomplish control sequence as outlined in Automatic Temperature Control section of specifications.
  - b. Field installed controls provided by the section 15900 contractor is acceptable provided the control sequence as outlined in Automatic Temperature Control section of specifications is met.
- M. A water level sensing device shall be factory provided in the unit condensate pan which shall shut down the unit in the event this device's level is exceeded. Device shall be located in a readily accessible location.

## 2.03 ELECTRICAL COMPONENTS

- A. All electrical controls shall be ETL listed and the entire unit shall be factory wired in accordance with the National Electrical Code Standard.
- B. The outdoor constructed units shall be supplied with a weatherproof non-fused main power disconnect switch. A single point power connection shall be provided for all units.
- C. Unit shall be equipped with all necessary high voltage components as follows:
  1. Motor starters on all high voltage motors for constant speed applications.
  2. Thermal protection on all high voltage motors.
  3. Fuses and fuse holders.
  4. All necessary control transformers.

- D. Unit shall be completed with all necessary relays, time delay, damper actuators with auxiliary switches (as required).
- E. Terminal board shall be provided for low voltage control wiring. Low voltage is 24V.
- F. Fan access doors are equipped with a momentary interrupt switch that shuts off the unit when a protected door is opened. These switches can be removed if belt guards are installed on the fan assembly.
- G. An integral control panel shall be provided having a hinged access door and an approved locking device.
- H. All control devices, except those not mounted directly to the unit, shall be factory mounted and wired. Control panel shall have a labeled strip to land all wires for field installed control components.
- I. All components are fully wired and 100% tested prior to shipping.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. **Factory Start-up** - The manufacturer shall supply complete factory start-up by a factory approved start-up agent. Manufacturer shall provide on-site startup and commissioning assistance through job completion. Complete installation and startup checks according to manufacturer's written instructions. This shall include a factory startup for factory provided control devices as well as configuring control points for other DO devices. Service representative shall completely configure all control devices.
- B. **Demonstration** - Engage manufacturer or factory authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain individual units and complete system. This shall include training of the Owner's energy management department representatives as to establish control system programming, scheduling routines, alarm reporting, system topography, communication protocols and password level assignments.
- C. The rooftop unit shall be installed complete with all accessories in accordance with the manufacturer's recommendations, as listed in the specifications and as shown on the drawings.
- D. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction

dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.

- E. Provide a typed list of all the different units and their filter and belt sizes to be included in the O & M manuals. The list shall include the unit designation, filter size and the number of filters required for each unit, and belt size and number of belts for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, Gatehouse Administrative Center, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032
- F. Provide one set of spare fuses for each rooftop unit.
- G. Provide one spare set of belts per unit per drive.
- H. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Identification tag shall be black with engraved 1/2" white letters which reads:

|                                     |                                    |
|-------------------------------------|------------------------------------|
| <b>UNIT #</b>                       | (unit number) _____                |
| <b>INSTALLED BY:</b>                | (contracting company's name) _____ |
| <b>WARRANTY EXPIRES:</b>            | (month/day/year) _____             |
| <b>COMPRESSOR WARRANTY EXPIRES:</b> | (month/day/year) _____             |

END OF SECTION

## SECTION 15770

### PACKAGE TERMINAL AIR CONDITIONING UNITS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Furnish permanently installed electric cooling/hot water packaged terminal air conditioner of size and capacity shown on drawing. Conditioner shall consist of a room cabinet-wall sleeve, Heating/Cooling chassis, control module, and outside air louver.

##### 1.03 QUALITY ASSURANCE

The packaged units shall have published ratings and be listed by Underwriters Laboratories.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 PACKAGED TERMINAL UNIT

The thru-wall unit shall be of the type and capacity shown on the drawings. The units shall be manufactured by TRANE. Units fully equal to the specified manufacturer and manufactured by DAIKIN, CARRIER or FRIEDRICH are acceptable.

- A. Outside Air Louver - Shall be anodized extruded aluminum with finish selected by Architect. Louver shall be easily installed from inside of building.
- B. Room Cabinet-Wall Sleeve - Shall be entirely constructed of zinc-coated, phosphatized steel. Top and sides shall be 18 gauge with baked epoxy corrosion resistant finish. Base pan shall be 16 gauge dipped in thermo-setting plastic, epichlorhydrin bisphenol, and baked to form a continuous film of corrosion protection. Discharge grilles shall be four-position stamped aluminum. Front panel shall be capable of being opened and/or removed without the use of tools.

- C. Heating-Cooling Chassis - Shall be a slide-in, plug-in chassis with self-contained refrigerant cycle consisting of compressor, condenser fan and coil, evaporator fan and coil, hot water coil, refrigerant tubing and controls, electrical and operating controls, pressure ventilation system and condensate removal system.
  - 1. Compressor shall be welded hermetic, internally and externally vibration isolated. Refrigeration control shall provide full cooling capacity at ambient temperatures down to 35 degrees F without evaporator coil freeze-up, compressor short-cycling or slugging. Refrigerant shall be 410A.
  - 2. Evaporator and condenser fans shall be driven by one two-speed, permanent split capacitor, permanently lubricated fan motor located in conditioned air stream.
  - 3. Heating coil shall be serpentine hot water type. The coil shall be constructed of aluminum fins mechanically bonded to seamless copper tubes with continuous fin collars and sleeved coil and supports. Coils shall be factory tested at 300 psi. Provide supply and return gate valves, automatic air vents and drain plugs. Provide hailguard at coils.
- D. Operating Controls - Shall be provided in a separable, plug-in module as part of the cooling chassis. Control module shall consist of self-contained adjustable thermostat, with OFF-HEAT-COOL-HIGH-LOW selector switches.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The packaged unit shall be installed complete with all accessories in accordance with the manufacturer's recommendations and as shown on the drawings.
- B. New filters shall be installed after construction is over and before the final inspection. Filters shall have a minimum MERV rating of 13.
- C. Provide a typed list of all the different units and their filter sizes to be included in the O & M manuals. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032.

END OF SECTION



## SECTION 15771

### PACKAGE ROOFTOP HEATING AND COOLING UNITS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, and Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 QUALITY ASSURANCE

- A. The packaged units shall have published ratings and shall be UL listed, conforms to the current International Energy Conservation Code and current ASHRAE standards.
- B. Construct gas fired heating sections in accordance with AGA safety standards and provide AGA label.
- C. Factory start-up-The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- D. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### 1.03 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted

#### PART 2 - PRODUCTS

##### 2.01 PACKAGED ROOFTOP HEATING AND COOLING UNIT

The rooftop unit shall be of the type and capacity shown the drawings. The units shall be manufactured by TRANE. Units fully equal to the specified manufacturer and manufactured by CARRIER or DAIKIN are acceptable.

- A. Packaged Assembly: Unit shall consist of a completely assembled, piped, wired and tested unit composed of a weatherproof enclosure that is insulated with foil faced insulation having a thickness of 1" and a density of 1 pound with all edges sealed and hinged gasketed locking access doors and, non-corrosive, sloped, cleanable insulated IAQ type condensate drain pan centrifugal blower with belt drive air handling section, low velocity throwaway filter section complete direct

expansion air cooled cooling system section, single point power connection and gas fired or hot water heating section all mounted on one base with additional roof adapting components and accessories as required in this specification or as shown on the plans.

- B. Enclosure: Shall be heavy gauge zinc-coated steel with baked enamel finish and shall be completely weatherized for outdoor installation.
- C. Air Handling Section: Fan shall have forward curved blades, belt driven with adjustable motor sheaves. The motor and fan shall have permanently lubricated ball bearings. The motor shall have thermal overload protection.
- D. Filter Section: Shall fit into integral racks inside casing. Maximum velocity through filter 350 fpm. Filters shall be throwaway, 2" thick pleated with 35% efficiency, and a MERV rating of 13. Two complete sets of spare filters shall be supplied in addition to the set used during construction.
- E. Cooling Section: Shall have vibration isolated hermetic compressor(s), copper tube aluminum fin air cooled condensing coil and propeller type condenser fans direct-connected to inherently protected motors. Provide metal hail / vandal guards to protect the condenser coil fins. Complete system shall be factory dehydrated, tested and charged. Refrigeration cycle shall include condenser and evaporator fan compressor cutouts, 24-volt transformers, low and high pressure cutouts, liquid line solenoid valves for system pump-down and compressor protection cutout with reset. Units rated 10 tons and above shall have 50% capacity reduction capability. Units with a cooling capacity of 54 MBH and greater shall be equipped with an economizer cycle and shall include industry standard acceptable low leakage outside air damper. Refrigerant shall be R-410A.
- F. Hot Water Heating Coils: Shall be ARI certified non-freeze type pitched within the ductwork for proper drainage. Headers shall be heavy-gauge galvanized steel. Maximum work pressure limit of coil shall be 175 psig at 400 degrees F. Coils shall be within unit or remote in ductwork as shown on plans. When in unit, piping to coils shall be within unit.
- G. Heat Exchangers: Provide manufacturer's standard construction for gas-fired heat exchangers and burners, designed for minimum of 2-stage operation. Provide single gas connection.
  - 1. Gas Controls.  
Provide the following controls:
    - Redundant gas valves
    - Intermittent pilot ignition
    - Electronic spark ignition system
    - High limit cutout
    - Flame rollout switch

- H. Economizer Control: Provide economizer control consisting of return and outside air dampers, outside air filter, fully modulating electric control system with enthalpy control, and adjustable mixed-air thermostat. Design system for 100% outside air capability. Provide automatic changeover through adjustable enthalpy control device. Units without economizer cycle shall have 25% motorized outside air damper. Units which are scheduled for demand ventilation shall be configured to accept a control signal from the Automatic Temperature Control system for control of the outside air damper to accomplish the demand ventilation sequence as described in division 15900.
- I. Factory built-in controls shall be provided for control of the refrigeration cycle, refrigeration safeties, heating cycle, heating safeties and economizer (if applicable). The Automatic Temperature Control contractor shall furnish controls for temperature control and energy management routines. The unit manufacturer shall provide a terminal strip for control wiring terminations.
- J. Accessories: Units shall include the following accessories:
1. All units 15 tons and larger shall have vibration isolation roof curb assembly. All other units shall have vibration isolation roof curb assembly, when shown on drawings. Pre-fabricated aluminum or galvanized steel curbs 14" high shall be provided to match the rooftop unit. The curb shall be flashed to match the roofing system. Provide wood nailer. The rooftop unit and curb shall be provided by the same manufacturer. Roof curbs shall be one piece; two piece curbs will not be accepted.
  2. Units with a cooling capacity less than 54 MBH shall have two-position, motorized outside air dampers (25% minimum) and low ambient control to 0°F. Accessories shall be of the same manufacturer as the rooftop unit.
  3. Units with cooling capacities of 54 MBH or greater shall have economizer cycle and 100% barometric relief.
  4. All damper actuators shall be spring return type (for loss of power). Units using means other than true spring return are not acceptable.
  5. Conventional thermostat interface for connection to the automatic temperature control system.
  6. Accessories shall be of the same manufacturer as the rooftop unit.
  7. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this device's level is exceeded. Condensate float shall be located in a readily accessible location.

8. Units with Hot Gas Reheat, provide factory mounted sensor between evaporator coil and hot gas reheat coil for connection to the ATC system. Signal to be coordinated with the Division 15900 contractor.
9. Units with Demand Control Ventilation capabilities shall be furnished with an outdoor airflow monitoring device. This device shall be compatible with the Building Automation System (BAS) such that the outdoor airflow volume shall be set in Cubic Feet per Minute (CFM) and displayed on the BAS graphics.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Factory Start-up – The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- B. The packaged rooftop unit shall be installed complete with all accessories in accordance with the manufacturer's recommendations, as indicated in the specifications and as shown on the drawings.
- C. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- D. Provide one spare fan belt for each air handling unit.
- E. Provide a typed list of all the different units, their filter sizes, and belt sizes to be included in the O & M manuals. The list shall include the unit designation, filter size belt size and the number of filters and belts required for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
  2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032.
- F. Supply and return air ductwork connecting to package rooftop units setting on steel framing shall have flexible connections in the ductwork located inside the building, just below the roofline or inside of wall for horizontal discharge units. Package rooftop units setting on roof curbs which discharge horizontally shall have the flexible connection located within the building.

- G. Provide one set of spare fuses for each package rooftop unit.
- H. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Identification tag shall be black with engraved 1/2" white letters which read:

|                              |   |
|------------------------------|---|
| UNIT #                       | <i>(unit number)</i> _____                |
| INSTALLED BY:                | <i>(contracting company's name)</i> _____ |
| WARRANTY EXPIRES:            | <i>(month/day/year)</i> _____             |
| COMPRESSOR WARRANTY EXPIRES: | <i>(month/day/year)</i> _____             |

END OF SECTION

## SECTION 15772

### PACKAGE ROOFTOP HEAT PUMP UNITS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Furnish permanently installed electric cooling/heating packaged rooftop heat pump conditioner of size and capacity shown on drawing.

##### 1.03 QUALITY ASSURANCE

- A. The packaged units shall have published ratings and be listed by Underwriters Laboratories.
- B. Factory Start-up – The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- C. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 PACKAGED ROOFTOP HEAT PUMP UNIT

The rooftop heat pump unit shall be of the type and capacity shown on the drawings. The units shall be manufactured by TRANE. Units fully equal to the specified manufacturer and manufactured by CARRIER or DAIKIN are acceptable.

- A. Packaged Assembly: Conditioner shall consist of a completely assembled, piped, wired and tested unit composed of weatherproof enclosure with resealable hinged access panels, centrifugal blower with belt drive air handling section, low velocity throwaway filter section, complete direct expansion air to air reverse cycle heat pump system section completely prewired and interlocked

and all mounted on one base with additional roof adapting components and accessories as required in this specification or as shown on plans. Roof curb shall be by the same manufacturer.

- B. Enclosure: Shall be heavy gauge zinc-coated steel with baked enamel finish and shall be completely weatherized for outdoor installation.
- C. Air Handling Section: Fan shall have forward curved blades, belt driven with adjustable motor sheaves. The motor and fan shall have permanently lubricated ball bearings. The motor shall have thermal overload protection.
- D. Filter Section: Shall fit into integral racks inside casing. Maximum velocity through filter 350 FPM. Filters to be throwaway type, pleated, 2" thick, 35% efficient, and a MERV rating of 13. Provide unit with 25% motorized outside air damper.
- E. Heating/Cooling Section: Shall have vibration isolated hermetic compressor(s), copper type aluminum fin air cooled condenser/evaporator coil and propeller type outdoor fans direct connected to inherently protected motors. Provide metal hail / vandal guards to protect coil fins. Complete system shall be factory dehydrated, tested and charged. Refrigeration cycle control shall include condenser and evaporator fan and compressor contractors, 24-volt transformers, low and high pressure cutouts, refrigerant and charging valves, reversing valve, automatic defrost control, low ambient control, suction line accumulator, and compressor protection cutout with reset. Provide an IAQ type sloped cleanable non-corrosive insulated condensate drain pan. Refrigerant shall be 410A.
- F. Supplementary Electric Heating Coil: Shall be enclosed nickel-chromium wire heating element. Heating section shall contain built-in contractors, thermal cutouts, interlock relays and box, and line voltage terminal blocks with lugs. Heaters shall be UL listed.
- G. Factory built-in controls shall be provided for control of the refrigeration cycle, refrigeration safeties, heating cycle, heating safeties and economizer (if applicable). The Automatic Temperature Control contractor shall furnish controls for temperature control and energy management routines. The unit manufacturer shall provide a terminal strip for control wiring terminations.
- H. Pre-fabricated aluminum or galvanized steel curbs 14" high shall be provided to match the heat pump unit. The curb shall be flashed to match the roofing system. The heat pump unit and curb shall be provided by the same manufacturer. Provide wood nailer. All units shall set on curbs unless indicated differently on drawings. Roof curbs shall be one piece; two piece curbs will not be accepted.

- I. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded. Condensate float shall be located in a readily accessible location.
- J. Units with Hot Gas Reheat, provide factory mounted sensor between evaporator coil and hot gas reheat coil for connection to the ATC system.
- K. Units with Demand Control Ventilation capabilities shall be furnished with an outdoor airflow monitoring device. This device shall be compatible with the Building Automation System (BAS) such that the outdoor airflow volume shall be set in Cubic Feet per Minute (CFM) and displayed on the BAS graphics.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Factory Start-up – The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- B. The packaged rooftop heat pump unit shall be installed complete with all accessories in accordance with the manufacturer's recommendations, as listed in the specifications and as shown on the drawings.
- C. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- D. Provide one spare fan belt for each unit.
- E. Provide a typed list of all the different units, their fan belt sizes and their filter sizes to be included in the O & M manuals. The list shall include the unit designation, filter size and the number of filters required as well as belt size and number of belts for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032
- F. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Identification tag shall be black with engraved 1/2" white letters which read:



|                              |   |
|------------------------------|---|
| UNIT #                       | <i>(unit number)</i> _____                |
| INSTALLED BY:                | <i>(contracting company's name)</i> _____ |
| WARRANTY EXPIRES:            | <i>(month/day/year)</i> _____             |
| COMPRESSOR WARRANTY EXPIRES: | <i>(month/day/year)</i> _____             |

END OF SECTION

## SECTION 15773

### ENERGY RECOVERY UNITS (Self-Contained) (Engineer to edit for Job specific application)

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 QUALITY ASSURANCE

- A. The system shall deliver the specified air volume at the static pressure scheduled.
- B. The unit shall be constructed to provide smooth interior surfaces and to limit the casing leakage at less than 1% of the specified air volume at operating static.
- C. Unit shall be constructed in accordance with CSA C22.2 and UL 1812 and shall carry the ETL label of approval.
- D. Unit shall be constructed in accordance with industrial design practices.
- E. Insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.
- F. Airflow data shall comply with AMCA 210 method of testing.
- G. Cabinet and exterior components shall be tested and certified weatherproof.
- H. All units shall be 100% factory tested.
- I. All effectiveness data of heat and energy recovery components shall be certified by the ARI 1060 certification program directory.
- J. Equipment installer shall attend a controls coordination meeting with the Section 15900 contractor as described in 15900, 1.03.

##### 1.03 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

**PART 2 - PRODUCTS**

## 2.01 MANUFACTURERS

- A. Energy recovery unit(s) shall be manufactured by GREENHECK, VALENT, INNOVENT AIR HANDLING EQUIPMENT, AAON.

## 2.02 EQUIPMENT

- A. General - Factory assembled, consisting of fan and motor assemblies (supply and exhaust), compressor section, heat wheel, all necessary dampers, hoods, plenums, filters, drain pans, wiring and controls. Unit shall be stand-alone controlled with all control devices provided by the unit manufacturer— Unit shall have single point power connection.
- B. Unit Cabinet
1. The energy recovery unit is to be installed outdoors by the mechanical contractor. Indoor units weatherized for outdoor use are not acceptable.
  2. All unit panels are fixed with zinc plated hexagonal head type screws complete with a washer and rubber gasket for a weatherproof assembly. Self-drilling, self-tapping screws are used and therefore no tools are required from the unit interior for panel removal. These panels allow for fast service to all major components.
  3. All panel joints must be caulked with a weatherproof silicone. The silicone used must be clear to match any color surfaces. After application, the silicone must react with atmospheric moisture to produce a formed-in-place silicone rubber glazing and curtain wall seal.
  4. The unit base frame shall be constructed from a bolted, structural formed G90 galvanized steel with internal structural cross members properly sized to allow rigging and handling of the unit. All major components shall be supported by the base without sagging or pulsating. Lifting lugs shall be provided and strategically located to allow equilibrium during lifting.
  5. Unit construction consists of an insulated 14 gauge galvanized structural frame complete with die cast aluminum corners. The rigid frame provides stable construction allowing for panel removal without affecting the unit integrity. Panels shall be double wall construction using 2" thick mineral wool insulation 1.5 lbs/ft<sup>3</sup> density, 18 gauge galvanized steel exterior panels (satin coat finish) and 26 gauge G90 galvanized steel inner liner. The unit shall be designed to resist any snow, ice and wind loads, as well as seismic loads in compliance with the National Building Code. Single wall construction with coated insulation will not be acceptable. Exposed insulation edges in the air stream will not be acceptable.

6. Internal partition wall shall be insulated and constructed the same as the unit cabinet.
  7. Full size access door(s) to allow for periodic maintenance and inspections must be provided for all serviceable components. Serviceable components include but are not limited to coils, heat exchanger, damper sections, motor sections, compressor sections, and piping enclosures. Doors shall be double wall construction made of 18 gauge galvanized steel on both outer and inner liner for maximum rigidity. Door insulation is the same as the unit panels. Provide doors with heavy duty corrosion resistant aluminum hinges that allow the door to open at 180°. Compression type handles operable from both sides of the unit access door(s) and neoprene resilient bubble gaskets for an enclosure that is sealed tight shall also be provided. Plastic latch hinges are not acceptable.
  8. Outdoor constructed units shall have a pitched roof to dissipate water accumulation. Rain gutters must be provided above access doors. All roof joint seams are "T" shape construction, minimum height of 1.5", sealed and encapsulated by a metal strip.
  9. All weather hoods for outdoor constructed units shall be provided with birdscreen and rain gutters. Hoods may ship loose for field assembly.
  10. Recessed, double-sloped drain pans shall be made of formed sections of stainless steel. Drain pans are sloped with a threaded drain pipe connection of 1 1/2" in diameter ending outside through the structural base channel. All drain pan corners shall be welded.
  11. Paint
    - a. Outdoor constructed units shall have one coat of primer and two coats of enamel paint.
    - b. All galvanized steel surfaces that require paint shall be made of satin coat-finished galvanized steel of the specified gauge(s).
    - c. All galvanized steel surfaces without any paint shall be made of G90 galvanized steel of the specified gauges.
    - d. All unit surfaces that require paint must be cleaned and free from all oil, dirt, and other contaminants before painting.
- C. Energy Recovery Heat Wheel
1. Heat Wheels shall comply with UL standards.

2. Heat Wheel - Provide aluminum or polymer transfer media, flame spread rating of not more than 25 and smoke developed rating of not more than 50 and shall be independently tested in accordance with ASTM standard E-84. Rotor media shall be independently tested in accordance with ASHRAE Standards. It shall allow laminar flow (but not radial) at usual velocities and prevent leakage, bypassing and cross contamination by cross flow within wheel. Size the transfer media to allow passage of 300 micron particles without fouling or clogging. Treat media with non-degrading desiccant that is bacteriostatic, non-corroding and non-toxic. No asbestos material will be allowed. Wheel shall not condense water directly or require a condensate drain for summer or winter operation. Performance rating shall be in accordance with ARI Standard 1060.
3. Provide casing seals on periphery of rotor as well as on duct divider and purge section. Seals are to be adjustable, of extended life materials and effective in limiting air leakage.
4. Wheel shall be supported by ball or roller bearings and belt driven by a fractional horsepower, totally enclosed, NEMA Standard motor through a close coupled positively lubricated speed reducer, or gear/chain speed reduction. Wheel motor shall be controlled by a manufacturer provided variable frequency drive.
5. Unit shall be constructed of heavy gage steel to insure rigidity and stability. Casing side panels shall be removable to insure easy access to internal parts. Provide integral flanges for flanged duct connection and provide lifting holes or lugs.
6. Provide rotation sensor to monitor energy recovery wheel rotation.

D. Fans

1. Fan performance ratings for flow rate, pressure, power, air density, speed or rotation, and efficiency shall be factory tested and shall comply with the requirements of AMCA 210.
2. All fans shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 300.
3. Fans shall be of centrifugal type, rigidly braced and reinforced to help prevent vibration or pulsation. Wheel diameters and outlet areas shall be in accordance with the standard sizes adopted by AMCA.

4. Fan and motors shall be mounted inside the unit casing with 1" (minimum 90% efficiency) deflection spring vibration isolators and supplied with neoprene flexible connections.
5. Fans shall be selected for a stable operation, at least 20% under the fans first critical speed.
6. Units shall be equipped with non-overloading, airfoil, SWSI plenum fan, Arrangement 3 (AMCA labeled) supply and exhaust fans to provide scheduled airflows against static pressures indicated.
7. Fan shaft shall be solid steel, turned, ground, polished, and completed with a corrosion resistant coating. Fan wheels shall be keyed to the shaft.
8. Bearings shall be heavy duty, grease-lubricated, self-aligning ball or pillow block type. Bearing shall be selected for a basic rating fatigue life (L-50) in excess of 200,000 hours at maximum operating speed in accordance with AFBMA 9 regulations.
9. Fan drives shall be designed for a 1.4 service factor. Drives are factory mounted with final alignment and belt adjustment made before unit start-up.
10. Belt drives with motor pulley shall be adjustable pitch for use with motors up to and including 10 HP. Fan pulleys shall be fixed pitch.

E. Motors

1. All motors are internal to the unit casing and are mounted on an adjustable base allowing for belt alignment and tensioning.
2. Fan motors shall be heavy duty, 1800 rpm, high efficiency (E-pact Series), open drip proof (ODP), NEMA Design B with Class F insulation and 1.15 service factor. Motors shall be constant speed operable at field voltage: 460 volts, 60 Hz, 3 phase.
3. Torque characteristics shall be sufficient to accelerate the drive loads satisfactorily.
4. Motor sizes shall be minimum size indicated in the equipment schedule. If not indicated, large enough so that the drive load will not require the motor to operate in the service factor range.
5. Temperature rating shall be 122°F (50°C) maximum temperature rise at 104°F (40°C) ambient for continuous duty at full load (Class B Insulation).
6. Motor construction shall be NEMA Standard MG 1, general purpose, continuous duty, Design B.

- a. Bases shall be adjustable.
  - b. Bearings shall be:
    - 1) Ball or roller bearing with inner and outer shaft seals.
    - 2) Grease lubricated.
    - 3) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motors.
  - c. Energy efficient motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112-B. If efficiency is not specified, motors shall give a higher efficiency than "average standard industry motors" in accordance with IEEE Standard 112-B.
- F. Filters
1. Filters shall be UL 900 Class II.
  2. Outside and return air inlet shall be equipped with galvanized steel racks that permit slide out removal of filters (side access) for units equal or smaller than 78", and universal holding frames with upstream access for units taller than 78".
  3. Filter banks shall be arranged for flat orientation. The air velocity shall not exceed 500 fpm through each filter bank.
  4. Unit shall include 2" disposable type air filters, 25-30% DSE efficiency, consisting of viscous coated fibers with filtering media encased in fiberboard cell sides having perforated metal grids on each face to provide media support. Airflow resistance with clean media shall not exceed 0.28 inch w.g. at a face velocity of 500 fpm and filter arrestance efficiency of 90% based on ASHRAE Test Standard 52. Filters shall have a minimum MERV rating of 13.
- G. Dampers
1. Air leakage through a 48" x 48" damper shall not exceed 10.3 cfm/sq.ft. against 4 in. wg. differential static pressure at standard air. Standard air leakage data to be certified under AMCA certified rating program.
  2. Dampers are designed for operation in temperatures ranging between -40°F and 212°F.

3. Unit shall be equipped with all necessary dampers. Dampers for outside air intake, exhaust air and all other dampers required for the system, including the dampers for defrost (if required).
  4. Intake outside air dampers are opposed blade type and exhaust air dampers are parallel blade type. For other dampers, see manufacturer's recommendations.
  5. Outside air dampers shall be motorized. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
  6. Exhaust air dampers shall be gravity backdraft type. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
  7. Dampers construction shall be as followed:
    - a. Damper frame shall be extruded aluminum.
    - b. Blades shall be extruded aluminum.
    - c. Dampers shall be opposed blade type or parallel blades where indicated
    - d. Damper blade ends shall be sealed with neoprene flexible edge seals complete with bottom and top blade wiper seals.
    - e. Frame and blades shall be non-insulated.
- H. Direct Expansion Cooling Section
1. Compressors - Shall be quiet-running hermetic, digital scroll-type. They shall be mounted in an isolated compartment to be serviceable without affecting airflow, and mounted on neoprene isolators to minimize vibration transmission and noise. Unit shall be capable of full modulation to maintain discharge temperature. Refrigerant shall be R-410-A.
  2. Condenser and Evaporator Coils - Shall have copper tubes with permanently expanded aluminum fins. Evaporator coils shall be mounted on a stainless steel drain pan. Condenser coils shall be provided with hail/ vandal guards to protect the coils. Provide factory mounted sensor between evaporator coil and hot gas reheat coil for connection to the ATC system.
  3. Thermal Expansion Valves - Shall provide refrigerant control.
  4. Standard features of the packaged direct expansion cooling include:



- a. Liquid-Line Filter Drier
  - b. High Pressure Manual Reset Cutout
  - c. Low Pressure Auto-Reset Cutout
  - d. Time Delay Relay for Compressor Protection
  - e. Service/Charging Valves
  - f. Moisture Indicating Sight Glass
- I. Indirect Gas Fired Heating Section - Shall be 80% efficient, ETL Listed for outdoor installation to ANSI Standard Z83.8 - 2002, CGA approved per 2.6 - 2002 and have a blow through fan design. Furnace shall operate with natural gas and have a power venting system. The burner and heat exchanger shall be constructed of aluminized steel. Standard furnace features shall include main gas pressure regulator, main gas valve, minimum 10:1 turn down electronic modulation controls to maintain discharge temperature, direct spark ignition system, high limit, and a 24-volt control transformer.
- J. Hot Gas Reheat for Dehumidification - Hot gas reheat coils, piping, and modulating controls shall be factory installed for humidity control.
- K. Roof curb shall be supplied by the unit manufacturer for field assembly. Curb shall consist of formed 18 gauge galvanized steel sections. Manufacturer's curb is standard double wall, 14" in height, un-insulated. Unit base design is made for recessed curb installation. Stiffeners will be provided for field assembly when required. Pitch roof curb to match building roof. Provide wood nailer. Curb shall be one piece. Two piece curbs are not acceptable. See detail for critical dimensions.
- L. Temperature Controls shall be provided by the unit manufacturer.
- 1. Shall be provided to accomplish control sequence as outlined in the automatic temperature control section of specifications. All temperature controls shall be factory installed, wired, and programmed by the manufacturer or see item 3 below.
  - 2. Manufacturer shall provide an interface which will allow the Owner's energy management system to access the control points shown on the points list. This interface shall be in complete compliance with the current ANSI/ASHRAE Standard #135. Provide any coordination as required to facilitate this interface into the Owner's EMS. Provide all necessary protocol documentation and gateway hardware and software (if required) such that the section 15900 system suppliers may successfully create a communication interface between the control system furnished in this

section of the specification and the 15900 control system. Provide an adequate level of technical support to guide the section 15900 personnel towards completion of subject communication interface. Protocol must support reading/writing status and analog and digital point information from this section of the specification. All documentation, gateway hardware and software, and required technical support are understood to be included in the bid.

3. Temperature Controls shall be accomplished by either of the following methods:
  - a. Factory built-in controls shall be provided to interface with the ATC to accomplish control sequence as outlined in Automatic Control section of specifications.
  - b. Field installed controls provided by the section 15900 contractor is acceptable provided the control sequence as outlined in Automatic Temperature Control section of specifications is met.
  
- M. A water level sensing device shall be factory provided in the unit condensate pan which will shut down the unit in the event this device level is exceeded. Device shall be located in a readily accessible location.

### 2.03 ELECTRICAL COMPONENTS

- A. All electrical controls shall be ETL listed and the entire unit shall be factory wired in accordance with the National Electrical Code Standard.
- B. The outdoor constructed units shall be supplied with a weatherproof non-fused main power disconnect switch. A single point power connection shall be provided for all units.
- C. Unit shall be equipped with all necessary high voltage components as follows:
  1. Variable frequency drives shall be provided on supply, return, and exhaust fan motors. Motors shall operate at constant speed. Fan airflow capacity shall be balanced by manually adjusting the variable frequency drives. See specification section 15905 for variable frequency drives.
  2. Thermal protection on all high voltage motors.
  3. Fuses and fuse holders.
  4. All necessary control transformers.
- D. Unit shall be completed with all necessary relays, time delay, damper actuators with auxiliary switches (as required).

- E. Terminal board shall be provided for low voltage control wiring. Low voltage is 24V.
- F. Fan access doors are equipped with a momentary interrupt switch that shuts off the unit when a protected door is opened. These switches can be removed if belt guards are installed on the fan assembly.
- G. An integral control panel shall be provided having a hinged access door and an approved locking device.
- H. All control devices, except those not mounted directly to the unit, shall be factory mounted and wired. Control panel shall have a labeled strip to land all wires for field installed control components.
- I. All components are fully wired and 100% tested prior to shipping.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Factory Start-up – The manufacturer shall supply complete factory start-up by a factory approved start-up agent. Manufacturer shall provide on-site startup and commissioning assistance through job completion. Complete installation and startup checks according to manufacturers written instructions. This shall include a factory startup for factory provided control devices as well as configuring control points for other DO devices. Service representative shall completely configure all control devices and establish remote internet connectivity with the owner's energy management department web server.
- B. Demonstration - Engage manufacturer or factory-authorized service representative to train Owners maintenance personnel to adjust, operate and maintain individual units and complete system. This shall include training of the owner's energy management department representatives as to establish control system programming, scheduling routines, alarm reporting, system topography, communication protocols and password level assignments.
- C. The energy recovery units shall be installed complete with all accessories in accordance with the manufacturer's recommendations, as listed in the specifications and as shown on the drawings.
- D. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.

- E. Provide a typed list of all the different units and their filter and belt sizes to be included in the O & M manuals. The list shall include the unit designation, filter size and the number of filters required for each unit, and belt size and number of belts for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
1. Project Manager, Office of Design and Construction Services, Gatehouse Administrative Center, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.
  2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032
- F. Provide one set of spare fuses for each energy recovery unit.
- G. Provide one spare set of belts per unit per drive.
- H. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Tag is to be screwed or riveted to unit. Identification tag shall be black with engraved 1/2" white letters which reads:

|                              |                                     |
|------------------------------|-------------------------------------|
| UNIT #                       | <u>(unit number)</u>                |
| INSTALLED BY:                | <u>(contracting company's name)</u> |
| WARRANTY EXPIRES:            | <u>(month/day/year)</u>             |
| COMPRESSOR WARRANTY EXPIRES: | <u>(month/day/year)</u>             |

END OF SECTION

## SECTION 15774

### ENERGY RECOVERY UNITS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, and Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 QUALITY ASSURANCE

- A. The system shall deliver the specified air volume at the static pressure scheduled.
- B. The unit shall be constructed to provide smooth interior surfaces and to limit the casing leakage at less than 1% of the specified air volume at operating static.
- C. Unit shall be constructed in accordance with CSA C22.2 and UL 1812 and shall carry the ETL label of approval.
- D. Unit shall be constructed in accordance with industrial design practices.
- E. Insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.
- F. Airflow data shall comply with AMCA 210 method of testing.
- G. Cabinet and exterior components shall be tested and certified weatherproof.
- H. All units shall be 100% factory tested.
- I. All effectiveness data of heat and energy recovery components shall be certified by the ARI 1060 certification program directory.
- J. Factory Start-Up – The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- K. Equipment installer shall attend a controls coordination meeting with the division 15900 contractor as described in 15900, 1.03.

##### 1.03 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

## PART 2 - PRODUCTS

### 2.01 MANUFACTURERS

- A. Energy recovery unit(s) shall be supplied by Innovent Air Handling Equipment, Valent, Seasons Four , Greenheck and AAON.

### 2.02 EQUIPMENT

General: Factory assembled, consisting of fan and motor assemblies (supply and exhaust), Flat Plate Heat Exchanger, Heat Recovery Wheel, all necessary dampers, hoods, plenums, filters, drain pans, wiring and controls. Unit shall be stand-alone controlled with all control devices provided by the unit manufacturer or control contractor. Unit shall have single point power connection.

A. Unit Cabinet:

1. The energy recovery unit is to be installed outdoors by the mechanical contractor. Indoor units weatherized for outdoor use are not acceptable.
2. All unit panels are fixed with zinc plated hexagonal head type screws complete with a washer and rubber gasket for a weatherproof assembly. Self-drilling, self-tapping screws are used and therefore no tools are required from the unit interior for panel removal. These panels allow for fast service to all major components.
3. All panel joints must be caulked with a weatherproof silicone. The silicone used must be clear to match any color surfaces. After application, the silicone must react with atmospheric moisture to produce a formed-in-place silicone rubber glazing and curtain wall seal.
4. The unit base frame shall be constructed from a bolted, structural formed G90 galvanized steel with internal structural cross members properly sized to allow rigging and handling of the unit. All major components shall be supported by the base without sagging or pulsating. Lifting lugs shall be provided and strategically located to allow equilibrium during lifting.

Options:

- Structural formed G90 galvanized steel (8" [203mm] high) with 6" [152mm] fiberglass insulation (R24)
- Structural "C" channel (5" [127mm] high) with fiberglass insulation (R16)
- All lifting lugs shall be removable after rigging and installation of the unit

5. Unit construction consists of an insulated 14 gauge galvanized structural frame complete with die cast aluminum corners. The rigid frame provides stable construction allowing for panel removal without affecting the unit integrity. Panels shall be double wall construction using 2" thick mineral wool insulation 1.5 lbs/ft<sup>3</sup> density, 18 gauge galvanized steel exterior panels (satin coat finish) and 26 gauge G90 galvanized steel inner liner. The unit shall be designed to resist any snow, ice and wind loads, as well as seismic loads in compliance with the National Building Code. Single wall construction with coated insulation will not be acceptable. Exposed insulation edges in the air stream will not be acceptable.

**Insulating Value**

|                        | Thickness |
|------------------------|-----------|
| Type of Insulation     | 2" [51mm] |
| Mineral wool (3.5 pcf) | R8.6      |
| Urethane               | R14.8     |

6. Internal partition wall shall be insulated and constructed the same as the unit cabinet.
7. Full size access door(s) to allow for periodic maintenance and inspections must be provided for all serviceable components. Serviceable components include but are not limited to Coils, Heat Exchanger, Damper sections, Motor sections and piping enclosures. Doors shall be double wall construction made of 18 gauge galvanized steel on both outer and inner liner for maximum rigidity. Door insulation is the same as the unit panels. Provide doors with heavy duty corrosion resistant aluminum hinges that allow the door to open at 180°. Compression type handles are operable from both sides of the unit access door(s) and neoprene resilient bubble gaskets for an enclosure that is sealed tight shall also be provided. Plastic latches and hinges are not acceptable.
8. Outdoor constructed units shall have a pitched roof to dissipate water accumulation. Rain gutters must be provided above access doors. All roof joint seams are "T" shape construction, minimum height of 1.5", sealed and encapsulated by a metal strip.
9. All weather hoods for outdoor constructed units are provided with birdscreen and rain gutters. Hoods may ship loose for field assembly.
10. Recessed, double-sloped drain pans shall be made of formed sections of steel. Drain pans are sloped with a threaded drain pipe connection of 1 1/2" in diameter ending outside through the structural base channel. All drain pan corners shall be welded.
11. Paint:

- a. Outdoor constructed units shall have one coat of primer and two coats of enamel paint.
- b. All galvanized steel surfaces that require paint shall be made of satin coat-finished galvanized steel of the specified gauge(s).
- c. All galvanized steel surfaces without any paint shall be made of G90 galvanized steel of the specified gauges.
- d. All unit surfaces that require paint must be cleaned and free from all oil, dirt and other contaminants before painting.

B. Flat Plate Heat Exchanger

1. The flat plate heat exchanger assembly shall be CERTIFIED to ARI Standard 1060 and tested in accordance to ASHRAE 84-91.
2. The flat plate heat exchanger shall be cross-flow type made of 6 mil embossed pure aluminum designed to maximize the efficiency and the cleanability while minimizing the pressure loss.
3. The flat plate heat exchanger shall be sectioned within the unit to allow for a section replacement without requiring any lifting devices.
4. Access to all four sides of the flat plate heat exchanger for cleaning and inspection shall be provided.
5. An access section with a sloped IAQ drain pan shall be provided upstream and downstream of the flat plate heat exchanger allowing for service, collection of condensate and cleaning of the flat plate heat exchanger without allowing any standing water to be contained within the unit cabinet.

C. Energy Recovery Heat Wheel (Engineer to edit)

1. Heat Wheels shall comply with UL standards.
2. Heat Wheel - Provide aluminum or polymer transfer media, flame spread rating of not more than 25 and smoke developed rating of not more than 50 and shall be independently tested in accordance with ASTM standard E-84. Rotor media shall be independently tested in accordance with ASHRAE Standards. It shall allow laminar flow (but not radial) at usual velocities and prevent leakage, bypassing and cross contamination by cross flow within wheel. Size the transfer media to allow passage of 300 micron particles without fouling or clogging. Treat media with non-degrading desiccant that is bacteriostatic, non-corroding and non-toxic. No asbestos material will be allowed. Wheel shall not condense water



directly or require a condensate drain for summer or winter operation. Performance rating shall be in accordance with ARI Standard 1060.

3. Provide casing seals on periphery of rotor as well as on duct divider and purge section. Seals are to be adjustable, of extended life materials and effective in limiting air leakage.
4. Wheel shall be supported by ball or roller bearings and belt driven by a fractional horsepower, totally enclosed, NEMA Standard motor through a close coupled positively lubricated speed reducer, or gear/chain speed reduction.
5. Unit shall be constructed of heavy gage steel to insure rigidity and stability. Casing side panels shall be removable to insure easy access to internal parts. Provide integral flanges for flanged duct connection and provide lifting holes or lugs.

D. Defrost Strategies (Engineer to edit)

1. The traversing defrost system is DDC controlled. Independent traversing dampers with actuators and bypass damper (if free-cooling is required). This defrost strategy allows for the recovery of energy while the unit is in defrost.
2. Recirculation defrost including outside air, exhaust air and recirculation dampers with actuators and the appropriate controls.
3. Exhaust only defrost including outside air and exhaust air dampers with actuators and the appropriate controls.
4. Face and bypass defrost including face and bypass dampers with actuators and the appropriate controls. Bypass may also be used for free-cooling in summer operation (if required).

E. Fans:

1. Fan performance ratings for flow rate, pressure, power, air density, speed or rotation and efficiency shall be factory tested and shall comply with the requirements of AMCA 210.
2. All fans shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 300.

3. Fans shall be of centrifugal type, rigidly braced and reinforced to help prevent vibration or pulsation. Wheel diameters and outlet areas shall be in accordance with the standard sizes adopted by AMCA.
4. Fan and motors shall be mounted inside the unit casing with 1" (minimum 90% efficiency) deflection spring vibration isolators and supplied with neoprene flexible connections.
5. Fans shall be selected for a stable operation, at least 20% under the fans first critical speed.
6. Units shall be equipped with non-overloading, airfoil, SWSI plenum fan, Arrangement 3 (AMCA labeled) supply and exhaust fans to provide scheduled airflows against static pressures indicated.
7. Fan shaft shall be solid steel, turned, ground, polished and completed with a corrosion resistant coating. Fan wheels shall be keyed to the shaft.
8. Bearings shall be heavy duty, grease-lubricated, self-aligning ball or pillow block type. Bearing shall be selected for a basic rating fatigue life (L-50) in excess of 200,000 hours at maximum operating speed in accordance with AFBMA 9 regulations.
9. Fan drives shall be designed for a 1.4 service factor. Drives are factory mounted with final alignment and belt adjustment made before unit start-up.
10. Belt drives with motor pulley shall be adjustable pitch for use with motors up to and including 10 HP. Fan pulleys shall be fixed pitch.

F. Motors:

1. All motors are internal to the unit casing and are mounted on an adjustable base allowing for belt alignment and tensioning.
2. Fan motors shall be heavy duty, 1800 rpm, high efficiency (E-pact Series), open drip proof (ODP), NEMA Design B with Class F insulation and 1.15 service factor. Motors shall be constant speed operable at field voltage: 460 Volts, 60 Hz, 3 phase.
3. Torque characteristics shall be sufficient to accelerate the drive loads satisfactorily.
4. Motor sizes shall be minimum size indicated in the equipment schedule. If not indicated, large enough so that the drive load will not require the motor to operate in the service factor range.

5. Temperature rating shall be 122°F (50°C) maximum temperature rise at 104°F (40°C) ambient for continuous duty at full load (Class B Insulation).
  6. Motor construction shall be NEMA Standard MG 1, general purpose, continuous duty, Design B.
    - a. Bases shall be adjustable.
    - b. Bearings shall be:
      - 1). Ball or roller bearing with inner and outer shaft seals.
      - 2). Grease lubricated.
      - 3). Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motors.
    - c. Energy efficient motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112-B. If efficiency is not specified, motors shall give a higher efficiency than "average standard industry motors" in accordance with IEEE Standard 112-B.
- G. Filters:
1. Filters shall be UL 900 Class II.
  2. Outside and return air inlet shall be equipped with galvanized steel racks that permit slide out removal of filters (side access) for units equal or smaller than 78", and universal holding frames with upstream access for units taller than 78".
  3. Filter banks shall be arranged for flat orientation. The air velocity shall not exceed 500 fpm through each filter bank.
  4. Unit shall include 2" disposable type air filters, 25-30% DSE efficiency, consisting of viscous coated fibers with filtering media encased in fiberboard cell sides having perforated metal grids on each face to provide media support. Airflow resistance with clean media shall not exceed 0.28 inch w.g. at a face velocity of 500 fpm and filter arrestance efficiency of 90% based on ASHRAE Test Standard 52. Filters shall have a minimum MERV rating of 13.
- H. Dampers:
1. Air leakage through a 48" x 48" damper shall not exceed 10.3 cfm/sq.ft. against 4 in. wg. differential static pressure at standard air. Standard air leakage data to be certified under AMCA certified rating program.

2. Dampers are designed for operation in temperatures ranging between -40°F and 212°F.
  3. Unit shall be equipped with all necessary dampers. Dampers for outside air intake, exhaust air and all other dampers required for the system, including the dampers for defrost (if required).
  4. Intake outside air dampers are opposed blade type and exhaust air dampers are parallel blade type. For other dampers, see manufacturer's recommendations.
  5. Outside air dampers shall be motorized. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
  6. Exhaust air dampers shall be *gravity backdraft type*. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
  7. Dampers construction shall be as followed:
    - a. Damper frame shall be extruded aluminum.
    - b. Blades shall be extruded aluminum.
    - c. Dampers shall be opposed blade type or parallel blades where indicated
    - d. Damper blade ends shall be sealed with neoprene flexible edge seals complete with bottom and top blade wiper seals.
    - e. Frame and blades shall be non-insulated.
- I. Coils – General Information:
1. Acceptable coils shall have ARI Standard 410 certification and bear the ARI symbol. Coil manufacturer must be ISO 9002 certified.
  2. Coils shall be submerged in water and tested with a minimum of 315 psi air pressure for standard copper tube coils. Coils must display a tag with the inspector's identification as proof of testing.
  3. Tubes shall have a nominal thickness of 0.020" unless otherwise specified.
  4. Fins shall be made of 0.0075" thick aluminum unless otherwise specified.
  5. Tubing, return bends and headers shall be constructed from UNS 12200 seamless copper conforming to ASTM B75 and ASTM B251 for standard

pressure applications. Coil return headers shall be equipped with factory installed 1.2" fpt air vent connection placed at the highest point available on the face of the header (except for evaporator coils).

6. Casings and endplates shall be made of 16 gauge galvanized steel, meeting ASTM A527 unless otherwise noted. Double flanged casings on the top and bottom of finned height are to be provided to allow for stacking of the coils. On applications where cooling coils are stacked, use an intermediate drain pan to dissipate water accumulation. All drain lines shall be field trapped as per manufacturer's recommendations. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded.
7. Piping, control valve and valve operator shall be supplied and installed by others.
  - a. Hot Water Coils:
    - 1) Coils shall be designed to withstand 250 psi maximum operating pressure and a maximum steam temperature of 300°F (149°C) for standard duty copper tube coils.
    - 2) Coil tube size and wall thickness is 5/8" x 0.020" [16 x 0.5mm] standard for copper.
    - 3) Standard construction fluid connections are male pipe thread (MPT) and constructed from red brass conforming to ASTM B43 or Schedule 40 steel pipe as a minimum.
  - b. Chilled Water Coils:
    - 1) Coils shall be designed to withstand 250 psi maximum operating pressure and a maximum fluid temperature of 300°F for standard duty copper tube coils.
    - 2) Coil tube size and wall thickness is 5/8" x 0.020" standard for copper.
    - 3) Standard construction fluid connections are male pipe thread (MPT) and constructed from red brass conforming to ASTM B43 or Schedule 40 steel pipe as a minimum.
- J. Roofcurb: Roofcurb shall be supplied by the unit manufacturer for field assembly. Curb shall be one piece; two piece curbs will not be accepted. Curb shall consist of formed 18 gauge galvanized steel sections. Manufacturer's curb is standard double wall, 18" in height, 2" thick fiberglass insulation. Unit base design is made for recessed curb installation. Stiffeners will be provided for field

assembly when required. Pitch roof curb to match building roof. Provide wood nailer.

K. Sound Ratings:

1. The sound power rating (re:  $10^{-12}$  watts) leaving the energy recovery unit under the tabulated conditions shall not exceed the following in any octave band:

ENERGY RECOVERY UNITS SOUND POWER BY  
OCTAVE BAND  $10^{-12}$  WATTS at Specified AirFlow and  
Static Pressure

| Octave Band   | 1   | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---------------|---|---|---|---|---|---|---|---|
| Mid Frequency | <u>**ENGINEER TO LIST CORRESPONDING NUMBERS**</u> |   |   |   |   |   |   |   |
| ERU-1         | #   | # | # | # | # | # | # | # |
| ERU-2         | #   | # | # | # | # | # | # | # |

2. Energy recovery unit sound ratings shall be based on tests in a sound laboratory reverberant room strictly conforming to ASHRAE Standard 36-62, in accordance with AMCA 300 procedures. Sound data must be accurate to within  $\pm 5$  db @ 63 Hz,  $\pm 4$  db @ 125 Hz,  $\pm 2$  db from 250-2000 Hz,  $\pm 3$  db @ 4000 Hz and above.
3. Where the manufacturer's sound power data is not published, an officer of the company must certify that sound data conforms to the above requirements. If the manufacturer does not have acoustical facilities in accordance with the above requirements, the contractor must submit certified data that the specified operating conditions, to determine sound power levels by octave band

L. Temperature Controls shall be accomplished by either of the following methods:

1. Factory built-in controls shall be provided to interface with the ATC to accomplish control sequence as outlined in Automatic Temperature Control section of specifications.
2. Field installed controls provided by the section 15900 contractor is acceptable provided the control sequence as outlined in Automatic Temperature Control section of specifications is met.

The control contractor must have the ability to interface with and control the factory supplied outside airflow monitoring assembly.

- M. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded. Condensate float shall be located in a readily accessible location.

:

## 2.03 ELECTRICAL COMPONENTS

- A. All electrical controls shall be ETL listed and the entire unit shall be factory wired in accordance with the National Electrical Code Standard.
- B. The outdoor constructed units shall be supplied with a weatherproof non-fused main power disconnect switch. A single point power connection shall be provided for all units.
- C. Unit shall be equipped with all necessary high voltage components as follows:
  - 1. Variable frequency drives shall be provided on supply, return and exhaust fan motors. Motors shall operate at constant speed. Fan speed shall be adjustable through the variable frequency drive. See specification section 15905 for variable frequency drives.
  - 2. Thermal protection on all high voltage motors.
  - 3. Fuses and fuse holders.
  - 4. All necessary control transformers.
- D. Unit shall be completed with all necessary relays, time delay, damper actuators with auxiliary switches (as required).
- E. The automatic unit start-up is provided as standard via an external dry contact provided by others (ex: Building management system, DDC controller, time clock, etc.).
- F. Terminal board shall be provided for low voltage control wiring. Low voltage is 24V.
- G. Fan access doors are equipped with a momentary interrupt switch that shuts off the unit when a protected door is opened. These switches can be removed if belt guards are installed on the fan assembly.
- H. An integral control panel shall be provided having a hinged access door and an approved locking device.
- I. All control devices, except those not mounted directly to the unit, shall be factory mounted and wired. Control panel shall have a labeled strip to land all wires for field installed control components.

- J. All components are fully wired and 100% tested prior to shipping.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Factory Start-up- The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- B. The energy recovery units shall be installed complete with all accessories in accordance with the manufacturer's recommendations, as listed in the specifications and as shown on the drawings.
- C. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- D. Provide a typed list of all the different units and their filter sizes to be included in the O & M manuals. The list shall include the unit designation, filter size and the number of filters required for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032
- E. Provide one set of spare fuses for each energy recovery unit.
- F. Provide one spare belt per unit.
- G. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Identification tag shall be black with engraved 1/2 " white letters which reads:



|                              |                                     |
|------------------------------|-------------------------------------|
| UNIT #                       | <u>(unit number)</u>                |
| INSTALLED BY:                | <u>(contracting company's name)</u> |
| WARRANTY EXPIRES:            | <u>(month/day/year)</u>             |
| COMPRESSOR WARRANTY EXPIRES: | <u>(month/day/year)</u>             |

END OF SECTION

## SECTION 15775

### PACKAGE VAV ROOFTOP HEATING AND COOLING UNITS (Engineer to edit heating system used)

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010- General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 QUALITY ASSURANCE

- A. The packaged units shall be rated in accordance with ARI Standards 210/240 and 340/360. Unit shall be designed in accordance with UL standards. Unit shall comply with applicable requirements in ASHRAE 62.1-2004 sections 5 and 7 as well as ASHRAE/IESNA 90.1-2004 section 6.
- B. Construct gas fired heating sections in accordance with AGA safety standards and provide AGA label. Unit shall comply with ANSI Z21.47 and NFPA 54.
- C. Factory start-up- the manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- D. Equipment installer shall attend a controls coordination meeting with the section15900 contractor as described in 15900, 1.03.

##### 1.03 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 PACKAGED VAV ROOFTOP HEATING AND COOLING UNIT

The rooftop unit shall be of the type and capacity shown the drawings. The units shall be manufactured by TRANE. Units fully equal to the specified manufacturer and manufactured by CARRIER or DAIKIN are acceptable.

- A. Packaged Assembly: Unit shall consist of a completely assembled, piped, wired and tested unit composed of; a weatherproof enclosure with hinged gasketed locking access doors and a non-corrosive, sloped, cleanable, insulated, IAQ type condensate drain pan, centrifugal blower with belt drive air handling section, low velocity throwaway filter section, complete direct expansion air cooled cooling

system section, single point power connection, and gas fired or hot water heating section all mounted on one base with additional roof adapting components and accessories as required in this specification or as shown on the plans.

- B. Enclosure: Shall be heavy gauge zinc-coated steel with baked enamel finish and shall be completely weatherized for outdoor installation. The unit roof shall be cross broken and/or sloped to assure drainage. Access to compressors, controls, blower section, heating section and other items needing periodic checking or maintenance shall be through hinged access doors. All access doors shall have gaskets and provide a weather tight seal. The air handling section of the unit shall have ½ minimum non-eroding fiberglass insulation.
- C. Fan Section: Fan shall have forward curved blades, belt driven with adjustable motor sheaves. The motor and fan shall have permanently lubricated ball bearings. The motor shall have thermal overload protection. Supply air flow modulation shall be by a factory installed variable frequency drive. ( see section 15905 for acceptable drive manufacturer)
- D. Filter Section: Shall fit into integral racks inside casing. Maximum velocity through filter 350 fpm. Filters shall be pleated, 2" thick rigid extended surface, 35% efficient and a MERV rating of 13 throwaway type. Two complete sets of spare filters shall be supplied in addition to the set used during construction.
- E. Cooling Section: Shall have vibration isolated scroll or hermetic compressor(s), copper tube aluminum fin air cooled condensing coil and propeller type condenser fans direct-connected to inherently protected motors. Provide metal hail/vandal guards to protect the condenser coil fins. Complete system shall be factory de-hydrated, tested and charged. Refrigeration cycle shall include condenser and evaporator fan compressor cutouts, 24-volt transformers, low and high pressure cutouts, crankcase heaters, liquid line solenoid valves for system pump-down and compressor protection cutout with reset. Refrigerant shall be 410A. Units rated 10 tons and above shall have 50% capacity reduction capability. Units with a cooling capacity of 54 MBH and greater shall be equipped with an economizer cycle and shall include low leakage outside air damper.
- F. Hot Water Heating Coils: Shall be ARI certified non-freeze type pitched within the ductwork for proper drainage. Headers shall be heavy-gauge galvanized steel. Maximum work pressure limit of coil shall be 175 psig at 400 degrees F. Coils shall be within unit or remote in ductwork as shown on plans. When in unit, piping to coils shall be within unit.
- G. Gas Fired Furnace: Provide manufacturer's standard construction for gas-fired heat exchangers and burners, designed for fully modulating operation to maintain discharge temperature. Provide single gas connection.

1. Gas Burner Controls.  
Provide the following controls:
  - Redundant gas valves
  - Intermittent pilot ignition
  - Electronic spark ignition system
  - High limit cutout
  - Flame rollout switch
- H. Hot Gas Reheat for Dehumidification - Hot gas reheat coils, piping and fully modulating controls shall be factory installed for humidity control.
- I. Economizer Control: Provide economizer control consisting of return and outside air dampers, outside air filter, fully modulating electronic control system with reference enthalpy control and adjustable mixed-air thermostat. Design system for 100% outside air capability. Provide automatic changeover through adjustable enthalpy control device. Units without economizer cycle shall have 25% motorized outside air damper.
- J. Temperature Controls: Factory built-in controls shall be provided to interface with the ATC to accomplish control sequence as outlined in Automatic Temperature Control section of specifications.
  1. Manufacturer shall provide a interface device which will allow the Owner's energy management system to access the control points required by the specification section 15900. Provide any coordination as required to facilitate this interface with the Owners energy management system. Provide all necessary protocol documentation and gateway hardware and software (if required) such that the section 15900 system supplier may successfully create a communication interface between the control system furnished in this section of the specification and the 15900 control system. Provide an adequate level of technical support to guide the section 15900 personnel towards completion of subject communication interface. Protocol must support reading status and analog and digital point information from this section of the specification. All documentation, gateway hardware and software, and required technical support are understood to be included in the bid.
  2. Unit shall be equipped an electronic supply air discharge temperature controller with zone, return and outdoor air reset capabilities.
- K. Accessories: Units shall include the following accessories:
  1. All units 15 tons and larger shall have vibration isolation roof curb assembly. All other units shall have vibration isolation roof curb assembly, when shown on drawings. Pre-fabricated aluminum or galvanized steel curbs 14" high shall be provided to match the rooftop unit. The curb shall be flashed to match the roofing system. Provide

wood nailer. The rooftop unit and curb shall be provided by the same manufacturer.

2. Units with a cooling capacity less than 54 MBH shall have two-position, motorized outside air dampers (25% minimum) and low ambient control to 0 deg F. Accessories shall be of the same manufacturer as the rooftop unit.
3. Units with cooling capacities of 54 MBH or greater shall have economizer cycle and 100% barometric relief. Units that incorporate a modulating power exhaust based on building static or economizer damper position are acceptable.
4. All damper actuators shall be spring return type (for loss of power). Actuators using means other than true spring return are not acceptable.
5. Provide a factory installed outside air flow monitoring device to ensure minimum outside air flow requirements are met. This device shall compensate the outside air flow in relation to supply air percentage as it increases and decreases.
6. Provide extended grease lines for all fan bearings.
7. Accessories shall be of the same manufacturer as the rooftop unit.
8. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded. Condensate float shall be located in a readily accessible location.
9. Roof curbs shall be one piece; two piece curbs will not be accepted.
10. Provide factory mounted sensor between evaporator coil and hot gas reheat coil for connection to the ATC system.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Factory start-up- The manufacturer shall supply a complete factory start-up by a factory approved start-up agent.
- B. The packaged vav rooftop unit shall be installed complete with all accessories in accordance with the manufacturer's recommendations, as indicated in the specifications and as shown on the drawings.

- C. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- D. Provide one spare fan belt for each packaged vav rooftop unit.
- E. Provide a typed list of all the different units, their filter sizes, and belt sizes to be included in the O & M manuals. The list shall include the unit designation, filter size belt size and the number of filters and belts required for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032
- F. Supply and return air ductwork connecting to package rooftop units setting on steel framing shall have flexible connections in the ductwork located inside the building, just below the roofline. Package VAV rooftop units setting on roof curbs which discharge horizontally shall have the flexible connection located within the building.
- G. Provide one set of spare fuses for each package rooftop unit.
- H. Warranty Tag - The contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Identification tag shall be black with engraved 1/2 "white letters which reads:

UNIT # (unit number)

INSTALLED BY: (contracting company's name)

WARRANTY EXPIRES: (month/day/year)

COMPRESSOR WARRANTY EXPIRES: (month/day/year)

- I. Tag is to be screwed or riveted to unit.

END OF SECTION

## SECTION 15776

### ENERGY RECOVERY UNITS - HEAT PUMP

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 QUALITY ASSURANCE

- A. The system shall deliver the specified air volume at the static pressure scheduled.
- B. The unit shall be constructed to provide smooth interior surfaces and to limit the casing leakage at less than 1% of the specified air volume at operating static.
- C. Unit shall be constructed in accordance with CSA C22.2 and UL 1812 and shall carry the ETL label of approval.
- D. Unit shall be constructed in accordance with industrial design practices.
- E. Insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.
- F. Airflow data shall comply with AMCA 210 method of testing.
- G. Cabinet and exterior components shall be tested and certified weatherproof.
- H. All units shall be 100% factory tested.
- I. All effectiveness data of heat and energy recovery components shall be certified by the ARI 1060 certification program directory.
- J. Factory Start-up - The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- K. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### 1.03 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

**PART 2 - PRODUCTS**

## 2.01 MANUFACTURERS

- A. Energy recovery unit(s) shall be supplied by GREENHECK, INNOVENT AIR HANDLING EQUIPMENT, SEASONS 4, VALENT and AAON.

## 2.02 EQUIPMENT

- A. General: Factory assembled, consisting of fan and motor assemblies (supply and exhaust), heat wheel, all necessary dampers, hoods, plenums, filters, drain pans, wiring and controls. Unit shall be stand-alone controlled with all control devices provided by the unit manufacturer or control contractor. Unit shall have single point power connection.
- B. Unit Cabinet:
1. The energy recovery unit is to be installed outdoors by the mechanical contractor. Indoor units weatherized for outdoor use are not acceptable.
  2. All unit panels are fixed with zinc plated hexagonal head type screws complete with a washer and rubber gasket for a weatherproof assembly. Self-drilling, self-tapping screws are used and therefore no tools are required from the unit interior for panel removal. These panels allow for fast service to all major components.
  3. All panel joints must be caulked with a weatherproof silicone. The silicone used must be clear to match any color surfaces. After application, the silicone must react with atmospheric moisture to produce a formed-in-place silicone rubber glazing and curtain wall seal.
  4. The unit base frame shall be constructed from a bolted, structural formed G90 galvanized steel with internal structural cross members properly sized to allow rigging and handling of the unit. All major components shall be supported by the base without sagging or pulsating. Lifting lugs shall be provided and strategically located to allow equilibrium during lifting.
  5. Unit construction consists of an insulated 14 gauge galvanized structural frame complete with die cast aluminum corners. The rigid frame provides stable construction allowing for panel removal without affecting the unit integrity. Panels shall be double wall construction using 2" thick mineral wool insulation 1.5 lbs/ft<sup>3</sup> density, 18 gauge galvanized steel exterior panels (satin coat finish) and 26 gauge G90 galvanized steel inner liner. The unit shall be designed to resist any snow, ice and wind loads, as well as seismic loads in compliance with the National Building Code. Single wall construction with coated insulation will not be acceptable. Exposed insulation edges in the air stream will not be acceptable.



| INSULATING VALUE       |              |
|------------------------|--------------|
| TYPE OF INSULATION     | 2" THICKNESS |
| Mineral wool (3.5 pcf) | R8.6         |
| Urethane               | R14.8        |

6. Internal partition wall shall be insulated and constructed the same as the unit cabinet.
7. Full size access door(s) to allow for periodic maintenance and inspections must be provided for all serviceable components. Serviceable components include but are not limited to Coils, Heat Exchanger, Damper sections, Motor sections and piping enclosures. Doors shall be double wall construction made of 18 gauge galvanized steel on both outer and inner liner for maximum rigidity. Door insulation is the same as the unit panels. Provide doors with heavy duty corrosion resistant aluminum hinges that allow the door to open at 180°. Compression type handles are operable from both sides of the unit access door(s) and neoprene resilient bubble gaskets for an enclosure that is sealed tight shall also be provided. Plastic latches hinges are not acceptable.
8. Outdoor constructed units shall have a pitched roof to dissipate water accumulation. Rain gutters must be provided above access doors. All roof joint seams are "T" shape construction, minimum height of 1.5", sealed and encapsulated by a metal strip.
9. All weather hoods for outdoor constructed units are provided with birdscreen and rain gutters. Hoods may ship loose for field assembly.
10. Recessed, double-sloped drain pans shall be made of formed sections of steel. Drain pans are sloped with a threaded drain pipe connection of 1 1/2" in diameter ending outside through the structural base channel. All drain pan corners shall be welded.
11. Paint:
  - a. Outdoor constructed units shall have one coat of primer and two coats of enamel paint.
  - b. All galvanized steel surfaces that require paint shall be made of satin coat-finished galvanized steel of the specified gauge(s).
  - c. All galvanized steel surfaces without any paint shall be made of G90 galvanized steel of the specified gauges.

- d. All unit surfaces that require paint must be cleaned and free from all oil, dirt and other contaminants before painting.

C. Energy Recovery Heat Wheel

1. Heat Wheels shall comply with UL standards.
2. Heat Wheel - Provide aluminum or polymer transfer media, flame spread rating of not more than 25, and smoke developed rating of not more than 50, and shall be independently tested in accordance with ASTM standard E-84. Rotor media shall be independently tested in accordance with ASHRAE Standards. It shall allow laminar flow (but not radial) at usual velocities and prevent leakage, bypassing and cross contamination by cross flow within wheel. Size the transfer media to allow passage of 300 micron particles without fouling or clogging. Treat media with non-degrading desiccant that is bacteriostatic, non-corroding, and non-toxic. No asbestos material will be allowed. Wheel shall not condense water directly or require a condensate drain for summer or winter operation. Performance rating shall be in accordance with ARI Standard 1060.
3. Provide casing seals on periphery of rotor as well as on duct divider and purge section. Seals are to be adjustable, of extended life materials, and effective in limiting air leakage.
4. Wheel shall be supported by ball or roller bearings and belt driven by a fractional horsepower, totally enclosed, NEMA Standard motor through a close coupled positively lubricated speed reducer, or gear/chain speed reduction.
5. Unit shall be constructed of heavy gage steel to insure rigidity and stability. Casing side panels shall be removable to insure easy access to internal parts. Provide integral flanges for flanged duct connection and provide lifting holes or lugs.

D. Integral Water Cooled Heat Pump

1. Unit shall be provided with a complete integral factory piped and wired mechanical refrigeration system consisting of: scroll compressors, an ARI rated air-refrigerant coil, a UL listed water refrigerant coil, service valves, expansion valves, 4-way reversing valve, high/low pressure switches, anti-recycle timers, compressor contactors, suction accumulator, liquid receiver, line filter-drier, pressure ports, and sight glass shall be factory provided and installed. Hermetic scroll compressors shall be used, mounted on RIS vibration isolators, and provided with a sumpheater. Water refrigerant coil shall be of brazed plate stainless steel type. Air-refrigerant coil is constructed of seamless copper tube primary surface and rippled aluminum plate fin secondary surface. Air refrigerant coil core

is tested with 315 psig air pressure under warm water and guaranteed for 250 psig working pressure. All brazed plate heat exchangers, refrigerant specialties and refrigerant piping shall be factory insulated as required by the manufacturer to avoid sweating.

2. Integral heat pump system shall be capable of modulating the cooling and heating capacity to maintain specified discharge air temperature. Water/R-410A heat exchangers shall be provided with an entering fluid side strainer, leaving fluid side freeze stat, and fluid flow proving switch. Fluid flow valves and actuators shall be provided by the installing contractor and installed in the field. Field installed water piping must be field insulated.

E. Modulating Hot Gas Reheat

1. Unit shall be provided with a factory mounted and piped hot gas reheat coil, 3-way valve, and modulating gas control valve.

F. Fans

1. Fan performance ratings for flow rate, pressure, power, air density, speed or rotation and efficiency shall be factory tested and shall comply with the requirements of AMCA 210.
2. All fans shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 300.
3. Fans shall be of centrifugal type, rigidly braced and reinforced to help prevent vibration or pulsation. Wheel diameters and outlet areas shall be in accordance with the standard sizes adopted by AMCA.
4. Fan and motors shall be mounted inside the unit casing with 1" (minimum 90% efficiency) deflection spring vibration isolators and supplied with neoprene flexible connections.
5. Fans shall be selected for a stable operation, at least 20% under the fans first critical speed.
6. Units shall be equipped with non-overloading, airfoil, SWSI plenum fan, Arrangement 3 (AMCA labeled) supply and exhaust fans to provide scheduled airflows against static pressures indicated.
7. Fan shaft shall be solid steel, turned, ground, polished and completed with a corrosion resistant coating. Fan wheels shall be keyed to the shaft.
8. Bearings shall be heavy duty, grease-lubricated, self-aligning ball or pillow block type. Bearing shall be selected for a basic rating fatigue life (L-50) in

excess of 200,000 hours at maximum operating speed in accordance with AFBMA 9 regulations.

9. Fan drives shall be designed for a 1.4 service factor. Drives are factory mounted with final alignment and belt adjustment made before unit start-up.
10. Belt drives with motor pulley shall be adjustable pitch for use with motors up to and including 10 HP. Fan pulleys shall be fixed pitch.

G. Motors

1. All motors are internal to the unit casing and are mounted on an adjustable base allowing for belt alignment and tensioning.
2. Fan motors shall be heavy duty, 1800 rpm, high efficiency (E-pact Series), open drip proof (ODP), NEMA Design B with Class F insulation and 1.15 service factor. Motors shall be constant speed operable at field voltage: 460 Volts, 60 Hz, 3 phase.
3. Torque characteristics shall be sufficient to accelerate the drive loads satisfactorily.
4. Motor sizes shall be minimum size indicated in the equipment schedule. If not indicated, large enough so that the drive load will not require the motor to operate in the service factor range.
5. Temperature rating shall be 122°F (50°C) maximum temperature rise at 104°F (40°C) ambient for continuous duty at full load (Class B Insulation).
6. Motor construction shall be NEMA Standard MG 1, general purpose, continuous duty, Design B.
  - a. Bases shall be adjustable.
  - b. Bearings shall be:
    - 1) Ball or roller bearing with inner and outer shaft seals.
    - 2) Grease lubricated.
    - 3) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motors.
  - c. Energy efficient motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112-B. If efficiency is not specified, motors shall give a higher efficiency than "average

standard industry motors" in accordance with IEEE Standard 112-B.

#### H. Filters

1. Filters shall be UL 900 Class II.
2. Outside and return air inlet shall be equipped with galvanized steel racks that permit slide out removal of filters (side access) for units equal or smaller than 78", and universal holding frames with upstream access for units taller than 78".
3. Filter banks shall be arranged for flat orientation. The air velocity shall not exceed 500 fpm through each filter bank.
4. Unit shall include 2" disposable type air filters, 25-30% DSE efficiency, consisting of viscous coated fibers with filtering media encased in fiberboard cell sides having perforated metal grids on each face to provide media support. Airflow resistance with clean media shall not exceed 0.28 inch w.g. at a face velocity of 500 fpm and filter arrestance efficiency of 90% based on ASHRAE Test Standard 52. Filters shall have a minimum MERV rating of 13.

#### I. Dampers

1. Air leakage through a 48" x 48" damper shall not exceed 10.3 cfm/sq.ft. against 4 in. wg. differential static pressure at standard air. Standard air leakage data to be certified under AMCA certified rating program.
2. Dampers are designed for operation in temperatures ranging between -40°F and 212°F.
3. Unit shall be equipped with all necessary dampers. Dampers for outside air intake, exhaust air and all other dampers required for the system, including the dampers for defrost (if required).
4. Intake outside air dampers are opposed blade type and exhaust air dampers are parallel blade type. For other dampers, see manufacturer's recommendations.
5. Outside air dampers shall be motorized. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
6. Exhaust air dampers shall be gravity backdraft type. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
7. Dampers construction shall be as followed:

- a. Damper frame shall be extruded aluminum.
  - b. Blades shall be extruded aluminum.
  - c. Dampers shall be opposed blade type or parallel blades where indicated
  - d. Damper blade ends shall be sealed with neoprene flexible edge seals complete with bottom and top blade wiper seals.
  - e. Frame and blades shall be non-insulated.
- J. Roof curb: Roof curb shall be supplied by the unit manufacturer for field assembly. Curb shall consist of formed 18 gauge galvanized steel sections. Manufacturer's curb is standard double wall, 14" in height, un-insulated. Unit base design is made for recessed curb installation. Stiffeners will be provided for field assembly when required. Pitch roof curb to match building roof. Provide wood nailer. Curb shall be one piece. Two piece curbs are not acceptable.
- K. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded. Condensate float shall be located in a readily accessible location.
- L. Provide factory mounted sensor between evaporator coil and hot gas reheat coil for connection to the ATC system.
- M. Temperature Controls
1. Shall be provided to accomplish control sequence as outlined in the automatic temperature control section of specifications. All temperature controls shall be factory installed, wired, and programmed by the manufacturer or see item 3 below.
  2. Manufacturer shall provide an interface which will allow the Owner's energy management system to access the control points shown on the points list. This interface shall be in complete compliance with ANSI/ASHRAE Standard #135-1995. Provide any coordination as required to facilitate this interface into the Owner's EMS. Provide all necessary protocol documentation and gateway hardware and software (if required) such that the section 15900 system suppliers may successfully create a communication interface between the control system furnished in this section of the specification and the 15900 control system. Provide an adequate level of technical support to guide the section 15900 personnel towards completion of subject communication interface. Protocol must support reading/writing status and analog and digital point information from this section of the specification. All documentation, gateway hardware and software, and required technical support are understood to be included in the bid.

3. Temperature Controls shall be accomplished by either of the following methods:
  - a. Factory built-in controls shall be provided to interface with the ATC to accomplish control sequence as outlined in Automatic Temperature Control section of specifications.
  - b. Field installed controls provided by the section 15900 contractor is acceptable provided the control sequence as outlined in Automatic Temperature Control section of specifications is met.
  - c. The control contractor must have the ability to interface with and control the factory supplied outside airflow monitoring assembly.

### 2.03 ELECTRICAL COMPONENTS

- A. All electrical controls shall be ETL listed and the entire unit shall be factory wired in accordance with the National Electrical Code Standard.
- B. The outdoor constructed units shall be supplied with a weatherproof non-fused main power disconnect switch. A single point power connection shall be provided for all units.
- C. Unit shall be equipped with all necessary high voltage components as follows:
  1. Variable frequency drives shall be provided on supply, return, and exhaust fans. Motors shall operate at constant speed. Fan speed shall be adjustable through the variable frequency drive. See specification section 15905 for variable frequency drives.
  2. Thermal protection on all high voltage motors.
  3. Fuses and fuse holders.
  4. All necessary control transformers.
- D. Unit shall be completed with all necessary relays, time delay, damper actuators with auxiliary switches (as required).
- E. The automatic unit start-up is provided as standard via an external dry contact provided by others (ex: Building management system, DDC controller, time clock, etc.).
- F. Terminal board shall be provided for low voltage control wiring. Low voltage is 24V.

- G. Fan access doors are equipped with a momentary interrupt switch that shuts off the unit when a protected door is opened. These switches can be removed if belt guards are installed on the fan assembly.
- H. An integral control panel shall be provided having a hinged access door and an approved locking device.
- I. All control devices, except those not mounted directly to the unit, shall be factory mounted and wired. Control panel shall have a labeled strip to land all wires for field installed control components.
- J. All components are fully wired and 100% tested prior to shipping.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Factory Start-up - The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- B. The energy recovery units shall be installed complete with all accessories in accordance with the manufacturer's recommendations, as listed in the specifications and as shown on the drawings.
- C. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- D. Provide one set of spare fuses for each energy recovery unit.
- E. Provide one spare belt per unit.
- F. Provide a typed list of all the different units, their filter sizes, and belt sizes to be included in the O&M manuals. The list shall include the unit designation, filter size, belt size, and the number of filters and belts required for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, Gatehouse Administrative Center, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia 22032.
- G. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Identification tag shall be black with engraved 3 " white letters which reads:



|                              |                                     |
|------------------------------|-------------------------------------|
| UNIT #                       | <u>(unit number)</u>                |
| INSTALLED BY:                | <u>(contracting company's name)</u> |
| WARRANTY EXPIRES:            | <u>(month/day/year)</u>             |
| COMPRESSOR WARRANTY EXPIRES: | <u>(month/day/year)</u>             |

END OF SECTION

## SECTION 15777

### PACKAGE ROOFTOP HEATING AND COOLING UNITS WITH ENTHALPY PLATES

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 QUALITY ASSURANCE

- A. The system shall deliver the specified air volume at the static pressure scheduled.
- B. The unit shall be constructed to provide smooth interior surfaces and to limit the casing leakage at less than 1% of the specified air volume at operating static.
- C. Unit shall be constructed in accordance with CSA C22.2 and UL 1812 and shall carry the ETL label of approval.
- D. Unit shall be constructed in accordance with industrial design practices.
- E. Insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.
- F. Airflow data shall comply with AMCA 210 method of testing.
- G. Cabinet and exterior components shall be tested and certified weatherproof.
- H. All units shall be 100% factory tested.
- I. All effectiveness data of heat and energy recovery components shall be certified by the ARI 1060 certification program directory.
- J. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### 1.03 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

**PART 2 - PRODUCTS**

**2.01 MANUFACTURERS**

The rooftop unit shall be manufactured by VALENT. Units fully equal to the specified manufacturer and manufactured by DAIKIN or MUNTERS are acceptable.

**2.02 EQUIPMENT**

- A. General - Factory assembled, consisting of fan and motor assemblies (supply and exhaust), compressor section, enthalpy plates, all necessary dampers, hoods, plenums, filters, drain pans, wiring, and controls. Unit shall be stand-alone controlled with all control devices provided by the unit manufacturer. Unit shall have single point power connection.
- B. Unit Cabinet
1. The rooftop unit is to be installed outdoors by the mechanical contractor. Indoor units weatherized for outdoor use are not acceptable.
  2. All unit panels are fixed with zinc plated hexagonal head type screws complete with a washer and rubber gasket for a weatherproof assembly. Self-drilling, self-tapping screws are used and therefore no tools are required from the unit interior for panel removal. These panels allow for fast service to all major components.
  3. All panel joints must be caulked with a weatherproof silicone. The silicone used must be clear to match any color surfaces. After application, the silicone must react with atmospheric moisture to produce a formed-in-place silicone rubber glazing and curtain wall seal.
  4. The unit base frame shall be constructed from a bolted, structural formed G90 galvanized steel with internal structural cross members properly sized to allow rigging and handling of the unit. All major components shall be supported by the base without sagging or pulsating. Lifting lugs shall be provided and strategically located to allow equilibrium during lifting.
  5. Unit construction consists of an insulated 14 gauge galvanized structural frame complete with die cast aluminum corners. The rigid frame provides stable construction allowing for panel removal without affecting the unit integrity. Panels shall be double wall construction using 2" thick mineral wool insulation 1.5 lbs/ft<sup>3</sup> density, 18 gauge galvanized steel exterior panels (satin coat finish) and 26 gauge G90 galvanized steel inner liner. The unit shall be designed to resist any snow, ice and wind loads, as well as seismic loads in compliance with the National Building Code. Single wall construction with coated insulation will not be acceptable. Exposed insulation edges in the air stream will not be acceptable.

6. Internal partition wall shall be insulated and constructed the same as the unit cabinet.
  7. Full size access door(s) to allow for periodic maintenance and inspections must be provided for all serviceable components. Serviceable components include but are not limited to coils, heat exchanger, damper sections, motor sections, compressor sections, and piping enclosures. Doors shall be double wall construction made of 18 gauge galvanized steel on both outer and inner liner for maximum rigidity. Door insulation is the same as the unit panels. Provide doors with heavy duty corrosion resistant aluminum hinges that allow the door to open at 180°. Compression type handles are operable from both sides of the unit access door(s) and neoprene resilient bubble gaskets for an enclosure that is sealed tight shall also be provided. Plastic latch hinges are not acceptable.
  8. Outdoor constructed units shall have a pitched roof to dissipate water accumulation. Rain gutters must be provided above access doors. All roof joint seams are "T" shape construction, minimum height of 1.5", sealed and encapsulated by a metal strip.
  9. All weather hoods for outdoor constructed units shall be provided with birdscreen and rain gutters. Hoods may ship loose for field assembly.
  10. Recessed, double-sloped drain pans shall be made of formed sections of stainless steel. Drain pans are sloped with a threaded drain pipe connection of 1½" in diameter ending outside through the structural base channel. All drain pan corners shall be welded.
  11. Paint
    - a. Outdoor constructed units shall have one coat of primer and two coats of enamel paint.
    - b. All galvanized steel surfaces that require paint shall be made of satin coat-finished galvanized steel of the specified gauge(s).
    - c. All galvanized steel surfaces without any paint shall be made of G90 galvanized steel of the specified gauges.
    - d. All unit surfaces that require paint must be cleaned and free from all oil, dirt, and other contaminants before painting.
- C. Energy Recovery Enthalpy Plates
1. Cross-flow enthalpy plate heat exchanger shall transfer both sensible and latent energy between airstreams.

2. Plate shall be sized to meet or exceed ASHRAE 90.1 minimum effectiveness of 50%.
3. No additional moving parts shall be required to transfer energy between airstreams.
4. Heat exchanger assembly shall be cleanable with non-pressurized water.
5. Plate shall have antimicrobial protection to prevent the growth of bacteria and mold.
6. Plate shall have a 0% exhaust air transfer ratio as determined by AHRI 1060.

D. Fans

1. Fan performance ratings for flow rate, pressure, power, air density, speed or rotation, and efficiency shall be factory tested and shall comply with the requirements of AMCA 210.
2. All fans shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 300.
3. Fans shall be of centrifugal type, rigidly braced and reinforced to help prevent vibration or pulsation. Wheel diameters and outlet areas shall be in accordance with the standard sizes adopted by AMCA.
4. Fan and motors shall be mounted inside the unit casing with 1" (minimum 90% efficiency) deflection spring vibration isolators and supplied with neoprene flexible connections.
5. Fans shall be selected for a stable operation, at least 20% under the fan's first critical speed.
6. Units shall be equipped with non-overloading, airfoil, SWSI plenum fan, Arrangement 3 (AMCA labeled) supply and exhaust fans to provide scheduled airflows against static pressures indicated.
7. Fan shaft shall be solid steel, turned, ground, polished, and completed with a corrosion resistant coating. Fan wheels shall be keyed to the shaft.
8. Bearings shall be heavy duty, grease-lubricated, self-aligning ball or pillow block type. Bearing shall be selected for a basic rating fatigue life (L-50) in excess of 200,000 hours at maximum operating speed in accordance with AFBMA 9 regulations.
9. Fan drives shall be designed for a 1.4 service factor. Drives are factory mounted with final alignment and belt adjustment made before unit start-up.
10. Belt drives with motor pulley shall be adjustable pitch for use with motors up to and including 10 HP. Fan pulleys shall be fixed pitch.

E. Motors

1. All motors are internal to the unit casing and are mounted on an adjustable base allowing for belt alignment and tensioning.

2. Fan motors shall be heavy duty, 1800 rpm, high efficiency (E-pact Series), open drip proof (ODP), NEMA Design B Class F insulation and 1.15 service factor. Motors shall be constant speed operable at field voltage: 460 volts, 60 Hz, 3 phase.
3. Torque characteristics shall be sufficient to accelerate the drive loads satisfactorily.
4. Motor sizes shall be minimum size indicated in the equipment schedule. If not indicated, large enough so that the drive load will not require the motor to operate in the service factor range.
5. Temperature rating shall be 122°F (50°C) maximum temperature rise at 104°F (40°C) ambient for continuous duty at full load (Class B Insulation).
6. Motor construction shall be NEMA Standard MG 1, general purpose, continuous duty, Design B.
  - a. Bases shall be adjustable.
  - b. Bearings shall be:
    - 1) Ball or roller bearing with inner and outer shaft seals.
    - 2) Grease lubricated.
    - 3) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motors.
  - c. Energy efficient motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112-B. If efficiency is not specified, motors shall give a higher efficiency than "average standard industry motors" in accordance with IEEE Standard 112-B.

F. Filters

1. Filters shall be UL 900 Class II.
2. Outside and return air inlet shall be equipped with galvanized steel racks that permit slide out removal of filters (side access) for units equal or smaller than 78", and universal holding frames with upstream access for units taller than 78".
3. Filter banks shall be arranged for flat orientation. The air velocity shall not exceed 500 fpm through each filter bank.
4. Unit shall include 2" disposable type air filters, 25-30% DSE efficiency, consisting of viscous coated fibers with filtering media encased in fiberboard cell sides having perforated metal grids on each face to provide media support. Airflow resistance with clean media shall not exceed 0.28 inch w.g. at a face velocity of 500 fpm and filter arrestance efficiency of 90% based on ASHRAE Test Standard 52. Filters shall have a minimum MERV rating of 13.

G. Dampers

1. Air leakage through a 48" x 48" damper shall not exceed 10.3 cfm/sq.ft. against 4 in. wg. differential static pressure at standard air. Standard air leakage data to be certified under AMCA certified rating program.
2. Dampers are designed for operation in temperatures ranging between -40°F and 212°F.
3. Unit shall be equipped with all necessary dampers. Dampers for outside air intake, exhaust air and all other dampers required for the system including the dampers for defrost (if required).
4. Intake outside air dampers are opposed blade type and exhaust air dampers are parallel blade type. For other dampers, see manufacturer's recommendations.
5. Outside air dampers **and bypass dampers** shall be motorized. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
6. Exhaust air dampers shall be gravity backdraft type. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
7. Dampers construction shall be as followed:
  - a. Damper frame shall be extruded aluminum.
  - b. Blades shall be extruded aluminum.
  - c. Dampers shall be opposed blade type or parallel blades where indicated
  - d. Damper blade ends shall be sealed with neoprene flexible edge seals complete with bottom and top blade wiper seals.
  - e. Frame and blades shall be non-insulated.

H. Direct Expansion Cooling Section

1. Compressors - Shall be quiet-running hermetic, scroll-type. They shall be mounted in an isolated compartment to be serviceable without affecting airflow, and mounted on neoprene isolators to minimize vibration transmission and noise. Unit shall be capable of full modulation to maintain space temperature.
2. Condenser and Evaporator Coils - Shall have copper tubes with permanently expanded aluminum fins. Evaporator coils shall be mounted on a stainless steel drain pan. Condenser coils shall be provided with hail/ vandal guards

- to protect the coils.
3. Provide factory mounted sensor between the evaporator coil and the hot gas reheat coil for connection to the ATC system.
  4. Thermal Expansion Valves - Shall provide refrigerant control.
  5. Standard features of the packaged direct expansion cooling include:
    - a. Liquid-Line Filter Drier
    - b. High Pressure Manual Reset Cutout
    - c. Low Pressure Auto-Reset Cutout
    - d. Time Delay Relay for Compressor Protection
    - e. Service/Charging Valves
    - f. Moisture Indicating Sight Glass
  - I. Indirect Gas Fired Heating Section - Shall be 80% efficient, ETL Listed for outdoor installation to ANSI Standard Z83.8 - 2002, CGA approved per 2.6 - 2002 and have a blow through fan design. Furnace shall operate with natural gas and have a power venting system. The burner and heat exchanger shall be constructed of aluminized steel. Standard furnace features shall include main gas pressure regulator, main gas valve, fully modulating electronic controls to maintain discharge temperature, direct spark ignition system, high limit, and a 24-volt control transformer.
  - J. Hot Gas Reheat for Dehumidification - Hot gas reheat coils, piping, and modulating controls shall be factory installed for humidity control.
  - K. Roof curb: Roof curb shall be supplied by the unit manufacturer for field assembly. Curb shall consist of formed 18 gauge galvanized steel sections. Manufacturer's curb is standard double wall, 14" in height, un-insulated. Unit base design is made for recessed curb installation. Stiffeners will be provided for field assembly when required. Pitch roof curb to match building roof. Provide wood nailer. Curb shall be one piece. Two piece curbs are not acceptable. See Detail 5-4.2 on sheet M4.2 for critical dimensions.
  - L. Temperature Controls shall be provided by the unit manufacturer.
    1. Shall be provided to accomplish control sequence as outlined in the automatic temperature control section of specifications. All temperature controls shall be factory installed, wired, and programmed by the manufacturer or see item 3 below.
    2. Manufacturer shall provide an interface which will allow the Owner's energy management system to access the control points shown on the points list. This interface shall be in complete compliance with the current ANSI/ASHRAE Standard #135. Provide any coordination as required to facilitate this interface into the Owner's EMS. Provide all necessary protocol documentation and gateway hardware and software (if required) such that



the section 15900 system suppliers may successfully create a communication interface between the control system furnished in this section of the specification and the 15900 control system. Provide an adequate level of technical support to guide the section 15900 personnel towards completion of subject communication interface. Protocol must support reading/writing status and analog and digital point information from this section of the specification. All documentation, gateway hardware and software, and required technical support are understood to be included in the bid.

3. Temperature Controls shall be accomplished by either of the following methods:
  - a. Factory built-in controls shall be provided to interface with the ATC to accomplish control sequence as outlined in Automatic Temperature Control section of specifications.
  - b. Field installed controls provided by the section 15900 contractor is acceptable provided the control sequence as outlined in Automatic Temperature Control section of specifications is met.
  
- M. A water level sensing device shall be factory provided in the unit condensate pan which shall shut down the unit in the event this device's level is exceeded. Device shall be located in a readily accessible location.

### 2.03 ELECTRICAL COMPONENTS

- A. All electrical controls shall be ETL listed and the entire unit shall be factory wired in accordance with the National Electrical Code Standard.
- B. The outdoor constructed units shall be supplied with a weatherproof non-fused main power disconnect switch. A single point power connection shall be provided for all units.
- C. Unit shall be equipped with all necessary high voltage components as follows:
  1. Motor starters on all high voltage motors for constant speed applications. RTP-1 exhaust fan shall be modulated by the ATC.
  2. Thermal protection on all high voltage motors.
  3. Fuses and fuse holders.
  4. All necessary control transformers.
- D. Unit shall be completed with all necessary relays, time delay, damper actuators with auxiliary switches (as required).
- E. Terminal board shall be provided for low voltage control wiring. Low voltage is 24V.

- F. Fan access doors are equipped with a momentary interrupt switch that shuts off the unit when a protected door is opened. These switches can be removed if belt guards are installed on the fan assembly.
- G. An integral control panel shall be provided having a hinged access door and an approved locking device.
- H. All control devices, except those not mounted directly to the unit, shall be factory mounted and wired. Control panel shall have a labeled strip to land all wires for field installed control components.
- I. All components are fully wired and 100% tested prior to shipping.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. **Factory Start-up** - The manufacturer shall supply complete factory start-up by a factory approved start-up agent. Manufacturer shall provide on-site startup and commissioning assistance through job completion. Complete installation and startup checks according to manufacturer's written instructions. This shall include a factory startup for factory provided control devices as well as configuring control points for other DO devices. Service representative shall completely configure all control devices.
- B. **Demonstration** - Engage manufacturer or factory authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain individual units and complete system. This shall include training of the Owner's energy management department representatives as to establish control system programming, scheduling routines, alarm reporting, system topography, communication protocols and password level assignments.
- C. The rooftop units shall be installed complete with all accessories in accordance with the manufacturer's recommendations, as listed in the specifications and as shown on the drawings.
- D. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- E. Provide a typed list of all the different units and their filter and belt sizes to be included in the O & M manuals. The list shall include the unit designation, filter size and the number of filters required for each unit, and belt size and number of belts for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:

- 1. Project Manager, Office of Design and Construction Services, Gatehouse Administrative Center, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032
- F. Provide one set of spare fuses for each rooftop unit.
- G. Provide one spare set of belts per unit per drive.
- H. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Tag is to be screwed or riveted to unit. Identification tag shall be black with engraved 1/2" white letters which reads:

|                                     |   |
|-------------------------------------|---|
| <b>UNIT</b>                         | <i>(unit number)</i> _____                |
| <b>INSTALLED</b>                    | <i>(contracting company's name)</i> _____ |
| <b>WARRANTY</b>                     | <i>(month/day/year)</i> _____             |
| <b>COMPRESSOR WARRANTY EXPIRES:</b> | <i>(month/day/year)</i> _____             |

END OF SECTION

## SECTION 15821

### CABINET AND CEILING EXHAUST FANS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install the Cabinet and Ceiling Exhaust Fans as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

Exhaust fan shall have Certified Rating Seal by AMCA and shall be UL listed.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 CABINET AND CEILING EXHAUST FANS

The exhaust fan shall consist of a centrifugal type fan with a direct drive motor. Fan shall be of the low sound level type. Motor speed shall not exceed 1100 rpm. The manufacturer shall be PENN VENTILATOR COMPANY. Fans fully equal to the specified manufacturer by GREENHECK, ACME, JENCOFAN, CARNES, US FAN or LOREN COOK are acceptable.

##### 2.02 HOUSING

Shall be acoustically insulated and shall be provided with a backdraft damper, motor vibration isolation and electrical connections. Factory air inlet grille shall be provided on ceiling exhaust fans. Cabinet fans shall be arranged for inline duct mounting.

#### PART 3 - EXECUTION

##### 3.01 INSTALLATION

A. The exhaust fans shall be installed as recommended by the manufacturer and as

shown on the drawings.

- B. Fans shall be controlled as outlined in the Automatic Temperature Control section.

END OF SECTION

## SECTION 15822

### UTILITY VENT SETS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install the Utility Vent Set (UVS) as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

Utility vent sets shall have Certified Rating Seal by AMCA and shall be UL Listed.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 UTILITY VENT SETS

The utility vent sets shall be of the type, capacity and drive (belt drive or direct drive), and location as shown on the drawings. The utility vent sets shall be manufactured by TRANE, PEERLESS or NEW YORK BLOWER provided they are fully equal to the specified manufacturer shown on the drawings.

- A. Type - The utility vent set shall consist of a centrifugal type fan with backward inclined or forward curved blades, as noted. Fan shall be of the non-overloading type. Motor shall be belt-drive, unless otherwise noted.
- B. Belt Drive Units - Shall have a variable speed sheave pulley.
- C. Vibration Isolators - Shall be provided as recommended by the equipment manufacturer for quiet operation.
- D. Starter - Provide a manual starter for single-phase units and magnetic across-the-line starter for three phase units. The starter shall have ON-OFF and red running lights. See Section 15050 - 2.07.

- E. Control - The fan shall be controlled as outlined in the Temperature Control section of the specifications or as shown on the drawings.

**PART 3 - EXECUTION**

3.01 INSTALLATION

1. The utility vent sets shall be installed as recommended by the manufacturer and as shown on the drawings.
2. Provide one set of spare belts for each utility vent set.

3.02 VARIABLE SHEAVE PULLEY

If the belt drive utility vent sets do not have a variable speed sheave pulley, the contractor shall provide and install pulley and belts to meet the air flow requirements as shown on the drawings.

END OF SECTION

## SECTION 15827

### AIR CURTAIN FLY FANS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

Provide and install the fly fans as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

The fly fan shall have Certified Rating Seal by AMCA or published data by an acceptable manufacturer and shall be UL listed.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 FLY FANS

The fly fans shall be of the type, capacity and voltage shown on the drawings. The fly fans shall be manufactured by MARS. Fans fully equal to the specified manufacturer and manufactured by FANTECH, POWERED AIRE or BERNER MINIVEIL are acceptable.

- A. Cabinet - Shall be suitable for exposed indoor wall mounting and manufactured of polycarbonate or satin anodized aluminum painted with color selected by Architect. The air shall enter the fan through a horizontal louvered inlet grille. Air shall be diffused through a nozzle that extends the entire width of the unit and is equipped with air directional control vanes. Velocity control shall be through two speed motor control or adjustable intake louver damper control.
- B. Fan and Motor - Shall be direct drive, forward curved, centrifugal, continuous duty type with permanent lubricated sealed ball bearings and automatic thermal overload protection. The fans shall be selected for quiet operation with motor speed not exceeding 1750 rpm.



**PART 3 - EXECUTION**

3.01 INSTALLATION

- A. The fly fans shall be installed as recommended by the manufacturer and as shown on the drawings.
- B. Fans shall be controlled through a door switch provided under Division 16.

END OF SECTION

## SECTION 15830

### POWER ROOF VENTILATOR

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

Provide and install the Power Roof Ventilator as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

Power roof ventilators shall have Certified Rating Seal by AMCA or published data by an acceptable manufacturer and shall be UL listed.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 POWER ROOF VENTILATOR

The power roof ventilator shall be the type, capacity and drive (belt drive or direct drive), and be located as shown on the drawings. Power roof ventilator shall be manufactured by PENN VENTILATOR COMPANY. Ventilators fully equal to the specified manufacturer and manufactured by AEROVENT, CARNES, JENCOFAN, GREENHECK, ACME, US FAN or LOREN COOK are acceptable.

- A. Fan - Shall be provided with a backward inclined centrifugal wheel that has been statically and dynamically balanced. The bearings shall be heavy duty, self-aligning, sealed ball bearings. The motor and fan assembly shall be isolated from the base with rubber-in-shear vibration isolators.
- B. Belt drive ventilators shall have variable speed sheave pulley to adjust the speed of the ventilator.
- C. Motor - Shall be installed in a totally enclosed weatherproof housing outside of the air stream. The motor shall have sealed ball bearings and be internally thermally protected.

- D. Disconnect Switch - A factory wired non-fused toggle type disconnect switch shall be located under the housing of the unit.
- E. Starter - Provide a magnetic across-the-line starter for three phase units. The starter shall have ON-OFF-AUTO switch and red running light. See Section 15050 - 2.07.
- F. Pre-fabricated aluminum or galvanized steel curbs 12" high shall be provided to match the power roof ventilator. The curb shall be flashed to match the roofing system. Provide wood nailer. The power roof ventilator and curb shall be provided by the same manufacturer. Backdraft dampers shall be mounted in the curb and shall be full size of the opening.
- G. Accessories shall be provided as shown on the drawings. Such accessories shall be of the same manufacturer as the ventilators. All ventilators shall have gravity type backdraft dampers.
- H. Unit shall be controlled as described in the Automatic Temperature Control section of the specifications.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The power roof ventilator shall be installed as recommended by the manufacturer and as shown on the drawings. Backdraft damper shall be mounted on rails inside the curb and within the manufacturers recommended minimum distance from the fan. The power roof ventilator shall be secured to the roof curb using like fasteners, fasteners shall be self tapping stainless steel with a 5/16 hex head, 2 inches in length. The number of fasteners used shall be per the manufacturers' recommendations.
- B. VARIABLE SHEAVE PULLEY  

If the belt drive power roof ventilators do not have a variable speed sheave pulley, the contractor shall provide and install pulley and belts to meet the air flow requirements as shown on the drawings.
- C. Provide one spare fan belt for each unit.
- D. Provide a typed list of all the different units, their fan belt sizes to be included in the O & M manuals. The list shall include the unit designation, belt size and the number of belts required for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:

1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road, Suite 3500, Falls Church VA 22042.
2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032

END OF SECTION

## **SECTION 15834**

### **AIR HANDLING UNITS**

#### **PART 1 - GENERAL**

##### **1.01 GENERAL**

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### **1.02 SCOPE**

The work covered under this section shall include providing and installing, complete, the air handling unit as shown on the drawings and specified herein.

##### **1.03 QUALITY ASSURANCE**

- A. The air-handling unit shall have ARI certified ratings and shall be labeled as acceptable by an approved safety testing or inspection agency such as Underwriters Laboratories.
- B. The motor shall be manufactured under NEMA standards.
- C. The coils shall have ARI certified ratings.
- D. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### **1.04 SUBMITTALS**

Provide shop drawings on this equipment as described in section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

#### **PART 2 - PRODUCTS**

##### **2.01 AIR HANDLING UNIT**

The air-handling unit shall be provided and installed complete with the type, arrangement, capacities and accessories as shown on the drawings and specified herein. The air-handling unit shall be manufactured by Trane. Air handling units manufactured by Carrier or DAIKIN are acceptable providing all aspects of the specifications are met.

- A. Casing - The housing shall be constructed of heavy sheet mill galvanized steel

adequately reinforced with structural members and provided with sufficient access panels for proper lubrication and maintenance. Unit shall be of the arrangement shown on the drawings. Unit shall include one piece drain pan with 1/2" foamed-in-place, cellular insulation extending under coil and fan sections with drain connections on both sides. Hinged panels in fan, coil, filter and mixing box sections shall provide access to all internal parts. All unit panels shall be insulated with 1" foil faced glass fiberboard. Unit casing may be chemically cleaned, spray painted, baked and coated with an additional exterior coat of enamel after final assembly in lieu of mill galvanizing.

- B. Fans - Shall be double-inlet air foil type. All fans shall be statically and dynamically balanced and tested after being installed in factory-assembled fan sections. Permanently sealed prelubricated 200,000 hour life ball bearings shall be mounted externally on all units so bearings can be served without dismantling the unit.
- C. Motor and Drive:
  - 1. Shall be belt drive with guard and adjustable motor sheave. Motor nameplate horsepower shall exceed brake horsepower by a minimum of 5% with airfoil. Belts shall be of the oil resistant type. Motor shall be especially designed for quiet operation. Provide and install VFD Variable Frequency Drive.
  - 2. Motor speed for VAV units shall be controlled by a variable frequency drive. All VFD's shall be factory installed by the manufacturer.
- D. Chilled Water Coil - Shall be pitched within the casing for proper drainage. It shall be the continuous aluminum plate fin and copper tube type, with drawn and belled collars mechanically expanded to seamless copper tubes. The completely drainable coil shall be tested under water at 250 psig. Provide an IAQ type sloped cleanable non-corrosive one piece insulated drain pan.
- E. Hot Water Heating Coil - Shall be pitched within the casing for proper drainage. Coil shall be furnished with metering orifices in the supply header to insure equal distribution of hot water to each tube. The coil shall be tested at 250 psig under water. The hot water coil shall be placed in a pre-heat position on all chilled water systems and downstream on a DX system, except for VAV type unit.
- F. Mixing Box - Low Leak Dampers - The mixing box shall be a product of the air handling unit manufacturer with the arrangement as shown on the drawings. The return air and outside air dampers shall be sized for 100% air, shall be interconnected, and shall be as follows:
  - 1. Return Air Damper - The parallel blades shall be brake formed and secured to a minimum of 5/8" diameter steel-rods rotating in nylon bushings and mounted in rigid steel damper frames. The frame shall be

constructed of a minimum 13-gauge sheet steel and the blades of a minimum double 22 gauge sheet steel.

2. Outside Air Damper - Opposed Blade - The outside air damper supplied by the air handling unit manufacturer shall not be used. Mount one of the following dampers on the mixing box: ARROW-FOIL model OBDAF-207, AIR BALANCE model AC-116 or RUSKIN model CD-50.
- G. Filter Section - Low velocity medium capacity filter section shall be a matching part of the unit with access through hinged doors on both sides. Combination mixing box/filter sections are not acceptable. Filters shall be 2" FARR 30/30 medium efficiency, pleated, disposable type. Each filter shall consist of a non-woven cotton fabric media, media support grid and enclosing frame. The filter media shall have an average efficiency of 30-35% on ASHRAE Test Standard 52-76. It shall have an average arrestance of not less than 92% in accordance with that test standard. The filter shall be listed by Underwriters Laboratories as Class 2. Two complete sets of spare filters shall be supplied in addition to the set used during construction. Filters shall have a minimum MERV rating of 13.
- H. Filter Gauge - Shall be a manometer type with an operating range of 0 - 3" w.c. Furnish one for each air-handling unit. Prototype - DWYER.
- I. Isolation - Provide factory installed internal spring isolators or field installed external housed type spring isolators for all air handling units. Install external isolators in accordance with manufacturer's recommendations. Acceptable external isolator manufacturers: MASON INDUSTRIES, PEABODY NOISE CONTROL, VIBRATION ELIMINATOR COMPANY, or VIBRATION MOUNTINGS and CONTROLS.
- J. Starter - Provide magnetic line voltage starter with HAND-OFF-AUTO switch and red running light. See Electric Motor Starters, section 15050 - 2.07.
- K. Sound Ratings
1. The sound power rating (re:  $10^{-12}$  watts) leaving the air handling unit under the tabulated conditions shall not exceed the following in any octave band:

AIR HANDLING UNITS SOUND POWER BY OCTAVE BAND  
 $10^{-12}$  WATTS at Specified AirFlow and Static Pressure

|                  |   |   |   |   |   |   |   |   |
|------------------|---|---|---|---|---|---|---|---|
| Octave Frequency | 1   | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Mid Frequency    | <u>ENGINEER TO LIST CORRESPONDING NUMBERS</u> |   |   |   |   |   |   |   |
| AHU #1           |   |   |   |   |   |   |   |   |

AHU #2

AHU #3

AHU #n<sup>th</sup>

2. Air handling unit sound ratings shall be based on tests in a sound laboratory reverberant room strictly conforming to ASHRAE Standard 36-62, in accordance with AMCA 300 procedures. Sound data must be accurate to within  $\pm 5$  db @ 63 Hz,  $\pm 4$  db @ 125 Hz,  $\pm 2$  db from 250-2000 Hz,  $\pm 3$  db @ 4000 Hz and above.
3. Where the manufacturer's sound power data is not published, an officer of the company must certify that sound data conforms to the above requirements. If the manufacturer does not have acoustical facilities in accordance with the above requirements, the contractor must submit certified data that the specified units have been tested in an approved independent acoustics lab, capable of testing equipment at specified operating conditions, to determine sound power levels by octave band.

L. Temperature Controls –

1. All controls shall be provided by the BAS contractor under section 15900.

M. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded. Condensate float shall be located in a readily accessible location.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The air handling units shall be installed as shown on the drawings and as recommended by the manufacturer.

- A. The air handling unit fan speed shall be adjusted to deliver the amount of air as stated on the drawings by adjusting the motor sheave. If the proper amount of air cannot be obtained by this adjustment, the contractor shall provide and install new motor sheave and belts to obtain the proper amount of air.
- B. Two sets of spare filters shall be provided in addition to the set used during construction with each air-handling unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.



- C. Provide one spare belt for each air handling unit.
- D. Provide grease fitting extensions where necessary to have the grease fitting accessible.
- E. The mixing box dampers shall be checked by the owners representative after the damper motors have been installed and before the final inspection to make sure that the dampers are closing properly.
- F. Provide a typed list of all the different units, their fan belt sizes and their filter sizes to be included in the O & M manuals. The list shall include the unit designation, filter size and the number of filters belt sizes and number of belts required for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032.
- G. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Identification tag shall be black with engraved 1/2 " white letters which reads:

|                              |                                     |
|------------------------------|-------------------------------------|
| UNIT #                       | <u>(unit number)</u>                |
| INSTALLED BY:                | <u>(contracting company's name)</u> |
| WARRANTY EXPIRES:            | <u>(month/day/year)</u>             |
| COMPRESSOR WARRANTY EXPIRES: | <u>(month/day/year)</u>             |

END OF SECTION

## SECTION 15835

### ROOFTOP AIR HANDLING UNITS

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, section 15010 - General Provisions and section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include providing and installing complete the chilled water/hot water air handling unit as shown on the drawings and specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The air handling unit shall have ARI certified ratings and shall be labeled as acceptable by an approved safety testing or inspection agency such as Underwriters Laboratories.
- B. The motors shall be manufactured under NEMA standards.
- C. All wiring shall conform to the National Electric Code (NEC).
- D. The coils shall have ARI certified ratings.
- E. Factory Start-up – The manufacture shall supply complete factory start-up by a factory approved start-up agent.
- F. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 AIR HANDLING UNIT

The air handling unit shall be provided and installed complete with the type, arrangement, capacities and accessories as shown on the drawings and specified herein. The air handling unit shall be manufactured by TRANE. Air handling units

manufactured by CARRIER or DAIKIN are acceptable providing all aspects of the specifications are met. No substitutions.

- A. Casing -The housing shall be constructed of heavy sheet mill galvanized steel adequately reinforced with structural members and provided with sufficient access panels for proper lubrication and maintenance. Unit shall be of the arrangement shown on the drawings. Units shall be fully gasketed for weather protection. Piping to the roof mounted units shall be totally within the unit curb. Unit shall include one-piece, cellular insulation extending under coil and fan sections with drain connections on both sides. The double wall panels shall be two inches thick with 18 gauge mill galvanized steel outer wall and 22 gauge mill galvanized inner wall. Panels shall be individually removable for access and maintenance. The insulation shall be two inches thick fiberglass with 1.5 PCF density. Hinged, gasketed, double wall, insulated access doors shall be provided for access to all fan, filter, coil, energy recovery wheel sections and piping enclosures. Unit casing may be chemically cleaned, spray painted, baked and coated with an additional exterior coat of enamel after final assembly in lieu of mill galvanizing.
- B. Fans - Shall be airfoil type. All fans shall be statically and dynamically balanced and tested after being installed in factory-assembled fan sections. Permanently sealed prelubricated 200,000 hour life ball bearings shall be mounted externally on all units so bearings can be served without dismantling the unit.
- C. Motor and Drive
  - 1. Provide belt drive with guard and adjustable motor sheave. Motor nameplate horsepower shall exceed brake horsepower by a minimum of 5% with airfoil. Provide oil resistant type belts. Provide motor especially designed for quiet operation.
  - 2. Motor speed (for VAV units) shall be controlled by variable frequency drives. All variable frequency drives shall be factory installed by the manufacturer. See section 15905 for acceptable manufacturers.
- D. Chilled Water Coil - Shall be pitched within the casing for proper drainage. It shall be the continuous aluminum plate fin and copper tube type, with drawn and belled collars mechanically expanded to seamless copper tubes. The completely drainable coil shall be tested under water at 250 psig. Provide one piece sloped, non-corrosive, cleanable stainless steel or plastic IAQ type insulated drain pan. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded.
- E. Hot Water Heating Coil - Shall be pitched within the casing for proper drainage. Coil shall be furnished with metering orifices in the supply header to insure equal distribution of hot water to each tube. The coil shall be tested at 250 psig under

water. The hot water coil shall be placed in a pre-heat position on chilled water systems and downstream on a DX system.

- F. Energy Recover Heat Wheel (If so equipped);
1. Heat Wheels shall comply with UL standards.
  2. Heat Wheel - Provide aluminum or polymer transfer media, flame spread rating of not more than 25 and smoke developed rating of not more than 50 and shall be independently tested in accordance with ASTM standard E-84. Rotor media shall be independently tested in accordance with ASHRAE Standards. It shall allow laminar flow (but not radial) at usual velocities and prevent leakage, bypassing and cross contamination by cross flow within wheel. Size the transfer media to allow passage of 300 micron particles without fouling or clogging. Treat media with non-degrading desiccant that is bacteriostatic, non-corroding and non-toxic. No asbestos material will be allowed. Wheel shall not condense water directly or require a condensate drain for summer or winter operation. Performance rating shall be in accordance with ARI Standard 1060.
  3. Provide casing seals on periphery of rotor as well as on duct divider and purge section. Seals are to be adjustable, of extended life materials and effective in limiting air leakage.
  4. Wheel shall be supported by ball or roller bearings and belt driven by a fractional horsepower, totally enclosed, NEMA Standard motor through a close coupled positively lubricated speed reducer, or gear/chain speed reduction.
  5. Unit shall be constructed of heavy gage steel to insure rigidity and stability. Casing side panels shall be removable to insure easy access to internal parts. Provide integral flanges for flanged duct connection and provide lifting holes or lugs.
- G. Air Dampers - Opposed Blade - Air dampers shall be one of the following models: ARROW-FOIL model OBDAF-207, AIR BALANCE model AC-116, or RUSKIN model CD-50.
- H. Outside Air Damper (for VAV units) - Provide factory installed damper/airflow monitoring assembly for maintaining a constant quantity of outside air. Assembly shall consist of factory mounted TRANE Traq low leak dampers that both modulate and measure airflow.
- I. Filter Section - Low velocity medium capacity filter section shall be a matching part of the unit with access through hinged doors on both sides. Combination mixing box/filter sections are not acceptable. Filters shall be 2" FARR 30/30 medium efficiency, pleated, disposable type. Each filter shall consist of a non-woven cotton fabric media, media support grid and enclosing frame. The filter

media shall have an average efficiency of 30-35% on ASHRAE Test Standard 52-76. It shall have an average arrestance of not less than 92% in accordance with that test standard. The filter shall be listed by Underwriters Laboratories as Class 2. Two complete sets of spare filters shall be supplied in addition to the set used during construction. Filters shall have a minimum MERV rating of 13.

- J. Isolation - Provide factory installed internal spring isolators or field installed external housed type spring isolators for all air handling units. Install external isolators in accordance with manufacturer's recommendations. Acceptable external isolator manufacturers: MASON INDUSTRIES, PEABODY NOISE CONTROL, VIBRATION ELIMINATOR COMPANY, or VIBRATION MOUNTINGS and CONTROLS.
- K. Roof Curb - Provide pre-fabricated aluminum or galvanized steel 14" high curbs to match the unit. Provide wood nailer. The curb shall be flashed to match the roofing system. The unit and curb shall be provided by the same manufacturer. Roof curbs shall be one piece; two piece curbs will not be accepted.
- L. Starter - Provide magnetic line voltage starter with HAND-OFF-AUTO switch, red running light, and auxiliary contacts for all motors. See Electric Motor Starters, Section 15050 - 2.07. All starters shall be factory installed by the manufacturer.
- M. Wiring - All units shall have single point power connections. The units shall be completely pre-wired at the factory, including all motors, starters, variable frequency drives, internal transformers, actuators, and controls.
- N. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded. Condensate float shall be located in a readily accessible location.
- O. Temperature Controls
  - 1. Shall be provided to accomplish control sequence as outlined in the automatic temperature control section of specifications. All temperature controls shall be factory installed, wired and programmed by the manufacturer or see item 3 below.
  - 2. Manufacturer shall provide an interface which will allow the Owner's energy management system to access the control points shown on the points list. This interface shall be in complete compliance with ANSI/ASHRAE Standard #135-2000. Provide any coordination as required to facilitate this interface into the Owner's EMS. Provide all necessary protocol documentation and gateway hardware and software (if required) such that the section 15900 system suppliers may successfully create a communication interface between the control system furnished in this section of the specification and the 15900 control system. Provide an adequate level of technical support to guide the section 15900 personal towards completion of subject communication

interface. Protocol must support reading / writing status and analog and digital point information from this section of the specification. All documentation, gateway hardware and software, and required technical support are understood to be included in the bid.

3. Temperature Controls shall be accomplished by either of the following methods:
  - a. Factory built-in controls shall be provided to interface with the ATC to accomplish control sequence as outlined in Automatic Temperature Control section of specifications.
  - b. Field installed controls provided by the division 15900 contractor is acceptable provided the control sequence as outlined in Automatic Temperature Control section of specifications is met.

The control contractor must have the ability to interface with and control the factory supplied outside airflow monitoring assembly.

## **PART 3 - EXECUTION**

### **3.01 INSTALLATION**

The air handling units shall be installed as shown on the drawings and as recommended by the manufacturer.

- A. Factory Start-up – The manufacturer shall supply complete factory start-up by a factory approved start-up agent.
- B. The air handling unit fan speed shall be adjusted to deliver the amount of air as stated on the drawings by adjusting the motor sheave. If the proper amount of air cannot be obtained by this adjustment, the contractor shall provide and install new motor sheave and belts to obtain the proper amount of air.
- C. Provide a spare belt for each air handling unit.
- D. Two sets of spare filters shall be provided in addition to the set used during construction with each air handling unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- E. Provide grease fittings extensions where necessary to have the grease fitting accessible.
- F. Provide a typed list of all the different air handling units their filter sizes and their belt sizes to be included in the O&M manuals. The list shall include the unit designation, filter size and belt size the number of filters and belts required for

each unit in addition to this submit to the Owner two copies of the list distributed to:

1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
  2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia 22032.
  3. Include list in the Operation and Maintenance manuals.
- G. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Identification tag shall be black with engraved 1/2 " white letters which reads:

|                              |                                     |
|------------------------------|-------------------------------------|
| UNIT #                       | <u>(unit number)</u>                |
| INSTALLED BY:                | <u>(contracting company's name)</u> |
| WARRANTY EXPIRES:            | <u>(month/day/year)</u>             |
| COMPRESSOR WARRANTY EXPIRES: | <u>(month/day/year)</u>             |

END OF SECTION

## SECTION 15836

### ROOF MOUNTED MAKEUP AIR UNIT

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 General Provisions, and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include providing and installing complete the roof mounted makeup air unit as shown on the drawing and specified herein.

##### 1.03 QUALITY ASSURANCE

- A. The unit fan shall have ARI certified ratings and be UL listed.
- B. The motor shall be manufactured under NEMA standards.
- C. The coils shall have ARI certified ratings.
- D. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

#### PART 2 - PRODUCTS

##### 2.01 ROOF MOUNTED MAKEUP AIR UNIT

The roof mounted makeup air unit shall be provided and installed complete with the type, arrangement, capacities and accessories as shown on the drawings and specified therein. The unit shall be manufactured by INNOVENT AIR HANDLING EQUIPMENT. Units manufactured by DES CHAMPS or ENGINEERED AIR are acceptable providing all aspects of the specifications are met.

- A. Casing – The housing shall be constructed of heavy sheet mill galvanized steel adequately reinforced with structural members and provided with sufficient access panels for proper weatherproofing, lubrication and maintenance. Unit



shall be of the arrangement shown on the drawings. Provide internal piping pocket within casing to coils. Piping to the units shall be totally within the unit curb. External pipe chases, including those mounted on the units, are not acceptable. Unit shall include one-piece, cellular insulation extending under coil and fan sections with drain connections on both sides. The double wall panels shall be two inches thick with 18 gauge mill galvanized steel outer wall and 22 gauge mill galvanized inner wall. Panels shall be individually removable for access and maintenance. The insulation shall be two inches thick fiberglass with 1.5 PCF density. Hinged, gasketed, double wall, insulated access doors shall be provided for access to fan, filter, coil, damper, and heat exchanger sections. Unit casing may be chemically cleaned, spray painted, baked and coated with an additional exterior coat of enamel after final assembly in lieu of mill galvanizing.

- B. Fans – Shall be double-inlet airfoil type. All fans shall be statically and dynamically balanced and tested after being installed in factory-assembled fan sections. Permanently sealed prelubricated 200,000 hour life ball bearings shall be mounted externally on all units so bearings can be serviced without dismantling the unit.
- C. Motor and Drive - Shall be belt drive with guard and adjustable motor sheave. Motor nameplate horsepower shall exceed brake horsepower by a minimum of 5% with airfoil. Belts shall be of the oil resistant type. Motor shall be especially designed for quiet operation.
- D. Isolation – Fans and motors shall be mounted on spring isolated unitary bases, flexibly connected to the unit casing.
- E. Chilled Water Coil – Shall be pitched within the casing for proper drainage. It shall be the continuous aluminum plate fin and copper tube type, with drawn and belled collars mechanically expanded to seamless copper tubes. The completely drainable coil shall be tested under water at 250 psig. Provide one piece IAQ type insulated drain pan. Drain pan shall be sloped toward the condensate drain connection drain pan shall be non-corrosive and cleanable. All piping and isolation valves to coils shall be inside unit casing. Chilled water pipes exposed to the air stream shall be insulated with ¾" armaflex or equal.
- F. Hot Water Heating Coil – Shall be pitched within the casing for proper drainage. It shall be the continuous aluminum plate fin and copper tube type, with drawn and belled collars mechanically expanded to seamless copper tubes. The completely drainable coil shall be tested under water at 250 psig. The hot water coil shall be placed in a pre-heat position on chilled water systems and downstream on a DX system. All piping and isolation valves to coils shall be inside unit casing. Hot water pipes exposed to the airstream shall be insulated with ¾" armaflex or equal.
- G. Heat Exchanger – Shall be a flat plate air-to-air type with no moving parts. Plates shall be made of 0.008" thick aluminum and shall be constructed to withstand 10" of differential pressure between air paths. Entire transfer surface

shall be accessible for inspection and cleaning without removing the exchanger. Provide one piece IAQ type insulated drain pan. Drain pan shall be sloped toward the condensate drain connection. Drain pan shall be non-corrosive and cleanable.

- H. Outside Air Damper – Shall be low leakage opposed blade type with 16-gauge frame and 16 gauge blades. Maximum blade width 8". Provide neoprene seals at all blade edge and side meeting surfaces so that air leakage shall be no more than 1% at 4" static pressure. Provide teflon or oil impregnated bronze shaft bearings and standard finish. Provide one of the following dampers: ARROW-FOIL model OBDAF-207, AIR BALANCE model AC116, or RUSKIN model CD-50.
- I. Filter Section – Low velocity medium capacity filter section shall be a matching part of the unit with access through hinged doors on both sides. Filters shall be 2" FARR 30/30, medium efficiency, pleated, disposable type. Each filter shall consist of a non-woven cotton fabric media, media support grid, and enclosing frame. The filter media shall have an average efficiency of 30-35% of ASHRAE Test Standard 52-76. It shall have an average arrestance of not less than 92% in accordance with that test standard. The filter shall be listed by Underwriter's Laboratories as Class 2. Two complete sets of spare filters shall be supplied. Filters shall have a minimum MERV rating of 13.
- J. Starter – Provide magnetic line voltage starter with HAND-OFF-AUTO switch and red running light and auxiliary contacts. See Electric Motor Starters, Section 15050 – 2.07.
- K. Temperature Controls shall be accomplished by either of the following methods:
  - 1. Factory built-in controls shall be provided to interface with the ATC to accomplish control sequence as outlined in Automatic Temperature Control section of specifications.
  - 2. Field installed controls provided by the section 15900 contractor are acceptable provided the control sequence as outlined in Automatic Temperature Control section of specifications is met.

The control contractor must have the ability to interface with and control the factory supplied outside airflow monitoring assembly.
- L. Pre-fabricated aluminum or galvanized steel curbs 14" high shall be provided to match the roof mounted makeup air unit. The curb shall be flashed to match the roofing system. The unit and curb shall be provided by the same manufacturer. Roof curbs shall be one piece; two piece curbs will not be accepted.
- M. Provide inlet hood with moisture eliminator.
- N. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded.

Condensate float shall be located in a readily accessible location.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The roof mounted makeup air unit shall be installed as shown on the drawings and as recommended by the manufacturer.

- A. The unit fan speed shall be adjusted to deliver the amount of air as stated on the drawings by adjusting the motor sheave. If the proper amount of air cannot be obtained by this adjustment, the contractor shall provide and install new motor sheave and belts to obtain the proper amount of air.
- B. Two sets of spare filters shall be provided with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- C. Provide one spare belt for each air handling unit.
- D. Provide a typed list of all the different units, their filter sizes, and belt sizes are to be included in the O & M manuals. The list shall include the unit designation, filter size and the number of filters required for each unit as well as belt size and number of belts. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032.
- E. Provide grease-fitting extensions where necessary to have the grease fitting accessible.
- F. Provide one set of spare fuses for each roof mounted makeup air unit.
- G. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Identification tag shall be black with engraved 1/2 " white letters which reads:

|                              |                                     |
|------------------------------|-------------------------------------|
| UNIT #                       | <u>(unit number)</u>                |
| INSTALLED BY:                | <u>(contracting company's name)</u> |
| WARRANTY EXPIRES:            | <u>(month/day/year)</u>             |
| COMPRESSOR WARRANTY EXPIRES: | <u>(month/day/year)</u>             |

END OF SECTION

## SECTION 15837

### MAKEUP AIR UNIT - SELF CONTAINED

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 QUALITY ASSURANCE

- A. The system shall deliver the specified air volume at the static pressure scheduled.
- B. The unit shall be constructed to provide smooth interior surfaces and to limit the casing leakage at less than 1% of the specified air volume at operating static.
- C. Unit shall be constructed in accordance with CSA C22.2 and UL 1812 and shall carry the ETL label of approval.
- D. Unit shall be constructed in accordance with industrial design practices.
- E. Insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.
- F. Airflow data shall comply with AMCA 210 method of testing.
- G. Cabinet and exterior components shall be tested and certified weatherproof.
- H. All units shall be 100% factory tested.
- I. All effectiveness data of heat and energy recovery components shall be certified by the ARI 1060 certification program directory.
- J. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### 1.03 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

**PART 2 - PRODUCTS**

## 2.01 MANUFACTURERS

- A. Makeup air unit(s) shall be supplied by GREENHECK, INNOVENT AIR HANDLING EQUIPMENT, SEASONS 4, VALENT and AAON.

## 2.02 EQUIPMENT

- A. General - Factory assembled, consisting of fan and motor assemblies (supply and exhaust), compressor section, flat plate heat exchanger, all necessary dampers, hoods, plenums, filters, drain pans, wiring and controls. Unit shall be stand-alone controlled with all control devices provided by the unit manufacturer. Unit shall have single point power connection.
- B. Unit Cabinet
1. The makeup air unit is to be installed outdoors by the mechanical contractor. Indoor units weatherized for outdoor use are not acceptable.
  2. All unit panels are fixed with zinc plated hexagonal head type screws complete with a washer and rubber gasket for a weatherproof assembly. Self-drilling, self-tapping screws are used and therefore no tools are required from the unit interior for panel removal. These panels allow for fast service to all major components.
  3. All panel joints must be caulked with a weatherproof silicone. The silicone used must be clear to match any color surfaces. After application, the silicone must react with atmospheric moisture to produce a formed-in-place silicone rubber glazing and curtain wall seal.
  4. The unit base frame shall be constructed from a bolted, structural formed G90 galvanized steel with internal structural cross members properly sized to allow rigging and handling of the unit. All major components shall be supported by the base without sagging or pulsating. Lifting lugs shall be provided and strategically located to allow equilibrium during lifting.
  5. Unit construction consists of an insulated 14 gauge galvanized structural frame complete with die cast aluminum corners. The rigid frame provides stable construction allowing for panel removal without affecting the unit integrity. Panels shall be double wall construction using 2" thick mineral wool insulation 1.5 lbs/ft<sup>3</sup> density, 18 gauge galvanized steel exterior panels (satin coat finish) and 26 gauge G90 galvanized steel inner liner. The unit shall be designed to resist any snow, ice and wind loads, as well as seismic loads in compliance with the National Building Code. Single wall construction with coated insulation will not be acceptable. Exposed insulation edges in the air stream will not be acceptable.

6. Internal partition wall shall be insulated and constructed the same as the unit cabinet.
  7. Full size access door(s) to allow for periodic maintenance and inspections must be provided for all serviceable components. Serviceable components include but are not limited to coils, heat exchanger, damper sections, motor sections, compressor sections, and piping enclosures. Doors shall be double wall construction made of 18 gauge galvanized steel on both outer and inner liner for maximum rigidity. Door insulation is the same as the unit panels. Provide doors with heavy duty corrosion resistant aluminum hinges that allow the door to open at 180°. Compression type handles are operable from both sides of the unit access door(s) and neoprene resilient bubble gaskets for an enclosure that is sealed tight shall also be provided. Plastic latch hinges are not acceptable.
  8. Outdoor constructed units shall have a pitched roof to dissipate water accumulation. Rain gutters must be provided above access doors. All roof joint seams are "T" shape construction, minimum height of 1.5", sealed and encapsulated by a metal strip.
  9. All weather hoods for outdoor constructed units shall be provided with birdscreen and rain gutters. Hoods may ship loose for field assembly.
  10. Recessed, double-sloped drain pans shall be made of formed sections of stainless steel. Drain pans are sloped with a threaded drain pipe connection of 1 1/2" in diameter ending outside through the structural base channel. All drain pan corners shall be welded.
  11. Paint
    - a. Outdoor constructed units shall have one coat of primer and two coats of enamel paint.
    - b. All galvanized steel surfaces that require paint shall be made of satin coat-finished galvanized steel of the specified gauge(s).
    - c. All galvanized steel surfaces without any paint shall be made of G90 galvanized steel of the specified gauges.
    - d. All unit surfaces that require paint must be cleaned and free from all oil, dirt, and other contaminants before painting.
- C. Flat Plate Heat Exchanger
1. The flat plate heat exchanger assembly shall be CERTIFIED to ARI Standard 1060 and tested in accordance to ASHRAE 84-91.

2. The flat plate heat exchanger shall be cross-flow type made of 6 mil embossed pure aluminum designed to maximize the efficiency and the cleanability while minimizing the pressure loss.
3. The flat plate heat exchanger shall be sectioned within the unit to allow for a section replacement without requiring any lifting devices.
4. Access to all four sides of the flat plate heat exchanger for cleaning and inspection shall be provided.
5. An access section with a sloped IAQ drain pan shall be provided upstream and downstream of the flat plate heat exchanger allowing for service, collection of condensate and cleaning of the flat plate heat exchanger without allowing any standing water to be contained within the unit cabinet.

D. Fans

1. Fan performance ratings for flow rate, pressure, power, air density, speed or rotation, and efficiency shall be factory tested and shall comply with the requirements of AMCA 210.
2. All fans shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 300.
3. Fans shall be of centrifugal type, rigidly braced and reinforced to help prevent vibration or pulsation. Wheel diameters and outlet areas shall be in accordance with the standard sizes adopted by AMCA.
4. Fan and motors shall be mounted inside the unit casing with 1" (minimum 90% efficiency) deflection spring vibration isolators and supplied with neoprene flexible connections.
5. Fans shall be selected for a stable operation, at least 20% under the fan's first critical speed.
6. Units shall be equipped with non-overloading, airfoil, SWSI plenum fan, Arrangement 3 (AMCA labeled) supply and exhaust fans to provide scheduled airflows against static pressures indicated.
7. Fan shaft shall be solid steel, turned, ground, polished, and completed with a corrosion resistant coating. Fan wheels shall be keyed to the shaft.
8. Bearings shall be heavy duty, grease-lubricated, self-aligning ball or pillow block type. Bearing shall be selected for a basic rating fatigue life (L-50) in excess of 200,000 hours at maximum operating speed in accordance with AFBMA 9 regulations.



9. Fan drives shall be designed for a 1.4 service factor. Drives are factory mounted with final alignment and belt adjustment made before unit start-up.
10. Belt drives with motor pulley shall be adjustable pitch for use with motors up to and including 10 HP. Fan pulleys shall be fixed pitch.

E. Motors

1. All motors are internal to the unit casing and are mounted on an adjustable base allowing for belt alignment and tensioning.
2. Fan motors shall be heavy duty, 1800 rpm, high efficiency (E-pact Series), open drip proof (ODP), NEMA Design B Class F insulation and 1.15 service factor. Motors shall be constant speed operable at field voltage: 460 volts, 60 Hz, 3 phase.
3. Torque characteristics shall be sufficient to accelerate the drive loads satisfactorily.
4. Motor sizes shall be minimum size indicated in the equipment schedule. If not indicated, large enough so that the drive load will not require the motor to operate in the service factor range.
5. Temperature rating shall be 122°F (50°C) maximum temperature rise at 104°F (40°C) ambient for continuous duty at full load (Class B Insulation).
6. Motor construction shall be NEMA Standard MG 1, general purpose, continuous duty, Design B.
  - a. Bases shall be adjustable.
  - b. Bearings shall be:
    - 1) Ball or roller bearing with inner and outer shaft seals.
    - 2) Grease lubricated.
    - 3) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motors.
  - c. Energy efficient motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112-B. If efficiency is not specified, motors shall give a higher efficiency than "average standard industry motors" in accordance with IEEE Standard 112-B.

## F. Filters

1. Filters shall be UL 900 Class II.
2. Outside and return air inlet shall be equipped with galvanized steel racks that permit slide out removal of filters (side access) for units equal or smaller than 78", and universal holding frames with upstream access for units taller than 78".
3. Filter banks shall be arranged for flat orientation. The air velocity shall not exceed 500 fpm through each filter bank.
4. Unit shall include 2" disposable type air filters, 25-30% DSE efficiency, consisting of viscous coated fibers with filtering media encased in fiberboard cell sides having perforated metal grids on each face to provide media support. Airflow resistance with clean media shall not exceed 0.28 inch w.g. at a face velocity of 500 fpm and filter arrestance efficiency of 90% based on ASHRAE Test Standard 52. Filters shall have a minimum MERV rating of 13.

## G. Dampers

1. Air leakage through a 48" x 48" damper shall not exceed 10.3 cfm/sq.ft. against 4 in. wg. differential static pressure at standard air. Standard air leakage data to be certified under AMCA certified rating program.
2. Dampers are designed for operation in temperatures ranging between -40°F and 212°F.
3. Unit shall be equipped with all necessary dampers. Dampers for outside air intake, exhaust air and all other dampers required for the system including the dampers for defrost (if required).
4. Intake outside air dampers are opposed blade type and exhaust air dampers are parallel blade type. For other dampers, see manufacturer's recommendations.
5. Outside air dampers shall be motorized. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
6. Exhaust air dampers shall be gravity backdraft type. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
7. Dampers construction shall be as followed:
  - a. Damper frame shall be extruded aluminum.
  - b. Blades shall be extruded aluminum.

- c. Dampers shall be opposed blade type or parallel blades where indicated
  - d. Damper blade ends shall be sealed with neoprene flexible edge seals complete with bottom and top blade wiper seals.
  - e. Frame and blades shall be non-insulated.
- H. Direct Expansion Cooling Section
- 1. Compressors - Shall be quiet-running hermetic, scroll-type. They shall be mounted in an isolated compartment to be serviceable without affecting airflow, and mounted on neoprene isolators to minimize vibration transmission and noise. Refrigerant shall be R-410A. Unit shall be capable of full modulation to maintain discharge temperature.
  - 2. Condenser and Evaporator Coils - Shall have copper tubes with permanently expanded aluminum fins. Evaporator coils shall be mounted on a stainless steel drain pan. Condenser coils shall be provided with hail/ vandal guards to protect the coils.
  - 3. Thermal Expansion Valves - Shall provide refrigerant control.
  - 4. Standard features of the packaged direct expansion cooling include:
    - a. Liquid-Line Filter Drier
    - b. High Pressure Manual Reset Cutout
    - c. Low Pressure Auto-Reset Cutout
    - d. Time Delay Relay for Compressor Protection
    - e. Service/Charging Valves
    - f. Moisture Indicating Sight Glass
- I. Indirect Gas Fired Heating Section - Shall be 80% efficient, ETL Listed for outdoor installation to ANSI Standard Z83.8 - 2002, CGA approved per 2.6 - 2002 and have a blow through fan design. Furnace shall operate with natural gas and have a power venting system. The burner and heat exchanger shall be constructed of aluminized steel. Standard furnace features shall include main gas pressure regulator, main gas valve, fully modulating electronic controls to maintain discharge temperature, direct spark ignition system, high limit, and a 24-volt control transformer.

- J. Hot Gas Reheat for Dehumidification - Hot gas reheat coils, piping, and modulating controls shall be factory installed for humidity control.
- K. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded. Condensate float shall be located in a readily accessible location.
- L. Provide factory mounted sensor between evaporator coil and hot gas reheat coil for connection to the ATC system.
- M. Roof curb: Roof curb shall be supplied by the unit manufacturer for field assembly. Curb shall consist of formed 18 gauge galvanized steel sections. Manufacturer's curb is standard double wall, 14" in height, un-insulated. Unit base design is made for recessed curb installation. Stiffeners will be provided for field assembly when required. Pitch roof curb to match building roof. Provide wood nailer. Curb shall be one piece. Two piece curbs are not acceptable.
- N. Temperature Controls shall be accomplished by either of the following methods:
  - 1. Factory built-in controls shall be provided to interface with the ATC to accomplish control sequence as outlined in Automatic Temperature Control section of specifications.
  - 2. Field installed controls provided by the section 15900 contractor are acceptable provided the control sequence as outlined in Automatic Temperature Control section of specifications is met.
  - 3. The control contractor must have the ability to interface with and control the factory supplied outside airflow monitoring assembly.

### 2.03 ELECTRICAL COMPONENTS

- A. All electrical controls shall be ETL listed and the entire unit shall be factory wired in accordance with the National Electrical Code Standard.
- B. The outdoor constructed units shall be supplied with a weatherproof non-fused main power disconnect switch. A single point power connection shall be provided for all units.
- C. Unit shall be equipped with all necessary high voltage components as follows:
  - 1. Motor starters on all high voltage motors for constant speed applications.
  - 2. Thermal protection on all high voltage motors.
  - 3. Fuses and fuse holders.
  - 4. All necessary control transformers.

- D. Unit shall be completed with all necessary relays, time delay, damper actuators with auxiliary switches (as required).
- E. Terminal board shall be provided for low voltage control wiring. Low voltage is 24V.
- F. Fan access doors are equipped with a momentary interrupt switch that shuts off the unit when a protected door is opened. These switches can be removed if belt guards are installed on the fan assembly.
- G. An integral control panel shall be provided having a hinged access door and an approved locking device.
- H. All control devices, except those not mounted directly to the unit, shall be factory mounted and wired. Control panel shall have a labeled strip to land all wires for field installed control components.
- I. All components are fully wired and 100% tested prior to shipping.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Factory Start-up - The manufacturer shall supply complete factory start-up by a factory approved start-up agent. Manufacturer shall provide on-site startup and commissioning assistance through job completion. Complete installation and startup checks according to manufacturer's written instructions. This shall include a factory startup for factory provided control devices as well as configuring control points for other DO devices. Service representative shall completely configure all control devices and establish remote internet connectivity with the Owner's energy management department web server.
- B. Demonstration - Engage manufacturer or factory authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain individual units and complete system. This shall include training of the Owner's energy management department representatives as to establish control system programming, scheduling routines, alarm reporting, system topography, communication protocols and password level assignments.
- C. The makeup air units shall be installed complete with all accessories in accordance with the manufacturer's recommendations, as listed in the specifications and as shown on the drawings.
- D. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.

- E. Provide a typed list of all the different units and their filter and belt sizes to be included in the O & M manuals. The list shall include the unit designation, filter size and the number of filters required for each unit, and belt size and number of belts for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, Gatehouse Administrative Center, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032
- F. Provide one set of spare fuses for each makeup air unit.
- G. Provide one spare set of belts per unit per drive.
- H. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Tag is to be screwed or riveted to unit. Identification tag shall be black with engraved 3" white letters which reads:

|                              |                                     |
|------------------------------|-------------------------------------|
| UNIT #                       | <u>(unit number)</u>                |
| INSTALLED BY:                | <u>(contracting company's name)</u> |
| WARRANTY EXPIRES:            | <u>(month/day/year)</u>             |
| COMPRESSOR WARRANTY EXPIRES: | <u>(month/day/year)</u>             |

END OF SECTION

## SECTION 15838

### MAKEUP AIR UNIT - HEAT PUMP

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 QUALITY ASSURANCE

- A. The system shall deliver the specified air volume at the static pressure scheduled.
- B. The unit shall be constructed to provide smooth interior surfaces and to limit the casing leakage at less than 1% of the specified air volume at operating static.
- C. Unit shall be constructed in accordance with CSA C22.2 and UL 1812 and shall carry the ETL label of approval.
- D. Unit shall be constructed in accordance with industrial design practices.
- E. Insulation shall comply with NFPA 90A requirements for flame spread and smoke generation.
- F. Airflow data shall comply with AMCA 210 method of testing.
- G. Cabinet and exterior components shall be tested and certified weatherproof.
- H. All units shall be 100% factory tested.
- I. All effectiveness data of heat and energy recovery components shall be certified by the ARI 1060 certification program directory.
- J. Equipment installer shall attend a controls coordination meeting with the section 15900 contractor as described in 15900, 1.03.

##### 1.03 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010, 1.04. The controls coordination meeting described in 15900, 1.03 shall be held before the shop drawings are submitted.

**PART 2 - PRODUCTS**

## 2.01 MANUFACTURERS

- A. Energy recovery unit(s) shall be supplied by GREENHECK, INNOVENT AIR HANDLING EQUIPMENT, SEASONS 4, VALENT and AAON.

## 2.02 EQUIPMENT

- A. General: Factory assembled, consisting of fan and motor assemblies (supply and exhaust), Flat Plate Heat Exchanger, all necessary dampers, hoods, plenums, filters, drain pans, wiring and controls. Unit shall be stand-alone controlled with all control devices provided by the unit manufacturer or control contractor. Unit shall have single point power connection.
- B. Unit Cabinet
1. The energy recovery unit is to be installed outdoors by the mechanical contractor. Indoor units weatherized for outdoor use are not acceptable.
  2. All unit panels are fixed with zinc plated hexagonal head type screws complete with a washer and rubber gasket for a weatherproof assembly. Self-drilling, self-tapping screws are used and therefore no tools are required from the unit interior for panel removal. These panels allow for fast service to all major components.
  3. All panel joints must be caulked with a weatherproof silicone. The silicone used must be clear to match any color surfaces. After application, the silicone must react with atmospheric moisture to produce a formed-in-place silicone rubber glazing and curtain wall seal.
  4. The unit base frame shall be constructed from a bolted, structural formed G90 galvanized steel with internal structural cross members properly sized to allow rigging and handling of the unit. All major components shall be supported by the base without sagging or pulsating. Lifting lugs shall be provided and strategically located to allow equilibrium during lifting.
  5. Unit construction consists of an insulated 14 gauge galvanized structural frame complete with die cast aluminum corners. The rigid frame provides stable construction allowing for panel removal without affecting the unit integrity. Panels shall be double wall construction using 2" thick mineral wool insulation 1.5 lbs/ft<sup>3</sup> density, 18 gauge galvanized steel exterior panels (satin coat finish) and 26 gauge G90 galvanized steel inner liner. The unit shall be designed to resist any snow, ice and wind loads, as well as seismic loads in compliance with the National Building Code. Single wall construction with coated insulation will not be acceptable. Exposed insulation edges in the air stream will not be acceptable.



| INSULATING VALUE       |              |
|------------------------|--------------|
| TYPE OF INSULATION     | 2" THICKNESS |
| Mineral wool (3.5 pcf) | R8.6         |
| Urethane               | R14.8        |

6. Internal partition wall shall be insulated and constructed the same as the unit cabinet.
7. Full size access door(s) to allow for periodic maintenance and inspections must be provided for all serviceable components. Serviceable components include but are not limited to Coils, Heat Exchanger, Damper sections, Motor sections and piping enclosures. Doors shall be double wall construction made of 18 gauge galvanized steel on both outer and inner liner for maximum rigidity. Door insulation is the same as the unit panels. Provide doors with heavy duty corrosion resistant aluminum hinges that allow the door to open at 180°. Compression type handles are operable from both sides of the unit access door(s) and neoprene resilient bubble gaskets for an enclosure that is sealed tight shall also be provided. Plastic latches hinges are not acceptable.
8. Outdoor constructed units shall have a pitched roof to dissipate water accumulation. Rain gutters must be provided above access doors. All roof joint seams are "T" shape construction, minimum height of 1.5", sealed and encapsulated by a metal strip.
9. All weather hoods for outdoor constructed units are provided with birdscreen and rain gutters. Hoods may ship loose for field assembly.
10. Recessed, double-sloped drain pans shall be made of formed sections of steel. Drain pans are sloped with a threaded drain pipe connection of 1 1/2" in diameter ending outside through the structural base channel. All drain pan corners shall be welded.
11. Paint:
  - a. Outdoor constructed units shall have one coat of primer and two coats of enamel paint.
  - b. All galvanized steel surfaces that require paint shall be made of satin coat-finished galvanized steel of the specified gauge(s).

- c. All galvanized steel surfaces without any paint shall be made of G90 galvanized steel of the specified gauges.
  - d. All unit surfaces that require paint must be cleaned and free from all oil, dirt and other contaminants before painting.
- C. Flat Plate Heat Exchanger
1. The flat plate heat exchanger assembly shall be certified to ARI Standard 1060 and tested in accordance to ASHRAE 84-91.
  2. The flat plate heat exchanger shall be cross-flow type made of 6 mil embossed pure aluminum designed to maximize the efficiency and the cleanability while minimizing the pressure loss.
  3. The flat plate heat exchanger shall be sectioned within the unit to allow for a section replacement without requiring any lifting devices.
  4. Access to all four sides of the flat plate heat exchanger for cleaning and inspection shall be provided.
  5. An access section with a sloped IAQ drain pan shall be provided upstream and downstream of the flat plate heat exchanger allowing for service, collection of condensate and cleaning of the flat plate heat exchanger without allowing any standing water to be contained within the unit cabinet.
- D. Integral Water Cooled Heat Pump
1. Unit shall be provided with a complete integral factory piped and wired mechanical refrigeration system consisting of: scroll compressors, an ARI rated air-refrigerant coil, a UL listed water refrigerant coil, service valves, expansion valves, 4-way reversing valve, high/low pressure switches, anti-recycle timers, compressor contactors, suction accumulator, liquid receiver, line filter-drier, pressure ports, and sight glass shall be factory provided and installed. Hermetic scroll compressors shall be used, mounted on RIS vibration isolators, and provided with a sumpheater. Water refrigerant coil shall be of brazed plate stainless steel type. Air-refrigerant coil is constructed of seamless copper tube primary surface and rippled aluminum plate fin secondary surface. Air refrigerant coil core is tested with 315 psig air pressure under warm water and guaranteed for 250 psig working pressure. All brazed plate heat exchangers, refrigerant specialties and refrigerant piping shall be factory insulated as required by the manufacturer to avoid sweating.
- Provide factory mounted sensor between evaporator coil and hot gas reheat coil for connection to the ATC system.

2. Integral heat pump system shall be capable of modulating the cooling and heating capacity to maintain specified discharge air temperature. Water/R-410A heat exchangers shall be provided with an entering fluid side strainer, leaving fluid side freeze stat, and fluid flow proving switch. Fluid flow valves and actuators shall be provided by the installing contractor and installed in the field. Field installed water piping must be field insulated.
- E. Modulating Hot Gas Reheat
1. Unit shall be provided with a factory mounted and piped hot gas reheat coil, 3-way valve, and modulating gas control valve.
- F. Fans
1. Fan performance ratings for flow rate, pressure, power, air density, speed or rotation and efficiency shall be factory tested and shall comply with the requirements of AMCA 210.
  2. All fans shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower in accordance with AMCA 300.
  3. Fans shall be of centrifugal type, rigidly braced and reinforced to help prevent vibration or pulsation. Wheel diameters and outlet areas shall be in accordance with the standard sizes adopted by AMCA.
  4. Fan and motors shall be mounted inside the unit casing with 1" (minimum 90% efficiency) deflection spring vibration isolators and supplied with neoprene flexible connections.
  5. Fans shall be selected for a stable operation, at least 20% under the fans first critical speed.
  6. Units shall be equipped with non-overloading, airfoil, SWSI plenum fan, Arrangement 3 (AMCA labeled) supply and exhaust fans to provide scheduled airflows against static pressures indicated.
  7. Fan shaft shall be solid steel, turned, ground, polished and completed with a corrosion resistant coating. Fan wheels shall be keyed to the shaft.
  8. Bearings shall be heavy duty, grease-lubricated, self-aligning ball or pillow block type. Bearing shall be selected for a basic rating fatigue life (L-50) in excess of 200,000 hours at maximum operating speed in accordance with AFBMA 9 regulations.

9. Fan drives shall be designed for a 1.4 service factor. Drives are factory mounted with final alignment and belt adjustment made before unit start-up.
10. Belt drives with motor pulley shall be adjustable pitch for use with motors up to and including 10 HP. Fan pulleys shall be fixed pitch.

G. Motors

1. All motors are internal to the unit casing and are mounted on an adjustable base allowing for belt alignment and tensioning.
2. Fan motors shall be heavy duty, 1800 rpm, high efficiency (E-pact Series), open drip proof (ODP), NEMA Design B with Class F insulation and 1.15 service factor. Motors shall be constant speed operable at field voltage: 460 Volts, 60 Hz, 3 phase.
3. Torque characteristics shall be sufficient to accelerate the drive loads satisfactorily.
4. Motor sizes shall be minimum size indicated in the equipment schedule. If not indicated, large enough so that the drive load will not require the motor to operate in the service factor range.
5. Temperature rating shall be 122°F (50°C) maximum temperature rise at 104°F (40°C) ambient for continuous duty at full load (Class B Insulation).
6. Motor construction shall be NEMA Standard MG 1, general purpose, continuous duty, Design B.
  - a. Bases shall be adjustable.
  - b. Bearings shall be:
    - 1) Ball or roller bearing with inner and outer shaft seals.
    - 2) Grease lubricated.
    - 3) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motors.
  - c. Energy efficient motors shall have a minimum efficiency as scheduled in accordance with IEEE Standard 112-B. If efficiency is not specified, motors shall give a higher efficiency than "average standard industry motors" in accordance with IEEE Standard 112-B.

#### H. Filters

1. Filters shall be UL 900 Class II.
2. Outside and return air inlet shall be equipped with galvanized steel racks that permit slide out removal of filters (side access) for units equal or smaller than 78", and universal holding frames with upstream access for units taller than 78".
3. Filter banks shall be arranged for flat orientation. The air velocity shall not exceed 500 fpm through each filter bank.
4. Unit shall include 2" disposable type air filters, 25-30% DSE efficiency, consisting of viscous coated fibers with filtering media encased in fiberboard cell sides having perforated metal grids on each face to provide media support. Airflow resistance with clean media shall not exceed 0.28 inch w.g. at a face velocity of 500 fpm and filter arrestance efficiency of 90% based on ASHRAE Test Standard 52. Filters shall have a minimum MERV rating of 13.

#### I. Dampers

1. Air leakage through a 48" x 48" damper shall not exceed 10.3 cfm/sq.ft. against 4 in. wg. differential static pressure at standard air. Standard air leakage data to be certified under AMCA certified rating program.
2. Dampers are designed for operation in temperatures ranging between -40°F and 212°F.
3. Unit shall be equipped with all necessary dampers. Dampers for outside air intake, exhaust air and all other dampers required for the system, including the dampers for defrost (if required).
4. Intake outside air dampers are opposed blade type and exhaust air dampers are parallel blade type. For other dampers, see manufacturer's recommendations.
5. Outside air dampers shall be motorized. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
6. Exhaust air dampers shall be gravity backdraft type. Provide damper actuators with 24 VAC drive voltage. 0-10 VDC modulation.
7. Dampers construction shall be as followed:
  - a. Damper frame shall be extruded aluminum.
  - b. Blades shall be extruded aluminum.

- c. Dampers shall be opposed blade type or parallel blades where indicated
  - d. Damper blade ends shall be sealed with neoprene flexible edge seals complete with bottom and top blade wiper seals.
  - e. Frame and blades shall be non-insulated.
- J. Roof curb - Roof curb shall be supplied by the unit manufacturer for field assembly. Curb shall consist of formed 18 gauge galvanized steel sections. Manufacturer's curb is standard double wall, 18" in height, 2" thick fiberglass insulation. Unit base design is made for recessed curb installation. Stiffeners will be provided for field assembly when required. Pitch roof curb to match building roof. Curb shall be provided with wood nailer. Curb shall be one piece. Two piece curbs are not acceptable.
- K. Temperature Controls shall be accomplished by either of the following methods:
- 1. Factory built-in controls shall be provided to interface with the ATC to accomplish control sequence as outlined in Automatic Temperature Control section of specifications.
  - 2. Field installed controls provided by the section 15900 contractor are acceptable provided the control sequence as outlined in Automatic Temperature Control section of specifications is met.
  - 3. The control contractor must have the ability to interface with and control the factory supplied outside airflow monitoring assembly.
- L. A water level sensing device shall be provided in the unit condensate pan which will shut down the unit in the event this devices level is exceeded. Condensate float shall be located in a readily accessible location.

### 2.03 ELECTRICAL COMPONENTS

- A. All electrical controls shall be ETL listed and the entire unit shall be factory wired in accordance with the National Electrical Code Standard.
- B. The outdoor constructed units shall be supplied with a weatherproof non-fused main power disconnect switch. A single point power connection shall be provided for all units.
- C. Unit shall be equipped with all necessary high voltage components as follows:
  - 1. Motor starters on all high voltage motors for constant speed applications.
  - 2. Thermal protection on all high voltage motors.

3. Fuses and fuse holders.
4. All necessary control transformers.
- D. Unit shall be completed with all necessary relays, time delay, damper actuators with auxiliary switches (as required).
- E. The automatic unit start-up is provided as standard via an external dry contact provided by others (ex: Building management system, DDC controller, time clock, etc.).
- F. Terminal board shall be provided for low voltage control wiring. Low voltage is 24V.
- G. Fan access doors are equipped with a momentary interrupt switch that shuts off the unit when a protected door is opened. These switches can be removed if belt guards are installed on the fan assembly.
- H. An integral control panel shall be provided having a hinged access door and an approved locking device.
- I. All control devices, except those not mounted directly to the unit, shall be factory mounted and wired. Control panel shall have a labeled strip to land all wires for field installed control components.
- J. All components are fully wired and 100% tested prior to shipping.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. The makeup air units shall be installed complete with all accessories in accordance with the manufacturer's recommendations, as listed in the specifications and as shown on the drawings.
- B. Two sets of spare filters shall be provided in addition to the set used during construction with each unit. The filters shall be changed after the construction dust has been eliminated and before final inspection. The other set of filters shall be stored in the respective mechanical rooms or spaces.
- C. Provide one set of spare fuses for each makeup air unit.
- D. Provide one spare belt per unit.
- E. Provide a typed list of all the different units, their filter sizes, and belt sizes to be included in the O&M manuals. The list shall include the unit designation, filter

size, belt size, and the number of filters and belts required for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:

1. Project Manager, Office of Design and Construction Services, Gatehouse Administrative Center, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.
2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia 22032.

- F. Warranty Tag - The Contractor shall attach an engraved weatherproof Guarantee or Warranty tag to the exterior of each unit. Tag is to be screwed or riveted to unit. Identification tag shall be black with engraved 1/2" white letters which reads:

|                              |                                     |
|------------------------------|-------------------------------------|
| UNIT #                       | <u>(unit number)</u>                |
| INSTALLED BY:                | <u>(contracting company's name)</u> |
| WARRANTY EXPIRES:            | <u>(month/day/year)</u>             |
| COMPRESSOR WARRANTY EXPIRES: | <u>(month/day/year)</u>             |

END OF SECTION



## SECTION 15840

### DUCTWORK AND DUCT ACCESSORIES

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

The work covered under this section of the specifications shall include furnishing and installing the ductwork, accessories, associated items and all necessary connections to outlets, inlets and equipment required for a complete system as shown on the drawings and hereinafter specified.

##### 1.03 QUALITY ASSURANCE

- A. Galvanized sheet metal shall meet the requirements of ASTM A653 and A924 standards.
- B. Ductwork and duct accessories shall meet the requirements and recommendations of SMACNA standards, SMACNA Duct Cleanliness for New Construction (Advanced Level), UL-181 standard and ASHRAE recommendations.
- C. The installation of ductwork and duct accessories shall comply with NFPA standard 90A and state and local codes.

##### 1.04 SUBMITTALS

Provide shop drawings on ductwork materials and accessories as described in Section 15010 - 1.04. Shop drawings are not required for duct layouts.

#### PART 2 - PRODUCTS

##### 2.01 DUCTWORK SYSTEM CLASSIFICATION

For determination of ductwork construction criteria, all ductwork systems shall be classified as either low or medium pressure according to the following velocities or pressures. In all cases the higher of the two values shall be used to determine the system classification unless other overriding considerations are established on the drawings or in the specifications. A ductwork system is defined as, the complete run of a supply, return, exhaust, or intake air system, each classified individually.

- A. Ductwork systems with any portion having an average cross-sectional velocity up to and including 2000 FPM and not exceeding 2" w.g. maximum static pressure at any point in the system shall be classified as low pressure.
- B. Ductwork systems with any portion having an average cross-sectional velocity exceeding 2000 FPM or exceeding 2" w.g. maximum static pressure at any point in the system shall be classified as medium pressure.
- C. All Variable Air Volume (VAV) supply air duct systems and all air duct systems outside exposed to weather regardless of velocity and pressure conditions are classified as medium pressure and shall be constructed in compliance with SMACNA's three (3) inch pressure classification, formerly 'High Pressure Duct Construction Standard.' Joints and seams shall be sealed as described in this specification.

## 2.02 DUCT MATERIALS

- A. All ductwork, housings, dampers, access doors and all other duct related accessories shall be formed from galvanized steel sheets unless otherwise noted.
- B. All angles used for reinforcement, support, hanging and other construction uses shall be galvanized steel and shall be equal to that used for ductwork. Galvanized angle iron shall be used where required by SMACNA standards.

## 2.03 DUCTWORK CONSTRUCTION

- A. The low pressure ductwork as defined in Article 2.01 shall be constructed in accordance with the one (1) inch pressure classification, as described in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible".
- B. Ductwork classified as other than low pressure shall be constructed in accordance with the three (3) inch pressure classification, as described in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible".
- C. Duct sizes are shown on the drawings in inches. The dimensions given establish the free or unobstructed area required on the inside of the duct. In case a duct size is not shown the dimensions shall be requested from the Architect.
- D. The ductwork shall be fabricated from field measurements to avoid conflict with beams, columns, pipes and other obstructions. Where necessary to avoid obstructions, the ductwork shall be transformed, divided or moved to one side as long as the free area is not reduced and such changes meet the approval of the Architect.
- E. The minimum thickness of the sheet metal shall be either as described in

SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" or as shown in the following table:

DUCT CONSTRUCTION MINIMUM SHEET METAL GAUGES

**RECTANGULAR DUCTS**

| Maximum side<br>(inches) | Steel<br>(Minimum Galvanized<br>Sheet Gauge) | Aluminum<br>(Minimum B & S Gauge) |
|--------------------------|--|-----------------------------------|
| Thru 12"                 | 26 (0.022 inches)                            | 24 (0.020 inches)                 |
| 13" - 30"                | 24 (0.028 inches)                            | 22 (0.025 inches)                 |
| 31" - 54"                | 22 (0.034 inches)                            | 20 (0.032 inches)                 |
| 55" - 84"                | 20 (0.040 inches)                            | 18 (0.040 inches)                 |
| Over 84"                 | 18 (0.052 inches)                            | 16 (0.051 inches)                 |

**ROUND DUCTS**

| Diameter<br>(inches) | SPIRAL SEAM DUCT                             | LONGITUDINAL SEAM DUCT                       | FITTINGS                                     |
|----------------------|--|--|--|
|                      | Steel<br>(Minimum Galvanized<br>Sheet Gauge) | Steel<br>(Minimum Galvanized<br>Sheet Gauge) | Steel<br>(Minimum Galvanized<br>Sheet Gauge) |
| Thru 12"             | 28 (0.019 in.)                               | 26 (0.022 in.)                               | 26 (0.022 in.)                               |
| 13" - 18"            | 26 (0.022 in.)                               | 24 (0.028 in.)                               | 24 (0.028 in.)                               |
| 19" - 28"            | 24 (0.028 in.)                               | 22 (0.034 in.)                               | 22 (0.034 in.)                               |
| 29" - 36"            | 22 (0.034 in.)                               | 20 (0.040 in.)                               | 20 (0.040 in.)                               |
| 37" - 52"            | 20 (0.040 in.)                               | 18 (0.052 in.)                               | 18 (0.052 in.)                               |

- F. When required, heavier ductwork shall be installed to meet the requirements of the UL Fire Resistance Index.
- G. Where indicated on the drawings or where insufficient space is available for round ductwork, flat oval ductwork may be used. The conversion from round duct sizes to flat oval should be made on an equivalent pressure loss basis, not on an equal cross-sectional area. The flat oval ducts shall be constructed in accordance with current SMACNA standards.
- H. Rectangular Duct Section Connections - Shall be as described in the SMACNA Standards. Contractor may use zero leakage four corner bolted companion angle transverse joint as manufactured by DUCTMATE INDUSTRIES, INC. or LOCKFORMER. Joint shall be constructed of galvanized steel with bolting corner pieces, roll formed double wall mating angles, gasketing, mastic sealer and snap-on flange cover cleats.

2.04 FLEXIBLE DUCTWORK

- A. Where shown on the drawings provide flexible ductwork between branch ducts and terminals or air outlets. It shall be of a low or medium pressure to match duct system served.
- B. Ductwork
  - 1. Insulated flexible ductwork shall be factory pre-insulated duct composed of a corrosion-resistant reinforcing wire or band helix permanently bonded and enclosed in polyester film, covered with minimum R-6 density fiberglass insulation blanket sheathed in a vapor barrier of aluminum polyester film laminated to glass mesh, elastomer back coated. The flexible duct shall be rated for a minimum working velocity of 2000 fpm, shall be listed by Underwriters Laboratories under their UL-181 standards as a Class 1 air duct material and shall comply with NFPA standard No. 90A.
  - 2. Taps for flexible ductwork shall be high efficiency gasketed air-tite type with manual damper
- C. The maximum length of flexible duct connection shall be ten feet., or as otherwise shown.
- D. Flexible ductwork shall not be used for return air or exhaust air ductwork.

2.05 DUCT ACCESS DOORS

- A. Duct Access Doors shall be provided in both the low and medium pressure duct systems as shown on the contract drawings and as specified.
- B. Access doors shall be constructed as shown in SMACNA standards for the appropriate pressure classification. Door shall be the same gauge and material as the duct. All access doors shall be hinged, except where a removable type is required.
- C. The minimum size of all access doors shall be 20" x 14" except where the duct is less than 16", in which case one dimension shall be 20" and the other 2" less than the duct width.
- D. Access doors shall be provided in the following locations: At the linkage side of automatic dampers; at the manual volume control dampers; at smoke detection heads; fire dampers; and any other service, balance or control device requiring periodic maintenance.

2.06 FLEXIBLE CONNECTIONS AT FAN

- A. Flexible connections shall be provided at the inlet and outlet connection for each fan, between ductwork and inlet and outlet collars.
- B. Each flexible connection shall be designed to allow one inch of free movement and shall be completely air tight and shall have sewed and cemented seams.
- C. Flexible connections for low-pressure ductwork shall be in accordance with SMACNA standards. Material shall be neoprene coated glass fabric, 30 oz. per square yard.
- D. Flexible connections for medium pressure ductwork shall be the same as for low pressure except additional reinforcing shall be provided as required by the operating pressure of the system.
- E. Flexible connections to any roof mounted equipment shall not be exposed to the elements. Flexible connections shall be located inside the building just below the roofline. For side discharge units the flexible connection shall be located inside the building just inside the wall.

#### 2.07 TURNING VANES

- A. Any square elbow ductwork 18 inches or over in width shall require turning vanes of galvanized steel.
- B. Vanes for Low and Medium Pressure Systems: Shall be as shown in SMACNA standards for appropriate pressure classification.
- C. Vane lengths shall not exceed 36" for low-pressure systems or 48" for medium pressure systems. Where greater lengths are required, separate banked sections shall be provided.

#### 2.08 FIRE, SMOKE AND CEILING DAMPERS.

- A. Fire dampers, also known as flame retarding or primary dampers, may be of the individual folded blade type, the continuous folded stainless steel one piece curtain type, the pivoted single blade type or the pivoted multi-blade type, providing they bear a UL label for the complete assembly. Dampers shall be sized so that folded or open blades do not restrict the duct free area given by the duct dimensions. Dampers shall have a positive lock in the closed position. Fusible links shall be UL listed and marked 160°F.
- B. Ceiling dampers, also known as radiation shielding or secondary dampers, may be of the single blade spring loaded guillotine type, the continuous folded stainless steel one piece curtain type or the folded approved fire retardant fabric type provided they bear a UL label for the complete assembly. Single protected pivoted blade type ceiling damper constructed in accordance with the requirements of specific UL ceiling assemblies and SMACNA standards and

subject to field acceptance may be used where permitted by the conditions of the specific UL ceiling assembly used. Dampers shall be sized so that folded or open blades do not restrict the duct free area given by the duct dimensions. Dampers shall have a positive lock in the closed position. Fusible links shall be UL listed and marked 160°F.

- C. Smoke dampers shall meet the requirements of NFPA 90A & 92A and UL5555. Smoke dampers shall be UL Class I smoke damper, normally open and automatically operated by a 120 volt, electric actuator. Provide airfoil style blades. Elevated temperature rating shall be 350°F. Smoke damper shall operate upon activation of smoke detector and re-settable by a locally mounted momentary contact switch.
- D. All dampers shall be installed in sleeves a minimum of two gauges heavier than the connecting ductwork unless noted otherwise. Sleeves shall be mounted within and secured to wall, floor, ceiling or other structural penetration. Dampers shall be positioned only as permitted in the UL listing. Connecting ductwork shall be joined to the sleeve so that in the event of damage to the duct system it will break away leaving the fire damper and sleeve intact in the structural penetration. When necessary to avoid obstructions and after acceptance by the Architect, damper dimensions may be different from the connecting ductwork providing the required free area is maintained and 15° maximum transitions are used.
- E. Provide UL listed, photoelectric, 120 volt smoke detector for use with smoke damper and 120 volt, reset switch, (normally on, momentary off) mounted within sight of the damper and detector. This switch shall reset the damper and the detector. Smoke detectors shall be rated for air velocities of 500 to 4000 fpm and have integral, auxiliary contacts for "ALARM" and "TROUBLE" annunciation to the fire alarm system.

## 2.09 MANUAL VOLUME CONTROL DAMPERS

Manual Volume Control Dampers in ducts not exceeding 12" on the longest side shall be as shown in SMACNA Duct Standards. For ducts over 12", dampers of the opposed multi-blade type shall be used. Dampers shall be galvanized steel, swivel end bearings at one end of the blade, and quadrant with level and lock-screw at the opposite end. Multi-blade dampers shall have steel washers at ends of damper rods with self-aligning blade interconnecting hardware.

## 2.10 COATED DUCT LINER

- A. Duct Liner: Low-Pressure Ductwork
  - 1. All plenums and transfer ducts shall receive duct liner. Supply air ductwork shall receive duct liner from the fan discharge to 20 feet downstream from the fan discharge or as otherwise shown. Return air

duct work shall receive duct liner from the fan suction to 20 feet upstream from the fan suction or as otherwise shown. All supply air discharge ductwork from fan coil units shall receive duct liner.

2. Duct liner shall be designed for use as an acoustical and thermal insulation for sheet metal heating and cooling ducts and plenums. The duct liner shall have a density of 1.5 pounds per cubic foot a "K" factor not to exceed .24 @ 50°F mean temperature and a minimum NRC rating of .75. The minimum duct liner thickness shall be 1 inch.
3. Duct liner shall be designed for use as an acoustical and thermal insulation for sheet metal heating and cooling ducts and plenums. The duct liner shall have a density of 1.5 pounds per cubic foot a "K" factor not to exceed .24 @ 50°F mean temperature and a minimum NRC rating of .75. The minimum duct liner thickness shall be 1 inch.
4. Duct liner air stream surface shall be coated with an immobilized, EPA-registered antimicrobial agent so it will not support microbial growth. Duct liner shall be Johns Manville Linacoustic RC. Duct liners with similar characteristics will be considered as long as all aspects of the specifications are met.

B. Duct Liner: Medium Velocity

1. All rectangular supply/return air duct and all air duct outside exposed to weather shall receive duct liner. Rectangular supply air duct shall receive duct liner from the fan discharge to 20 feet downstream from the discharge or as otherwise shown. Return air duct work shall receive duct liner from the fan suction to 20 feet upstream from the fan suction or as otherwise shown.
2. Duct liner shall be designed for use as an acoustical and thermal insulation for sheet metal heating and cooling ducts. The duct liner shall have a density of 1.5 lbs./cu. ft., a 'K' factor not to exceed .24 @ 50 degrees F mean temperature and a minimum NRC rating of .95. The minimum duct liner thickness shall be 2 inches.
3. Duct liner air stream surface shall be coated with an immobilized, EPA-registered antimicrobial agent so it will not support microbial growth. Duct liner shall be Johns Manville Linacoustic RC. Duct liners with similar characteristics will be considered as long as all aspects of the specifications are met.

**PART 3 - EXECUTION**

3.01 DUCT INSTALLATION

- A. The ductwork, fittings, access doors, flexible connections, turning vanes, hangers and supports, fire dampers, volume dampers and other accessories shall be installed as recommended by SMACNA Duct Construction Standards. Ductwork shall not be supported from bottom chords of bar joists, bridging between bar joists or from metal decks. Ductwork shall be supported from the top chords of bar joists.
- B. All necessary allowances and provisions shall be made by this contractor for beams, columns or other obstructions of the building or the work of other contractors, whether or not same is indicated. Where necessary to avoid obstructions, the ducts shall be transformed, divided or moved to one side with the required free area being maintained, all as approved or directed by the Architect.
- C. Flexible ducts shall be secured to the metal ductwork, terminal units and supply diffusers by use of a 3/4" minimum width stainless steel drawband pulled tight with an adjusting worm drive type screw. Flexible duct insulation shall be properly sealed at connections to maintain vapor seal/barrier.
- D. All duct dimensions shown on the drawings are inside clear dimensions. The duct sizes of ducts with duct liner shall be increased accordingly.

3.02 DUCT LINER

Duct Liner Application: Coated duct liner shall be cut to assure overlapped and compressed longitudinal corner joints. Apply liner with coated surface facing the air stream and adhere with 100% coverage of fire retardant adhesive. Coat all exposed leading edges and all transverse joints with fire retardant adhesive. The liner shall be additionally secured with mechanical fasteners which shall compress the duct liner sufficiently to hold it firmly in place as follows:

- A. Low Velocity to 2000 FPM: Fasteners shall start within 3" of the upstream transverse edge of liner and 3" from the longitudinal joints and shall be spaced at a maximum of 12" o.c. around the perimeter of the duct, except that they may be a maximum of 12" from a corner break. Elsewhere they shall be a maximum of 18" o.c. except that they shall not be more than 6" from a longitudinal joint of liner nor 12" from a corner break. Coat all exposed joints with a fire retardant adhesive.
- B. Medium Velocity from 2000 FPM to 4000 FPM - Fasteners shall start within 3" of the upstream transverse edges of the liner and 3" from the longitudinal joints shall be spaced at a maximum of 6" o.c. around the perimeter of the duct, except that they may be a maximum of 6" from a corner break. Elsewhere they shall be a maximum of 16" o.c. except that they shall not be more than 6" from a longitudinal joint of liner nor 12" from a corner break.



- C. In addition to adhesive edge coating of transverse joints, any longitudinal joints shall be similarly coated with adhesive.

3.03 WATERPROOFING DUCTWORK ABOVE ROOF

- A. Exposed ductwork shall be waterproofed with a prefabricated self-adhering, sheet-type waterproofing membrane as manufactured by Venture Tape and offered as VentureClad-1579CW series. Additional manufacturers will be considered providing all aspects of the specifications are met.

B. MATERIALS:

1. Prefabricated, Self-Adhering, Sheet-Type Waterproofing Membrane.

a. Description:

- 1) Top Layer: Stucco-embossed, UV-resistant aluminum weathering surface.
- 2) Middle Layer: Double layer of high-density polyethylene reinforcement.
- 3) Bottom Layer: Uniform layer of rubberized asphalt adhesive, protected by disposable silicone release paper.
- 4) Heat Aging, ASTM D 794: No visible blistering or deterioration.
- 5) Tear Resistance, ASTM D 1424, Average: 660 grams.
- 6) Elongation, ASTM D 412, Minimum: 450 percent.
- 7) Low Temperature Flexibility, 1,000,000 Cycles at -10 Degrees F, 1,200 Cycles at 20 Degrees F: No cracking.
- 8) Water Vapor Transmission, ASTM E 96: 0.009 perms.
- 9) Flame Spread Index, ASTM E 84.0.
- 10) Smoke Density Index, ASTM E 84.5.
- 11) Wind-Driven Rain, SFBC TAS-110-95, 100 mph: No leakage or failure.
- 12) UV Stability: Excellent.

C. SURFACE PREPARATION AND APPLICATION.

1. Prepare surfaces in accordance with manufacturer's instructions.
2. Ensure tops of ducts have sufficient slope to eliminate ponding water.
3. Remove dirt, dust, oil, grease, hand oils, processing lubricants, moisture, frost, and other contaminants that could adversely affect adhesion of waterproofing membrane.

4. Ensure surfaces are clean and dry.
5. Apply membrane to clean, dry, primed metal ductwork and foil-faced rigid insulation boards. Do not apply over wet or nonrigid insulation.
6. Apply membrane in accordance with manufacturer's air, material, and surface temperature requirements.
7. Apply firm, uniform pressure with hand roller to entire membrane to ensure proper adhesion. Concentrate pressure at seams and on underside of ductwork.
8. Apply membrane to ducts in accordance with manufacturer's instructions.
9. Apply membrane shingle fashion to shed water over, not against laps.
10. Do not terminate membrane on bottom of duct.
11. Apply minimum 3-inch side laps and minimum 6-inch end laps for ductwork applications.

#### 3.04 DUCT SEALING FOR VARIABLE AIR VOLUME SYSTEMS

- A. All supply/return air metal and flexible duct joints shall be sealed with water based brush on duct sealant such as FLEX-GRIP 550 as manufactured by Hardcast, Inc. or UNI-FLEX as manufactured by McGill AirSeal LLC and applied in accordance with the manufacturer's directions.
- B. Where zero leakage transverse joints as manufactured by DUCTMATE INDUSTRIES or LOCKFORMER are used to join rectangular duct sections additional sealing is not required at those joints unless leakage is revealed during pressure tests.

#### 3.05 LEAKAGE

- A. All low pressure supply, return and outside air ductwork shall be tested and made substantially airtight at static pressure indicated for the system before covering with insulation or concealing in masonry. Substantially airtight shall be construed to mean that no air leakage is noticeable through the senses of feeling or hearing at all duct joints. Supply, return and outside air transverse duct joints shall be sealed a water based brush on duct sealant such as FLEX-GRIP550 as manufactured by HARDCAST or UNI-FLEX as manufactured by McGill LLC.
- B. The entire medium pressure ductwork system, including duct runouts to the variable air volume control units, shall be pressure tested for leakage at three (3) inches ductwork static pressure. Perform leakage tests in accordance with the

SMACNA HVAC Duct Leakage Test Manual, using test forms equivalent to those outlined in manual. Tests shall be observed by the Architect, Engineer and owner's representative. A test log shall be maintained by the contractor which will contain the results of systems tested and approval from test observer. Copies of the test log will be included in the operation and maintenance manuals.

### 3.06 CLEANING/STORAGE

Every effort should be made to ensure the components of the ductwork systems are kept clean and free of dust and debris. Stocked ductwork shall be stored in areas which are away from dust producing operations. Lined ductwork shall be stored in areas which are substantially weather-tight. Should any portion of lined ductwork become water saturated during storage or installation identified sections will be removed and replaced at no additional cost to the owner. As ductwork is being installed any open ductwork shall be temporarily sealed to prevent the ductwork from being contaminated with construction debris or dust. Temporary filter media shall be installed on the return systems of any equipment which is required to be run as a temporary control during the construction period. Temporary filters shall be monitored and changed frequently to ensure the cleanliness of the ducted systems.

After completing installation of ductwork, entire system shall be cleaned of rubbish, plaster, dirt and any other debris. After installation of equipment and connections are made on fan, and before any grilles are installed, entire system shall be blown out with dampers and outlets wide open.

### 3.07 DUCT SMOKE DETECTORS

Duct smoke detectors shall be furnished under and interconnected between the auxiliary contacts and the fire alarm system by the Division 16 contractor and installed under this section. The duct smoke detectors shall be installed in accordance with the manufacturer's recommendations, NFPA requirements and local fire marshal requirements. Duct smoke detectors shall be mounted to allow full access for service.

### 3.08 FIRE, SMOKE AND CEILING DAMPERS

- A. Provide fire dampers where ducts pass through fire-rated components and where required by the local authority. Install in accordance with local codes, NFPA, SMACNA-FSR and manufacturers requirements.
- B. Demonstrate the re-setting of the smoke damper and smoke detector to the Fire Marshal and the owner's representative.
- C. All interlock wiring between the 120 volt power supply and devices listed in this section shall be installed under this section. All wiring shall conform to the requirements of Division 16.

END OF SECTION

## SECTION 15845

### KITCHEN HEAT AND GREASE REMOVAL HOOD

(Engineer shall coordinate with the Architect to ensure the existing or specified equipment will physically fit under the proposed hood while maintaining factory recommended clearances and by at least a six inch overhang in all directions)

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install a complete Type I kitchen vapor removal system as outlined herein and as shown on the drawings. System shall consist of a sheetmetal hood, sheetmetal exhaust, and make-up air ductwork, and a wet chemical extinguishing system. Exhaust fan is specified separately.

##### 1.03 QUALITY ASSURANCE

The complete system shall conform to all state and local codes and to the requirements of the National Sanitation Foundation and the latest revisions of the National Fire Protection Association Standards Nos. 96 and 17 entitled "Removal of Smoke and Grease Laden Vapors from Commercial Cooking Equipment" and "Wet Chemical Extinguishing Systems".

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 KITCHEN RANGE HOOD

The kitchen range hood shall be manufactured by a firm that specializes in hood construction. The proposed manufacturer shall have done similar work for a minimum of 5 years and shall submit descriptive documentation for his capabilities and past experience with similar installations. Detailed drawings showing the proposed hood construction shall be submitted for approval before fabrication is begun. Premanufactured hoods by Captivaire or an equivalent manufacturer are acceptable. The kitchen range hood shall have capacity and dimensions as shown on the drawings.

A. Hood - Shall be fabricated of 18 gauge stainless steel with all seams and joints

having liquidtight continuous external weld. Refer to mechanical drawings for hood dimensions. Provide stainless steel enclosure panels (skirt) to close off the area between the top of the hood and the ceiling. The inside bottom lip of the kitchen hood shall angle up at 45 degrees to the vertical face of the hood to prevent a debris-catching horizontal surface.

- B. Grease filters and filter rack shall be stainless steel single sided type as manufactured by FARR or AMERICAN AIR FILTER. Provide removable drip tray, fasteners, holding frame, closure and filters.
- C. Exhaust Ductwork - Shall be fabricated of material and gauges noted below. All seams and joints shall be constructed with liquidtight continuous external weld. Ductwork shall have provisions for cleanout.
  - 1. Ductwork shall be 16 gauge galvanized or 18 gauge stainless steel with welds or braze ground smooth.
- D. Make-up Air Ductwork - Shall be fabricated of material and gauges noted below.
  - 1. Ductwork above the ceiling to the intake shall be 20 gauge galvanized.
  - 2. Ductwork above the roof shall be painted with one coat of black asphaltum.
  - 3. Provide motorized damper at outside air intake opening. Interlock to open when exhaust fan operates.
  - 4. Motorized dampers shall be low leakage opposed blade galvanized steel type with 16 gauge frame and 16 gauge blades. Maximum blade width 8". Provide neoprene seals at all blade edge and side meeting surfaces so that air leakage shall be no more than 2% at 3" static pressure. Provide Teflon or oil impregnated bronze shaft bearings and standard finish. Prototype - PENN VENTILATOR Model OBD-8. Motorized dampers fully equal to damper specified and manufactured by RUSKIN, AIR BALANCE, ARROW or CARNES will be acceptable.
- E. Fire Control System - Shall be wet chemical pre-engineered, piped, fixed nozzle type manufactured by the ANSUL COMPANY. It shall be specifically U/L Listed for the hazard and shall be installed in conformance with NFPA standards.
  - 1. System Design - Shall provide for protection of duct systems, grease removal devices and hoods, and cooking equipment such as fat fryers, ranges, griddles and broilers. All sources of fuel and heat to the cooking equipment shall be automatically shut off upon operation of the system.
  - 2. Operation - Shall be capable of manual operation and automatic operation controlled by a suitably listed system of detection and

actuation.

**PART 3 - EXECUTION**

3.01 INSTALLATION

The kitchen range hood shall be installed complete with all accessories in accordance with the manufacturer's recommendations and as shown on the drawings.

END OF SECTION



## SECTION 15846

### KITCHEN HEAT REMOVAL HOOD (For Elementary and Middle School)

(Engineer shall coordinate with the Architect to ensure the existing or specified equipment will physically fit under the proposed hood while maintaining factory recommended clearances and by at least a six inch overhang in all directions)

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this section.

##### 1.02 SCOPE

Provide and install a complete kitchen heat removal system as outlined herein and as shown on the drawings. System shall consist of a stainless steel hood, sheetmetal exhaust air ductwork. Exhaust fan is specified separately.

##### 1.03 QUALITY ASSURANCE

The complete system shall conform to all state and local codes and to the requirements of the National Sanitation Foundation and the latest revisions of the National Fire Protection Association Standards No. 96.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 KITCHEN HOOD

The kitchen hood shall be manufactured by a firm that specializes in hood construction. The proposed manufacturer shall have done similar work for a minimum of 5 years and shall submit descriptive documentation for his capabilities and past experience with similar installations. Detailed drawings showing the proposed hood construction shall be submitted for approval before fabrication is begun. Premanufactured hoods by Greenheck, Captivaire or an equivalent manufacturer are acceptable. The kitchen heat removal hood shall have capacity and dimensions as shown on the drawings.

- A. Hood - Shall be fabricated of 18 gauge stainless steel, with interior of the hood sealed and shall provide a smooth surface that is readily cleanable and water tight. Refer to mechanical drawings for hood dimensions. Provide stainless steel enclosure panels (skirt) to close off the area between the top of the hood and the

ceiling. The inside bottom lip of the kitchen hood shall angle up at 45 degrees to the vertical face of the hood to prevent a debris-catching horizontal surface. Refer to mechanical drawings for hood dimensions.

- B. Exhaust ductwork – Ductwork above the hood and through the roof to the exhaust fan shall be 22 gauge galvanized. Ducts subject to positive pressure shall be constructed, joined and sealed in the approved manner.
- C. Lights – Hood shall have U/L listed, vapor proof, incandescent light fixtures.
- D. Controls – Hood shall have integral switch panel with separate switches for the light and the exhaust fan. Exhaust fan switch shall have an indicating light.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

The kitchen range hood shall be installed complete with all accessories in accordance with the manufacturer's recommendations and as shown on the drawings.

END OF SECTION

## SECTION 15847

### KITCHEN MAKEUP AIR UNIT

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions, and Section 15050 - Basic Materials and Methods shall apply to this Section.

##### 1.02 SCOPE

- A. Install a complete factory assembled kitchen makeup air unit with a direct gas fired preheater.

##### 1.03 QUALITY ASSURANCE

- A. Conform to AMCA Bulletins regarding construction and testing. Fans shall bear AMCA certified rating seal.
- B. Provide fans with U/L label. Provide furnaces design-certified by the American Gas Association (AGA) and bear the AGA label.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 ACCEPTABLE MANUFACTURERS

The kitchen makeup air unit shall be manufactured by GREENHECK. Units fully equal to the specified manufacturer by CAPTIVEAIRE are acceptable.

##### 2.02 KITCHEN VENTILATION UNITS

- A. Supply:
  - 1. Filtered makeup air units shall have belt driven double width/double inlet, forward curved centrifugal type supply fans. The entire fan and motor assembly shall be mounted on vibration isolators to prevent noise transmission. Motors shall be permanently lubricated, heavy duty, ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. The fan shaft shall be ground and polished steel mounted in heavy duty, sealed ball bearings. Bearings shall be selected for a minimum average life in excess of 200,000 hours of maximum cataloged operating speeds. Pulleys shall be of the fully machined, cast iron type, keyed and securely attached to the wheel and motor shafts. Motor sheaves shall be adjustable for final

system balancing. Drives shall be sized for a minimum of 150% of driven horsepower.

2. Fan wheels shall be of the forward curved type, constructed of heavy gauge steel and statically and dynamically balanced to ensure smooth, vibration free operation.
3. Housing construction shall be heavy gauge galvanized steel with removable panels for access to fan and tempering unit components, filters and controls.
4. Filter Section - Low velocity medium capacity filter section shall be a matching part of the unit with access through hinged doors on both sides. Filters shall be 2" FARR 30/30, medium efficiency, pleated, disposable type. Each filter shall consist of a non-woven cotton fabric media, media support grid and enclosing frame. The filter media shall have an average efficiency of 30-35% of ASHRAE Test Standard 52-76. It shall have an average arrestance of not less than 92% in accordance with that test standard. The filter shall be listed by Underwriter's Laboratories as Class 2. Two complete sets of spare filters shall be supplied. Filters shall have a minimum MERV rating of 13.
5. The prewired control center shall include, but not be limited to, an integral master disconnect switch with fuse blocks for main power connection, magnetic motor starters with thermal overloads and manual reset, fused 115 volt control transformer, and distribution terminal control strip for control wiring connection. All electrical components shall be U/L listed, Approved or Classified where applicable and wired in compliance with the National Electrical Code. Wiring shall be complete, requiring only one-point field connection for power service and one-point field connection for low voltage.

B. Exhaust:

1. Roof exhaust fans shall be of the belt drive, upblast, vertical discharge type. Housings shall be constructed of heavy gauge aluminum. The windband shall have a rolled bead and additional structural members for added strength. The fan wheel shall be of the backward inclined, centrifugal type, constructed of aluminum and statically and dynamically balanced for smooth, vibration free operation.
2. Motors and drives shall be isolated from the airstream. Motors shall be permanently lubricated, heavy duty, ball bearing type, carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. Motors shall be cooled by air drawn from outside the exhaust airstream.
3. The fan shaft shall be ground and polished steel mounted on heavy duty ball bearings. Bearings shall be selected for a minimum average life in excess of 200,000 hours at maximum cataloged operating speeds.

4. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. Motor sheaves shall be adjustable for final system balancing. Drives shall be sized for a minimum of 150% of driven horsepower. The entire fan and motor assembly shall be mounted on vibration isolators to prevent noise transmission.
  5. The roof exhaust fans shall bear the AMCA certified ratings seals for air and sound performance.
- C. Heater:
1. Provide a direct gas fired preheater. The preheater shall be supplied as an integral part of the makeup air unit.
  2. The heater shall include, but not be limited to, a cast iron and stainless steel burner, gas valve with sensor, main and pilot electric gas valves and pressure regulators, main and pilot manual shutoff valves, an air flow switch, high limit control, flame safeguard control, flame rod, and electronic ignition pilot.
- D. Roof Curb: Provide prefabricated 12" roof curb lined with fiberglass insulation. Provide heavy gauge galvanized steel equipment supports.

### **PART 3 - EXECUTION**

#### **3.01 INSTALLATION**

- A. Supply and install sheaves as necessary for final air balancing.
- B. Set roof mounted fans on curbs. Provide acoustic insulation on duct to below roof line and on fan inlet plenum, and drip pan for collecting condensation.
- C. Provide a spare fan belt for each makeup air unit.
- D. Provide a typed list of all the different makeup air units and their filter and fan belt sizes and submit to the Owner two copies of the list distributed to:
  1. Project Manager, Office of Design and Construction Services, Gatehouse Administrative Center, 8115 Gatehouse Road, Suite 3500, Falls Church, VA 22042.
  2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia 22032.
  3. Include list in the Operation and Maintenance manuals.

END OF SECTION

## SECTION 15870

### AIR DISTRIBUTION DEVICES

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract Requirements, Division 1 - General Requirements, Section 15010 - General Provisions and Section 15050 - Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

The work covered under this section shall include various types of air outlets and inlets to be furnished and installed complete.

##### 1.03 QUALITY ASSURANCE

Air outlets and inlets shall be rated by a recognized testing agency such as the Air Diffusion Council, ASHRAE Standard 36-72, Air Movement and Control Association International, Inc., or an acceptable manufacturer's test laboratory.

##### 1.04 SUBMITTALS

Provide shop drawings on this equipment as described in Section 15010 - 1.04. Shop drawings shall include proposed uses of all items.

#### PART 2 - PRODUCTS

##### 2.01 GRILLES, REGISTERS AND CEILING DIFFUSERS

The grilles, registers and ceiling diffusers shall be provided as shown on the drawings along with accessories as required. The grilles, registers and ceiling diffusers shall be manufactured by CARNES, KRUEGER, TITUS, TUTTLE and BAILEY, NAILOR, PRICE or METALAIRE unless otherwise noted, provided the items are fully equal to the item specified below.

- A. Supply Air Diffuser, Ceiling, Square: lay-in type, steel, stamped type, fixed pattern, square louvered face, opposed blade volume damper, equalizing grid, (combination damper/grid are not acceptable) white powder coat finish. Price model SCD.
- B. Supply Air Louver, Exposed Duct Mounting, Drum Louver: Aluminum, adjustable pattern, aluminum finish with volume damper. Price model HCD1.
- C. Supply Air Registers: Steel adjustable vanes, double deflection, vertical front

vanes, opposed blade dampers, Aluminum finish. Price model 520D.

- D. Air Extractor: Pivoted adjusting curved blades with adjusting strap. Price model AE1.
- E. Return Air Grille, Ceiling: Steel individual fixed horizontal face bars, 0° deflection, white finish, size shall be minimum 12" x 24". Price model 510HZ.
- F. Return Air Grille, Wall: Steel, individual fixed horizontal face bars, 40° deflection, heavy duty type, aluminum finish. Price model 91.
- G. Return Air Register, Ceiling: Steel, individual fixed horizontal face bars, 0° deflection, volume damper, white enamel finish. Price model 510ZD. Exhaust air register shall be the same except aluminum, Price model 610ZD.
- H. Linear Slot Diffuser: Aluminum, adjustable blades, 1" slot with 1" frame, standard frame finish white, mounting hardware, 1" end caps at both ends, blank sections as required. Remove blades when used as a return. Coordinate with drawings for frame type, number of slots and length. Price model SDS100 Frame 2.

## 2.02 ROOF VENTS - RELIEF OR INTAKE

A. Roof vents shall have the following features:

1. Aluminum hood panels.
2. 12" high curb.
3. Aluminum bird screen.
4. Counterbalanced gravity backdraft damper.
5. Motorized damper.

B. Prototype: GREENHECK model Fabra.

## 2.03 LOUVERS

Louvers shall be furnished under Division 15 unless specified under the architectural sections.

Stationary Louvers: Shall be extruded aluminum, 4" blade spacing, 45° blades with rain hook and continuous underside reinforcing bosses. Provide boxed frame for mounting inside masonry openings and flanged frame for panel wall openings. Provide duct collar, 1/2" mesh aluminum bird screen and clear anodized finish; color selection shall

be approved by Architect. Louver shall meet AMCA test standards for pressure drop and water leakage. Prototype - ARROW model EA-405-FF. Louvers fully equal to the specified manufacturer and manufactured by RUSKIN, AIRLINE, AIR BALANCE, UNITED ENERTECH or CARNES will be acceptable.

#### 2.04 MOTORIZED DAMPERS

Motorized dampers shall be low leakage opposed blade galvanized steel type with 16 gauge frame and 16 gauge blades. Maximum blade width 8". Provide neoprene seals at all blade edge and side meeting surfaces so that air leakage shall be no more than 1% at 4" static pressure. Provide Teflon or oil impregnated bronze shaft bearings and standard finish. Prototype: ARROW model 395. Motorized dampers fully equal to damper specified and manufactured by RUSKIN, AIR BALANCE, PENN VENTILATOR, CESCO, DOWCO, GREENHECK or CARNES will be acceptable.

#### 2.05 VARIABLE AIR VOLUME CONSTANT VOLUME TERMINAL UNIT

- A. Provide and install fan powered terminals with electrically driven fan and automatically controlled modulating damper. Unit shall supply a constant volume of air to the space by mixing of the primary conditioned variable air with ceiling plenum return air as described herein and shown on the drawings. Capacities shall be as shown in the equipment schedule.
- B. Air Controlling Assembly - Shall consist of volume regulator, air flow throttling control device, device operator, and adjustment points, Regulator shall compensate for static pressure fluctuations by repositioning damper operator and shall act as reversing relay. Provide normally closed actuators for units with integral heating coils.
- C. Cabinet shall be galvanized steel wrap around one-piece structural frame with all exposed edges flanged and interior of discharge section insulated. Mixing section shall have single blade gasketed minimum leakage damper. Fans shall be centrifugal forward curved double width mounted on double-shafted three-speed permanent split capacitor motor. Fan wheels and housing shall be constructed of noncorrosive material.
- D. Coils - Shall be constructed of aluminum fins mechanically bonded to seamless copper tubes, with continuous fin collars and sleeved coil and supports. Coils shall be factory leak tested at a minimum 300 psi.
- E. Unit Supports - Control units and slot type diffusers shall be located as shown on drawings and shall be independently supported with mounted channel and SMACNA approved hanger strap.
- F. Filters – Shall be throwaway type.
- G. The Sound Power Levels (10 - 12 watts) generated when producing the specified



cfm shall not exceed the following figures in any octave band.

|                   |     |     |     |      |      |      |      |
|-------------------|-----|-----|-----|------|------|------|------|
| Octave Band       | 2   | 3   | 4   | 5    | 6    | 7    | 8    |
| Center Frequency  | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
| Sound Power Level | 73  | 69  | 66  | 59   | 54   | 53   | 56   |

- H. Fan and damper controls shall be furnished and installed under the Automatic Temperature Control section of the specification. The division 15900 contractor shall furnish and ship direct digital controllers to the terminal equipment manufacturer for factory installation. The division 15900 contractor shall provide the equipment manufacturer with the necessary wiring diagrams and mounting instructions. The terminal equipment manufacturer shall furnish transformers, relays, airflow sensors and enclosures.
- I. Manufacturer – PRICE or acceptable by ENVIRONMENTAL TECHNOLOGIES, CARRIER, TITUS, TRANE, or TEMPMASTER.

2.06 VARIABLE AIR VOLUME (VAV) EQUIPMENT TERMINAL UNITS

- A. Provide shutoff type air terminal components of an automatically controlled variable air volume system as described herein and shown on the drawings. The system shall consist of air modulating control units serving remote diffusers. Capacities shall be as shown in the equipment schedule.
- B. VAV box manufacturer shall provide all necessary transformers, relays, airflow rings and enclosures. The division 15900 contractor shall furnish and ship the direct digital controllers and actuators to the equipment manufacturer for installation. The division 15900 contractor shall provide the equipment manufacturer with the necessary wiring diagrams and mounting instructions.
- C. Air Control Units- Shall regulate the air volume delivered to diffusers either mounted on the unit or remotely connected by ductwork. Units shall be constructed of heavy gauge galvanized steel. All interior surfaces shall be acoustically and thermally insulated with glass fiber material, surface treated to prevent erosion. Insulation shall be U/L listed and meet NFPA requirements. Provide hanger holes at all four corners. Minimum box setting shall be factory adjusted to minimum airflow shown in the equipment schedule.
- D. Automatic Temperature Control System- Damper operator shall be controlled by a remote sensor as described in the temperature control section of the specifications.
- E. Air Controlling Assembly- Shall consist of volume regulator, airflow throttling control device, device operator, and adjustment points. Regulator shall compensate for static pressure fluctuations by repositioning damper operator and shall act as a reversing relay. Provide normally open direct acting actuator or

provide the necessary reversing relay to meet this requirement.

- F. Hot Water Coil- Shall be constructed of aluminum fins mechanically bonded to seamless copper tubes, with continuous fin collars and sleeved coil and supports. Coil shall be factory leak tested at minimum 300 psi.
- G. Manufacturer- PRICE or acceptable by ENVIRONMENTAL TECHNOLOGIES, CARRIER, TITUS, TRANE or TEMPMASTER.

## 2.07 THERMALLY POWERED VAV DIFFUSER

- A. Thermally powered VAV diffuser shall be a complete VAV terminal and thermostat self contained in a 24 inch square diffuser. They shall be thermally powered with one room thermostat / actuator and one changeover thermostat / actuator.
- B. The VAV diffusers shall have a thumbwheel and temperature scale to adjust the cooling setpoint and another thumbwheel and temperature scale for the heating setpoint. The adjustment shall be above the hinge down panel. Each setpoint shall be separately adjustable between 70°F and 78°F.
- C. In the cooling mode, the VAV diffuser shall open on a rise in room temperature and in the heating mode; it shall close on a rise in room temperature. The changeover thermostat shall be factory installed and adjusted to engage the heating mode when the supply air temperature rises above 80°F and return to cooling mode when the supply air temperature falls below 68°F. During the changeover, the diffuser shall close, or if a minimum flow is set, go to the minimum.
- D. All VAV diffusers shall have a dial and scale to adjust minimum flow between 5 CFM and 50% of maximum flow without tools. Minimum flow shall be factory set at 10%. A fixed maximum flow stop shall be factory set for the fully open air flow of the specified inlet size.
- E. All VAV diffusers shall have a lever which will open the damper for balancing without tools. The balancing lever shall be accessible from the outside of the diffuser without folding down the appearance panel or removing any part of the diffuser.
- F. Acceptable manufacturers – ACCUTHERM “Thermafuser”, PRICE “Varitherm”, or THERMAL PRODUCTS “Variflow”.

## PART 3 - EXECUTION

### 3.01 GRILLES, REGISTERS, DIFFUSERS, AND LOUVERS - INSTALLATION

- A. The grilles, registers and ceiling diffusers shall be installed in accordance with the manufacturer's recommendations. Dampers shall be installed where shown and where required to balance the air system.
- B. Before locating grilles and ceiling diffusers, check the Architectural and Electrical drawings to make sure that there is no conflict with floor moldings, electrical outlets, lighting fixtures or any other obstruction. Low sidewall grilles and registers shall be mounted with the bottom edge eight inches above the floor with the vanes turned down. High sidewall grilles and registers shall be mounted six inches below the ceiling or as shown on architectural drawings.
- C. Air extractors shall be provided and installed as shown on the drawings. Provisions shall be made to adjust air extractor from the exterior of the ductwork. When air extractor is installed, no damper for the register is required.

### 3.02 LOUVERS

Supply air, exhaust air and combustion air louvers shall be installed as shown on the drawings. The louvers shall be furnished under Division 15 unless specified under the architectural section. The louvers shall be provided with 1/2" aluminum bird screen, duct collars where required, and be installed in a manner where no water will enter the building.

### 3.03 TERMINAL UNIT

- A. Shall be installed in accordance with the manufacturers' recommendations. For the Variable Air Volume Terminal Units, the first unit installed will be considered the typical mock up and shall require notification, inspection and approval by designated owner representative and/or architect and engineer before any additional installations will be allowed.
- B. Filters - Shall be changed at the end of the construction period and before the final inspection. Provide a typed list of all the different units and their filter sizes to be included in the O & M manuals. The list shall include the unit designation, filter size and the number of filters required for each unit. In addition to this, submit to the Owner two additional copies of the list, distributed to:
  - 1. Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
  - 2. Coordinator, Mechanical Maintenance Division, Maintenance Services, 5025 Sideburn Road, Fairfax, Virginia, 22032

**SECTION 15900**  
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## SECTION 15900

### AUTOMATIC TEMPERATURE CONTROLS

#### PART 1. GENERAL

##### 1.01 RELATED DOCUMENTS

- A. The Bidding and Contract Requirements and Division-I – General Requirements for the Construction of this project shall apply to this section.
- B. Section 15010 - Mechanical General Provisions

##### 1.02 DESCRIPTION OF WORK

- A. Contractor shall furnish and install a direct digital control (DDC) and building automation system (BAS) Operator interface graphic software (GUI) and a web-based operator interface. This system shall reside on the owner's existing building automation server. The web-based operator interface shall allow access from a standard web browser. The new DDC/BAS shall utilize electronic sensing; microprocessor based digital control and electronic actuation of dampers and valves to perform control sequences and functions specified. The BAS for this project shall generally consist of monitoring and control of central heating and cooling plants, air handling systems, terminal equipment, and other miscellaneous equipment. The extent of Automatic Temperature Control Systems work is indicated on the drawings, schedules and by requirements of this section.
- B. Phasing - The project will be completed in phases extending over several years. The existing control system shall remain operational during the entire period to keep all existing systems not yet replaced operational.
- C. Single Source Responsibility - The control system shall be completely installed and placed in operating condition by a firm specializing in this type of work. The firm shall provide a single source responsibility for all system components, engineering services, maintenance and warranty. Qualifying conditions are more fully described in a separate paragraph.
  - 1. The ATC Contractor shall be qualified and thoroughly experienced in providing single source responsibility for the Automatic Temperature Control System.
  - 2. The ATC Contractor shall be fully responsible for the complete design, installation and proper operation of the system, including but not limited to: Data and control signal transmission systems, Intelligent field interface devices (IFID) and interfacing of all system equipment, sensors and controls, memory units and peripheral devices. The ATC Contractor shall

also coordinate the installation with the security system (i.e. if Master controller loses power a general alarm will be generated). This alarm signal shall be furnished by the security system.

3. After the installation, the Contractor shall be responsible for the debugging and calibration of the system, including all software, and maintenance of the system until the system functions in accordance with these specifications and successfully completes the final operational acceptance Test described in this Section. The Contractor's responsibilities shall also include all software and software maintenance during the warranty periods.
  4. The ATC contractor shall coordinate with the mechanical equipment supplier to successfully create a communication interface with the factory supplied communication protocol. The ATC contractor shall be responsible for the mounting of the manufacturer supplied interface device(s), this includes power wiring, communication wiring, necessary switches and enclosures. The ATC contractor shall be responsible for the mounting of VRF centralized and BACnet controllers/devices, in panels constructed in compliance with 2.02.F of this section.
- D. All documentation required shall be considered as much as part of this contract as the system installation itself. Its accuracy and applicability shall be considered for conformance to the specifications. Expenses incurred due to non-conformance shall be recoverable from the Contractor or his surety according to the conditions of the Performance Bond. Any system revisions and/or additions provided for or required under this contract shall be included in this documentation in the form of updated documents.
- E. Provide the following electrical work as work of this section, complying with requirements of Division-16 sections:
1. Power wiring from a dedicated circuit breaker at each 120 Volt panel to a junction box shall be provided by the Division 16 Contractor. Electrical circuits for use by the BAS Contractor are shown on the electrical drawings. This Contractor is responsible for all power wiring from this junction box to control panels, devices, controllers and components for a complete and operating system. See plans for details.
  2. Control wiring between field-installed controls, indicating devices, and unit control panels.
  3. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated.
  4. All other electrical wiring, conduit and additional electrical components required to complete the automatic temperature control system including, but not limited to, interlocking of motor controllers with all other control

and building system components, power wiring between junction boxes and control transformers and power wiring of auxiliary power receptacles, shall be provided and installed under this section of the specifications. Wiring shall comply with all requirements of Division 16 of this specification and the National Electrical Code. It shall be noted that while every attempt to show the sensor junction box locations on the Division 16 electrical drawings has been made, should a sensor or sensors, junction box location be inadvertently not shown and said sensor is required for operation or mentioned in the sequence of operation, the rough-in of these junction boxes shall be the responsibility of this contractor.

- F. Smoke Detectors – Shall be furnished and wired to the fire alarm system by the Division 16 contractor. Smoke detectors are to be furnished with one set of normally closed contacts for interface to the equipment starters. They shall be installed under Division 15 and interlocked to their respective starters under this section. Fire alarm modules for unit shutdown shall be provided and installed by the division 16 contractor. It shall interlock with the respective starters under this section.
- G. Contractor shall provide all LAN interface devices and software to provide an integrated system connecting Control Units, Operator Interfaces, printers, etc. as described in this Section. Communications throughout all levels shall be seamless and reliable.
- H. Furnish and provide all software, programming and dynamic color graphics for a complete and fully functioning system as specified.
- I. The Owner, and Commissioning Agent, shall work with the Contractor and the Design Engineer to ensure that the systems, equipment, and interfaces are installed, tested, and operate per the design intent and contract documents, that the systems are adequately documented; and that the Owner is adequately trained on system intent, operation, and maintenance.
- J. Completion - It is the intention of the specifications and drawings to call for furnished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean "provide and install complete and ready for use".

### 1.03 WORK BY OTHERS

- A. Coordination Meeting - The installer furnishing the DDC network shall meet with the installer(s) furnishing each of the following products to coordinate details of the interface between these products and the DDC network. The Owner or his designated representative shall be present at this meeting. Each installer shall provide the Owner and all other installers with details of the proposed interface including Protocol Implementation Conformance Statement (PICS) for BACnet equipment, hardware and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network

accessories. The purpose of this meeting shall be to ensure that there will be no unresolved issues regarding the integration of these products into the DDC network. Submittals for these products shall not be approved prior to the completion of this meeting.

- B. Variable Refrigerant Flow System (VRF) - The VRF systems shall be provided with all of the necessary interface hardware, software, and programming required to support the specified ATC interface. The ATC system is to provide individual start/stop points to each of the VRF systems as well as the control and monitoring points listed in the input/output summaries and sequences, at a minimum. The VRF control panel(s), provided by the VRF manufacturer, will accept these control points.
1. The connection to these points, which are listed by preference, shall be by one of the following methods;
    - a. BACnet MS/TP network connection.
    - b. BACnet/IP network connection.
    - c. BACnet over ARCNET network connection.
  2. The VRF system manufacturer and installing contractor shall coordinate and collaborate with the ATC contractor for the following:
    - a. Programming and protocols of the mechanical equipment by the equipment manufacturer to support the specified ATC interface.
    - b. Start-up coordination with the ATC contractor to verify correct operation.
    - c. Clearly defined termination points in the VRF control panel to allow ATC interface as specified.
- C. Chiller System - The chiller(s) shall be provided with all of the necessary interface hardware, software and programming required to support the specified ATC interface. The ATC system is to provide individual chiller start/stop points to each of the chillers as well as the control and monitoring points listed in the input/output summaries and sequences, at a minimum. The chiller control panel(s), provided by the chiller manufacturer, will accept these control points and provide start/stop, loading/unloading, staging and sequencing of the individual compressors.
1. The connection to these points, which are listed by preference, shall be by one of the following methods;
    - a. BACnet MS/TP network connection.
    - b. Hardwired connection such as relay, 0-10 VDC or 4-20 mA.
    - c. BACnet/IP network connection.



- d. BACnet over ARCNET network connection.
2. The chiller manufacturer and installing contractor shall coordinate and collaborate with the ATC contractor for the following:
    - a. Programming and protocols of the mechanical equipment by the equipment manufacturer to support the specified ATC interface.
    - b. Start-up coordination with the ATC contractor to verify correct operation.
    - c. Clearly defined termination points in the OEM control panel to allow ATC interface as specified.
- D. Energy Recovery Units, Packaged VAV Rooftop Units, Packaged Rooftop Units, Makeup Air Units, Rooftop Air Handling Units - This equipment shall be furnished configured to accept control inputs from an external building automation system controller as listed in the input/output summaries. Factory mounted safeties and other controls shall not interfere with this controller. Should an interface be specified, the equipment supplier shall furnish the system with an interface to the control and monitoring points listed in the input/output summaries.
1. The connection to these points, which are listed by preference, shall be by one of the following methods:
    - a. BACnet MS/TP network connection.
    - b. Hardwired connection such as relay, 0-10 VDC or 4-20 mA.
    - c. BACnet/IP network connection.
    - d. BACnet over ARCNET network connection.
  2. The equipment manufacturer and installing contractor shall coordinate and collaborate with the ATC contractor for the following:
    - a. Programming and protocols of the mechanical equipment by the equipment manufacturer to support the specified ATC interface.
    - b. Start-up coordination with the ATC contractor to verify correct operation.
    - c. Clearly defined termination points in the OEM control panel to allow ATC interface as specified.
- E. Variable Frequency Drives - The variable frequency drive (VFD) supplier shall furnish VFD's with an interface to the control and monitoring points listed in the input/output summaries.

1. The variable frequency drive manufacturer and installing contractor shall coordinate and collaborate with the ATC contractor for the following:
  - a. Programming and protocols of the mechanical equipment by the equipment manufacturer to support the specified ATC interface.
  - b. Start-up coordination with the ATC contractor to verify correct operation.
  - c. Clearly defined termination points in the OEM control panel to allow ATC interface as specified.
- F. Control Valves furnished under this section shall be installed under the applicable piping section under the direction of Section 15900 Contractor who shall be fully responsible for the proper operation of the valve.
- G. Control Dampers and air flow measuring stations furnished under this section shall be installed under the applicable air distribution or air handling equipment section under the direction of Section 15900 Contractor who shall be fully responsible for the proper operation of the dampers.
- H. Water Pressure Taps, Thermal Wells, Flow Switches, Flow Meters, etc. that shall have wet surfaces, shall be installed under the applicable piping section under the direction of Section 15900 Contractor who shall be fully responsible for the proper installation and application.
- I. Power Monitoring Equipment furnished under this section shall be installed under the applicable electrical equipment section under the direction of the Division 16 Contractor.
- J. The Division 16 Contractor at the location of the main ATC panels shall provide one Telecommunications outlet and one Data only outlet. Should the ATC suppliers system require more than one outlet for their system this requirement will be the ATC supplier's responsibility.
- K. Commissioning Agent and owner shall perform the commissioning process to establish and document the criteria for systems function, performance, and maintainability and to verify/document compliance with these criteria throughout the construction, equipment start-up, space turnover, and the initial period of operation.
- L. The division 16 contractor shall provide a conduit sleeve for all roof top equipment (not including PRV/EF). The required conduit size shall be coordinated with the division 15900 contractor.

## 1.04 PROCUREMENT

- A. The BAS and digital control and communications components installed, as work of this contract shall be an integrated distributed processing system of one of the following manufacturers.
- B. Acceptable Manufacturers
  - 1. Automated Logic Corporation - Interop with WebCtrl access software and controllers
  - 2. Delta Controls with ORCAView/ORCAweb software and web access controls
  - 3. Trane – Tracer Summit software with web access through a Tracer Summit Enterprise Server.
  - 4. Substitutions: NONE
- C. The BAS shall be installed by competent mechanics regularly employed by a specialty firm that is in the full time business of designing and installing environmental control systems and is an authorized representative of one of the prequalified control equipment manufacturers listed.
- D. Acceptable Installers
  - 1. Engineered Services Inc.
  - 2. EMS Consultants, Inc.
  - 3. Boland Trane.
  - 4. Substitutions: NONE

## 1.05 QUALITY ASSURANCE

- A. ATC System Qualifications: System shall be based on Manufacturer's standard integrated hardware and software product offering, which has been installed and fully operational in similar service for 2 years.
- B. Codes and Standards – Refer to most recent issue and/or State Adopted Standard:
  - 1. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
    - a. ASHRAE/ANSI 135-2012: Data Communication Protocol for Building Automation and Control Systems (BACNET).

2. Underwriters Laboratories (UL).
  - a. UL 916 Energy Management Systems.
  - b. UL 864 Control Units and Accessories for Fire Alarm Systems.
3. National Electrical Manufacturer's Association (NEMA):
  - a. NEMA 250 Enclosure for Electrical Equipment
  - b. NEMA ICS 1: General Standards for Industrial Controls.
4. National Fire Protection Association (NFPA):
  - a. NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences. NEMA ICS 1: General Standards for Industrial Controls
  - b. NFPA 70 National Electrical Code (NEC).
  - c. NFPA 72 National Fire Alarm Code (NEAC).
5. Institute of Electrical and Electronics Engineers (IEEE)
  - a. IEEE 142 Recommended Practice for Grounding of Industrial and Commercial Power Systems.
6. Electronics Industries Associations (EIA)
  - a. EIA 232 Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
  - b. EIA 485 Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.

#### 1.06 DEFINITIONS

- A. ASC – Application Specific Controller Intelligent control panel with limited capabilities designed for controlling terminal devices.
- B. BAS - Building Automation System - The entire integrated management and control system
- C. CA - Commissioning Agent and/or Owner
- D. CEF - Cabinet or Ceiling Exhaust Fan

- E. CHW - Chilled Water
- F. CHWR - Chilled Water Return
- G. CHWS - Chilled Water Supply
- H. CT - Cooling Tower
- I. CUH - Cabinet Unit Heater
- J. CW – Condenser water
- K. CZ - Control Zone
- L. DDC - Direct Digital Control - Microprocessor based control including Analog/Digital conversion and program logic.
- M. FCPS - Fairfax County Public Schools – The Owner
- N. HW - Hot water
- O. HWS - Hot water supply
- P. HWR- Hot water return
- Q. IFID/CU - Intelligent Field Interface Device/Control Unit, stand alone control panel, including both primary control units and application specific controllers
- R. O.A. - Outside Air
- S. OEM – Original Equipment Manufacturer
- T. OI - Operator Interface - A device used by the operator to manage the BAS including OW, POT, and HHD.
- U. OW - Operator Workstation - PC and connected devices used as the central graphic “front end” to the system.
- V. PCU - Primary Control Unit - Fully featured intelligent stand-alone control panel residing on the primary LAN.
- W. Physical Point - A point on the BAS that is physically connected to an I/O device such that a hardware point exists.
- X. POT - Portable Operators Terminal - Laptop PC used both for direct connection to a CU and for remote dial up connection.

- Y. Virtual Point - A point to store values (i.e.: a set point) that do not represent a physical device.
- Z. AHS - air handling system- any system which supplies conditioned air.
- AA. GUI - Graphical User Interface.
- BB. TU - terminal unit- unitary equipment ( fan coil unit, unit ventilator, valance, blower coil unit, VAV box etc.).

#### 1.07 SYSTEM SOFTWARE-GENERAL

- A. Functionality and Completeness: The Contractor shall furnish and install all software and programming necessary to provide a complete and functioning system as specified. The Contractor shall include all software and programming not specifically itemized in these Specifications, which is necessary to implement, maintain, operate, and diagnose the system in compliance with these Specifications.
- B. Configuration: The software shall support the system as a distributed processing network configuration.

#### 1.08 SUBMITTALS

- A. Submit under provisions of Section 15010.
- B. Product Data: Submit manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Also include installation and start-up instructions.
- C. Shop Drawings: Submit eight sets of shop drawings for each control system. Submit a completed drawing for each central plant system, air handling unit, terminal unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Shop drawings for system control schematics shall be provided in a format matching the design documents. Provide sample graphic display screen types. Shop drawings shall be submitted both on paper and electronic media as an AutoCAD Version 2006 or newer version-drawing file. (All x reference and font files must be provided on disk also). Each shop drawing shall contain the following information:
  - 1. Shop Drawings shall commence with Color-coded small-scale building plans showing different colors for each HVAC zone.
  - 2. Shop Drawings shall continue with scaled floor plans; CAD files showing all mechanical equipment and ducting are to be made available to the ATC contractor through the General Contractor or Mechanical Contractor for coordination. Floor plans produced and submitted by the ATC

contractor are to show the location of all mechanical equipment, all ATC control panels, all space sensors, all communication/data bus routing, duct sensors remote from the units such as supply static pressures, etc. Floor plan drawings are to clearly identify all area 'zones' and equipment groupings.

- a. Interior sensors locations noted on the contract drawings may be diagrammatic. The ATC contractor is responsible for the proper location/placement of all sensors. Interior sensors are to be located using the following criteria:
  - 1) Locations near the entrance door to the space are preferred.
  - 2) Locations near return air grills are preferred.
  - 3) Temperature and Humidity sensors must be located away from: supply air diffusers, mechanical or electrical equipment mounted in the room, shelving, lockers and anything that could adversely effect the sensor function.
  - 4) Any sensor that must be relocated from the position identified on the contract drawings must be reviewed with the Owner and Engineer.
3. System architecture one-line diagrams, indicating schematic location of all control units, workstations, LAN interface devices, gateways, etc. Indicate address and type for each control unit. Indicate protocol, baud rate, and type of each LAN.
4. Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. A verbal description of sequence of operation shall be on the same page as the flow schematic. Once construction is complete, contractor shall provide an "as built" reprint of the contractual sequence of operation.
5. All physical points shall be indicated with names, descriptors, and point addresses identified.
6. With each schematic, provide a detailed points list on the drawings with all physical points included.
7. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.

8. The ATC contractor shall submit for review a valve selection chart with data for each of the following items.
  - a. Valve Application or Location (indicate ATC supplied or OEM).
  - b. Line Size to Coil.
  - c. Coil GPM requirements (Coil requirements are to be based on the actual coils submitted by the mechanical contractor).
  - d. Coil Pressure Drop.
  - e. Control Valve Manufacturer and Part Number.
  - f. Control Valve Size.
  - g. Control Valve Type (Sweat, NPT, Flange).
  - h. Control Valve Configuration (2-way, 3-way).
  - i. Control Valve CV.
  - j. Control Valve Pressure Drop.
  - k. Control Valve Close Off Pressure.
  - l. Valve Actuator Manufacturer and Part Number.
  - m. Valve Actuator Operation (2-position, 0-10 modulating, floating, etc.).
  - n. Valve Actuator Power Source Voltage (24, 120, etc.).
  - o. Spring Return (Yes/No).
  
9. The ATC contractor shall submit for review a damper selection chart with data for each of the following items.
  - a. Damper Application or Location (indicate ATC supplied or equipment OEM)
  - b. Damper Manufacturer and Part Number
  - c. Damper Size/Shape
  - d. Damper Torque Requirements



- e. Damper CFM (requirements are to be based on the actual units submitted by the mechanical contractor)
  - f. Damper Type (Parallel, Opposed)
  - g. Damper Actuator Manufacturer and Part Number
  - h. Damper Actuator Operation (2-position, 0-10 modulating, floating, etc.)
  - i. Damper Actuator Power Source Voltage (24, 120, etc.)
  - j. Damper Actuator Spring Return (Yes/No)
  - k. Damper Actuator End Switches (Yes/No/Quantity)
  - l. Damper Actuator Mechanical Limit Stops (Yes/No/CFM at stop0)
  - m. Provide cut sheets and support data for each selected damper and actuator.
10. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide circuit number or panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that exist, factory-installed and portions to be field-installed.
11. Details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.
12. Points list including all physical I/O and virtual points. Points list shall be provided in both hard copy and in electronic format (Quote and Comma Delimited, ACCESS data table, or EXCEL spreadsheet formats are acceptable formats)
13. Sheets shall be consecutively numbered.
14. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.
15. Table of Contents listing sheet titles and sheet numbers.
16. Legend and list of abbreviations.
17. Override Panel control zone diagram graphic

## D. Control Logic Documentation:

1. Submit control logic graphical flow diagrams (for block type programs) or program listings and logic flow charts (for line type programs) to document the control software of all control units.
2. Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation. Logic flow charts for line type programs shall graphically show the logic flow of each application program.
3. Include a complete and concise written description of each control sequence and include icon files.
4. Include control response, settings, setpoints, throttling ranges, gains, reset schedules, adjustable parameters and limits.
5. Sheets shall be consecutively numbered.
6. Each sheet shall have a title indicating the controller designations and the HVAC system controlled.
7. Include Table of Contents listing sheet titles and sheet numbers
8. For block type programs, any two interconnected blocks that are shown on one sheet shall be shown with an interconnecting line, with limited use of references. Any two interconnected blocks that are shown on separate sheets shall include references to the connected block and the sheet number where the connected block is located. For line type programs, any program that calls a subroutine located on a separate sheet shall reference the line number where the subroutine is located.
9. Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation. This set shall count toward the required number of Operation and Maintenance manuals specified below and in Section 01700 and 01730.

## 1.09 DELIVERABLES

- A. Start-Up Checklists: Prior to start up and checkout, provide a sample check sheet for each type of equipment. Manufacturer's start up and checkout procedures shall be included with the checklists. Completed check sheets shall be furnished.
- B. Laminated Control Drawings: Laminated control drawings including system control schematics, sequences of operation and panel termination drawings,

shall be provided in panels for major pieces of equipment. Smaller equipment and terminal unit drawings shall be located in the central plant equipment panel or mechanical room panel. Laminating film shall be at least 10mil thick. Drawings for application specific controllers mounted above the ceiling shall be on plain paper and permanently attached to the inside of the door of the enclosure. Lamination is not required for these drawings.

C. ATC/BAS Start Up Report:

1. Submit Start Up Report documenting that the ATC/BAS has been fully tested, adjusted and calibrated and is ready for final inspection/demonstration. Report shall include, but shall not be limited to, completed test sheets and checklists. Required details of the report shall be as specified in "System Acceptance", Section 15900, Paragraph 3.09.
2. For phased construction projects the aforementioned test sheets and checklists shall be completed and made available to the owner for review prior to the occupancy of the completed phase.

D. Operation and Maintenance Manuals: Submit four copies for approval of Operation and Maintenance Manuals bound in hardback, loose leaf binders and turn over to the Owner prior to the time the systems or equipment test are performed. Provide an index and tabbed sections. The manual shall be identified with the contents of the manual on the cover.

1. Submit maintenance instructions, installation and checkouts procedures for each type of control device, control unit, and accessory.
2. Submit BAS system User's Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripherals.
3. Submit BAS system advanced Programming Manuals for each controller type and for all workstation software.
4. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual; in accordance with requirements of Division 1. Submit record copies of product data and control shop drawings updated to reflect the final installed condition in both reproducible hard copy and electronic format in AutoCAD 2016 (or later) drawing files.
5. Submit record copies of approved control logic programming and database on paper and on CD. Accurately record actual setpoints and settings of controls, all BACnet objects and their properties, and actual sequence of operation, including changes to programs made after

- submission and approval of shop drawings and including changes to programs made during specified testing.
6. Submit record copies of approved project specific graphic software on CD updated to reflect the final installed condition.
- E. Maintain project record documents throughout the warranty period and submit record of warranty calls at the end of the warranty period to the Project Manager, Office of Design and Construction Services, 8115 Gatehouse Road Suite 3500 Falls Church VA 22042.
- F. Project Record Documents
1. Two weeks prior to the ATC demonstration, provide record documents to represent the final control configuration with actual set points and tuning parameters as existed at acceptance.
  2. Record documents shall be modified control drawings with the actual installed information. Drawings shall be delivered in both reproducible hard copy and electronic format in AutoCAD 2006 (or later) drawing files. Provide all supporting files, blocks, fonts, etc. required by the drawings.
  3. Provide final points list-as-described above.
  4. Provide final detailed wiring diagrams with all wire numbers and termination points indicated.
  5. Accurately record final sequences and control logic diagrams made after submission of shop drawings.
- G. Spare Parts
1. Within 45 days of approved shop drawings provide a complete package of spare parts as follows:
    - a. Computer hardware:
      - 1) Primary Control Unit (PCU's)- minimum 1 or 10% of each type used.
      - 2) Application Specific Controller- minimum 1 or 10% of each used.
  2. Provide an itemized listing of the proposed spare parts, for review, prior to submitting spare parts.

## 1.10 CONSTRUCTION AND WARRANTY MAINTENANCE

- A. Contractor shall warrant all products and labor for a period of one year after date of substantial completion. Refer to Section 01740 for clarification. The ATC system shall not be considered substantially complete until the successful completion of the final inspection and demonstration. Refer to section 3.08 system acceptance.

The warranty period shall begin only after the successful completion of the ATC final inspection and demonstration for new construction and renovation projects.

- B. At no cost to the Owner, during the construction and warranty period, the Contractor shall provide maintenance services for software and hardware components as specified below:

1. Maintenance services shall be provided for all devices and hardware specified in this Section. Service all equipment per the manufacturers recommendations. All devices shall be calibrated within the last month of the warranty period.
2. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the Owner to the Contractor.
  - a. Response by telephone to any request for service shall be provided within one hour of the Owner's initial telephone request for service.
  - b. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware or software technician, trained in the system to be serviced, shall be dispatched to the Owner's site within two (2) hours of the Owner's initial telephone request for such services, as specified.
  - c. Failure to respond within the described time frames shall be cause to hold the Contractor liable for damages incurred due to the lack of response.
3. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the Owner to the Contractor.
  - a. Response by telephone to any request for service shall be provided within one (1) working hour (contractor specified 40 hr per week normal working period) of the Owner's initial telephone request for service.

- b. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware or software technician, trained in the system to be serviced, shall be dispatched to the Owner's site within one (1) working day of the Owner's initial telephone request for such services, as specified.
4. Owners Telephonic Request for Service: Contractor shall specify a maximum of three service technicians' telephone numbers for Owner to call in the event of a need for service. At least one of the lines shall be attended at any given time at all times. One of the three paged technicians shall respond to every call within 15 minutes.
5. Technical Support: Contractor shall provide technical support by telephone throughout the warranty period.
6. Preventive maintenance shall be provided throughout the warranty period in accordance with the hardware component manufacturer's requirements.

#### 1.11 DELIVERY, STORAGE, AND HANDLING

- A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

#### 1.12 LISTING AND LABELING

- A. The BAS system and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.
- B. Only those components which are directly wired to the Building Fire Alarm System shall be listed by Underwriters Laboratories (UL 864) as a Control Unit and Accessories for Fire Alarm Systems.

#### 1.13 LICENSING

- A. Provide licensing and original software copies for 2 (two) Owner provided Operator Workstations or Portable Operator Terminals. Include licensing for all required software packages.
- B. Upgrade all software packages to the release (version) in effect at the end of the Warranty Period and prior to the end of the Warranty Period.

#### 1.14 COMMISSIONING

- A. CONTRACTOR RESPONSIBILITIES

1. This contractor shall be responsible for participation and coordination with the commissioning process as specified in section 01660.

## **PART 2. PRODUCTS**

### **2.01 MATERIALS AND EQUIPMENT**

#### **A. General:**

1. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where drawings or specifications specifically allow existing materials to remain in place.
2. Provide control products in sizes and capacities indicated, consisting of valves, dampers, thermostats, relays, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.

### **2.02 BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS**

- #### **A.**
- All wiring installed in areas with accessible ceilings shall be installed bundled together and run exposed above the ceilings. Bundles shall be supported by "J" hooks mounted not more than four feet on center.

#### **B. COMMUNICATION WIRING:**

1. All wiring shall be in accordance with National Electrical Codes and Division 16 of this specification. Exposed wiring or cabling installed in return air plenum ceilings or air cavities shall be rated for that application.
2. Contractor shall supply all communication wiring between Owners WAN active hubs and LANIDs/PCUs, between CUs and LANIDs/PCUs and local and remote peripherals (e.g., operator workstations, printers).
3. Primary LAN communication wiring shall be 100% individually shielded pairs. Communication wiring shall be 24 gauge minimum or of heavier/lighter gauge if recommended by the PCU manufacturer for the specific installation requirements, with overall PVC cover, with no splices, separate from any wiring over thirty (30) volts. Shield shall be terminated as recommended by PCU manufacturer. Cable shall be single-shielded pair type suitable for Arcnet (IEEE802.4), Ethernet (IEEE802.3)

4. Secondary LAN communication wiring shall be 100% individually shielded pairs. Communication wiring shall be 24 gauge minimum or of heavier/lighter gauge if recommended by the PCU manufacturer for the specific installation requirements, with overall PVC cover, with no splices, separate from any wiring over thirty (30) volts. Shield shall be terminated as recommended by PCU manufacturer. Cable shall be single-shielded pair type suitable for Arcnet (IEEE8802.4), Ethernet (IEEE8802.3), MS/TP, TP/FT-10.
5. Data communication wiring from CUs and peripherals (i.e., operator interface devices, printers, etc.) shall be minimum 4-conductor, 22-gauge wire, or of heavier/lighter gauge if recommended by control manufacturer, 100% shielded, with PVC cover and RS-232C connectors at both ends.
6. Contractor may elect to run unshielded cable if noise immunity is ensured by another means. Contractor shall fully responsible for noise immunity and rewire with shielded cable if electrical or RF noise affects

C. SIGNAL WIRING:

1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be twisted, 100% shielded pair, minimum 18-gauge wire, with PVC cover. Run with no splices, separate from any wiring above thirty (30) volts.
2. Signal wiring shield shall be grounded at CU end, only as recommended by the CU manufacturer.
3. Contractor may elect to run unshielded cable if noise immunity is ensured by another means. Contractor shall fully responsible for noise immunity and rewire with shielded cable if electrical or RF noise affects performance.

D. LOW VOLTAGE OUTPUT WIRING:

1. Low voltage control wiring shall be minimum 18-gauge, twisted pair, stranded, 100% shielded, with PVC cover, separate from any wiring above thirty (30) volts.
2. Contractor may elect to run unshielded cable if noise immunity is ensured by another means. Contractor shall fully responsible for noise immunity and rewire with shielded cable if electrical or RF noise affects performance.

E. CONTROL POWER WIRING:

1. Power wiring shall be minimum 12-gauge stranded installed in conduit, separated from any other wiring.



## F. CONTROL PANELS: (PCUS AND ASCS)

1. Provide control panels with suitable brackets for wall mounting for each control system. Locate panels for roof top units in areas shown on drawings. Locate panels in ceilings for unit ventilators, fan coil units, finned tube radiation, terminal units, variable refrigerant flow units, water source heat pumps and heating coils. Panels located in ceilings shall be identified with a nameplate attached with 1/4" head, self-tapping screw to the ceiling grid or access door identifying the equipment. Mounting control panels for VAV boxes on the VAV box itself is acceptable. See additional identification requirements in Section 15900, Paragraph 2.02 X, NAMEPLATES. Control panels may also be factory mounted inside terminal and packaged units (FCU's UV's RTU's VRF's WSHP's etc.)
2. Indoor enclosures shall meet the requirements of NEMA 250, Type 1.
3. Outdoor enclosures shall meet the requirements of NEMA 250 Type 3R.
4. Wall mounted enclosures below ceiling shall be fabricated panels of 16-gage furniture-grade steel, with hinged door and keyed lock. Keyed lock shall be compatible with Owner's 2052 key. Enclosures above the ceiling shall be fabricated panels of 16-gauge steel, with hinged door and coin lock. All enclosures shall be totally enclosed on four sides with back plate and shall have manufacturer's shop painted finish (KELE HC12124). Junction boxes are not acceptable. Minimum size: 12" x 12".
5. Provide UL-listed cabinets for use with line voltage devices.
6. Control panel shall be completely factory wired, and all electrical connections made to a separate terminal strip. Field wiring of panels is not acceptable. Terminal strip is not required on ASCs mounted above ceiling.
7. All control components shall be identified.
8. Complete as-built wiring diagrams shall be mounted in or adjacent to the panel.
9. All control wiring shall be run neatly and orderly in open slot wiring duct with cover. Not required for ASCs above ceiling.
10. PCU's shall be provided with a combination disconnect / receptacle with fuse holder and fuse (KELE part number PRK-FS) mounted within the enclosure and wired such that when the disconnect is opened, the receptacle remains energized. Provide single gang wiremold box in master control panel for punch down of the FCPS data drop.

**G. ZONE OVERRIDE PANEL**

1. Provide a zone override panel located in the custodians office, main mechanical room or as shown on the drawings. Elementary School Panels shall include override timers (One for each control zone as shown on the control zone diagram on the mechanical drawings) mounted below the control zone graphic. Panels for Middle and High Schools shall incorporate a Touch Screen (whose graphical pages shall be reproduced from the control zone diagram as shown on the mechanical drawings) and shall include one graphically represented timer for each control zone. Access to each graphically represented timer, shall be through the touch screen, when individually indexed, and shall allow a 1 to 3 hour override of that zone. Touch screen shall be mounted below the control zone graphic. The graphic shall show the outline of the entire school with multiple floors shown separately. The Contractor shall provide the size and/or number of panels necessary to include all zones and timers. The control zones, as shown on the drawings, shall be delineated with each zone shown in a different color. The number of each zone shall be shown in its respective areas and the graphic shall be titled "CONTROL ZONES". The graphic shall be made of engraved acrylic, phenolic or micarta with minimum dimensions of 20" x 20", and shall be made by a firm specializing in this type of work. Submissions of a professionally painted graphic panel will be considered. Provide shop drawings on this graphic panel with the automatic temperature control submittal.

**H. CONTROL VALVES**

1. General: Provide factory fabricated control valves of type, body material and pressure class indicated. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve. Equip control valves with heavy-duty actuators, with proper shutoff rating for each individual application. Required close-off pressure for water valve applications shall be the shutoff head of associated pump. Required close-off rating of steam valve applications shall be design inlet steam pressure. For close-off pressure ratings less than 30 psid the minimum close off shall be 30 psid.
2. Plug-Type Globe Pattern for Water Service:
  - a. Valve Sizing: Modulating valves shall be sized for maximum full flow pressure drop between 3 and 5 PSIG unless scheduled otherwise.

- b. Single Seated (Two-way) Valves: Equal percentage characteristics. Cage type trim, providing seating and guiding surfaces for plug on “top and bottom” guided plugs.
  - c. Double Seated (Three-way) Valves: Linear characteristics. Balanced plug type, with cage type trim providing seating and guiding surfaces on “top and bottom” guided plugs.
  - d. Temperature Rating: 25°F minimum, 250°F maximum.
  - e. Body: Bronze, screwed, 250 psi maximum working pressure for ½” to 2”; Cast Iron, flanged, 125 psi maximum working pressure for 2-1/2” and larger.
  - f. Valve Trim: Bronze; Stem: Polished stainless steel.
  - g. Packing: Spring Loaded Teflon or Synthetic Elastomer U-cups, self-adjusting. O-ring packings are unacceptable.
  - h. Plug: Brass, bronze or stainless steel, Seat: Brass.
  - i. Disc: Replaceable Composition or Stainless Steel Filled PTFE.
  - j. Ambient Operating Temperature Limits: -10 to 150°F.
  - k. Valves shall be suitable for 200°F water service.
  - l. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    - 1) Johnson Controls
    - 2) Siebe Environmental Controls
    - 3) Warren
    - 4) Delta
    - 5) Belimo
    - 6) TAC
3. Butterfly Type
- a. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, shall have minimum 4” stem extension, ANSI Class 125 or 250 bolt pattern to match specified flanges.
  - b. Seat: EPDM.

- c. Disc: Bronze or stainless steel, pinned or mechanically locked to shaft.
  - d. Bearings: Bronze or stainless steel.
  - e. Shaft: 300 or 400 series stainless steel.
  - f. Cold Service Pressure: 175 psi.
  - g. Valves shall be suitable for 200°F water service.
  - h. Bubble-tight shutoff to 150 psi.
  - i. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    - 1) Jamesbury WS815
    - 2) Bray Series 31
    - 3) Keystone AR2
    - 4) Dezurik BGS
    - 5) Belimo F6/F7
4. Ball Type
- a. Body: Brass or Bronze, one, two, or three piece design, threaded ends.
  - b. Seat: Reinforced Teflon.
  - c. Ball: Stainless steel.
  - d. Port: Standard or 'V' style.
  - e. Stem: Stainless steel, blow out proof design, extended to match thickness of insulation. Provide stem protective sleeve that allows operation of valve without breaking the vapor seal on chilled water service valves.
  - f. Cold Service Pressure: 250 psi WOG.
  - g. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    - 1) Conbraco

- 2) Worcester
- 3) Nibco
- 4) Jamesbury
- 5) PBM
- 6) Delta
- 7) Belimo
- 8) TAC

#### I. CONTROL DAMPERS

1. General: Provide factory fabricated automatic control dampers of sizes, velocity and pressure classes as required for smooth, stable, and controllable airflow. Dampers not supplied as an integral part of factory fabricated equipment shall be furnished under this section of the specifications and shall be installed under the respective sheet metal specification sections. Provide parallel or opposed blade dampers as recommended by manufacturers sizing techniques. For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close off pressure, and recommended by damper manufacturer for fan discharge damper service. Required close-off rating of air damper applications shall be shutoff pressure of associated fan.
2. General Isolation and Modulating Control Service in rectangular ducts at velocities not greater than 1500 fpm, differential pressure not greater than 2.5" w.c.
  - a. Performance: Test in accordance with AMCA 500.
  - b. Frames: Galvanized steel, 16 gauge minimum thickness, welded or riveted with corner reinforcement.
  - c. Blades: Galvanized steel, maximum blade size 8 inches wide by 48 inches long, attached to minimum ½ inch shafts with set screws, 16 gauge minimum thickness.
  - d. Blade Seals: Synthetic elastomer, mechanically attached.
  - e. Jamb Seals: Stainless steel.

- f. Shaft Bearings: Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.
- g. Linkage concealed in frame
- h. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
- i. Leakage: Less than one percent based on approach velocity of 1500 ft./min. and 1-inch wg.
- j. Maximum Pressure Differential: 2.5 inches wg.
- k. Temperature Limits: 40 to 200°F.
- l. Where opening size is larger than 48 inches wide, or 72 inches high, provide dampers in multiple sections, with appropriate intermediate frames, jackshafts and linkages.
- m. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
  - 1) Arrow-Foil model OBDAF-207
  - 2) Air Balance model AC-116
  - 3) Ruskin model CD-50
  - 4) Greenheck model VCD-23

## J. ACTUATORS

- 1. General: Damper, Valve and VAV box actuators/operators not supplied as an integral part of the factory fabricated equipment shall be furnished and installed under this section of the specifications. Size actuators and linkages to operate their appropriate dampers or valves with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. All heating valve actuators for valves 1 1/4" and larger and OA damper actuators shall have a manual override with spring return. Required close-off pressure for water valve applications shall be the shutoff head of associated pump. Required close-off rating of air damper applications shall be shutoff pressure of associated fan. Modulating actuators shall have minimum rangeability of 40 to 1. Provide mechanical stops as necessary.

### a. Damper Actuators

- 1) Ambient Operating Temperature Limits: -10 to 150°F

- 2) Two Position Electric Actuators: Line voltage with spring return and mechanical stops.
  - 3) Electronic Actuators: Provide actuators for two position (24v), 0-5vdc, 0-10vdc, 2-10vdc, 4-20 ma, or 3 position floating input as required. All actuators shall be spring return for fail positioning (except VAV box damper actuators). Actuators shall travel full stroke in less than 90 seconds. Provide stroke indicator. Actuators shall have positive positioning circuit. Where two actuators are required in parallel or in sequence provide an auxiliary actuator driver. Actuators shall have current limiting motor protection. Actuators shall have manual override. Modulating actuators shall have minimum rangeability of 40 to 1.
  - 4) Close-off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close off pressure. Required close-off rating of air damper applications shall be shutoff pressure of associated fan.
  - 5) Floating Motor: Provide actuators for VAV terminal boxes primary air dampers as required, sized for required close off pressure. Actuators shall be 3 wire, 24V 50/60 Hz, 90° stroke with a maximum travel time of 90 seconds. Torque switches shall limit travel in CW and CCW directions.
  - 6) Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    - a) Johnson Controls
    - b) Belimo
    - c) Delta
- b. Globe Valve Gear Train Actuators
- 1) Ambient Operating Temperature Limits: -10 to 140° regardless of valve media temperature.
  - 2) Two Position Electric Actuators: Line voltage with spring return.
  - 3) Modulating Electronic Actuators: Provide actuators for 0-5vdc, 0-10vdc, 2-10vdc, 4-20 ma, or 3 position floating

input as required. Actuators for heating system valves shall be spring return, normally open, for fail positioning. Actuators shall travel full stroke in less than 60 seconds. Provide stroke indicator. Actuators shall have positive positioning circuit. Actuators shall have current limiting motor protection. Actuators shall have manual override. Modulating actuators shall have minimum rangeability of 40 to 1.

- 4) Close-off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close off pressure. Required close-off pressure for water valve applications shall be the shutoff head of associated pump. Required close-off rating of steam valve applications shall be design inlet steam pressure.
  - 5) All 24 VAC/VDC actuators shall operate on Class 2 wiring.
  - 6) Actuators shall be provided with a minimum ½" conduit fitting for wiring connections.
  - 7) Actuators shall be Underwriters Laboratories 873 listed and Canadian Standards Association certified for the application.
  - 8) Actuator shall have a NEMA Type 1 enclosure, and actuators located in plenum ceilings shall meet the UL-465 rating for flame/smoke spread.
  - 9) Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.
  - 10) Provide position feedback where required.
  - 11) For valves 5 inches and larger a battery back-up system is acceptable for failsafe operations
  - 12) Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
    - a) Johnson Controls
    - b) Belimo
    - c) Delta
- c. Quarter turn actuators for ball and butterfly valves



- 1) Motor: Suitable for 24VAC/VDC, 120 or 240 volt single phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 100 percent duty cycle. Motors shall have inherent overload protection.
- 2) Gear Train. Motor output shall be directed to a self-locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque. Actuators shall be spring return for fail positioning for heating system valves.
- 3) Enclosure: Actuator Enclosure shall be NEMA 4 rated, and shall have a threaded conduit connection for installation in exposed areas.
- 4) Limit Switches: Travel limit switches shall be UL and CSA approved. Switches shall limit actuator in both open and closed positions.
- 5) Mechanical Travel Stops: The actuator shall include mechanical travel stops of stainless steel construction to limit actuator to specific degrees of rotation.
- 6) Manual override: Actuators shall have manual actuator override to allow operation of the valve when power is off. For valves 4 inches and smaller the override may be a removable wrench or lever or geared handwheel type. For larger valves, the override shall be a fixed geared handwheel type. An automatic power cut-off switch shall be provided to disconnect power from the motor when the handwheel is engaged for manual operation.
- 7) Valve position indicator: A valve position indicator with arrow and open and closed position marks shall be provided to indicate valve position.
- 8) Torque Limit Switches: Provide torque limit switches to interrupt motor power when torque limit is exceeded in either direction of rotation.
- 9) Position Controller: For valves used for modulating control, provide an electronic positioner capable of accepting 4-20 mA, 0-10 VDC, 2-10 VDC, 3 position floating and 135  $\Omega$  potentiometer.
- 10) Ambient Conditions: Actuator shall be designed for operation from -140 to 150 °F ambient temperature with 0-100 percent relative humidity.

- 11) For valves 5 inches and larger a battery back-up system is acceptable for failsafe operations.
- 12) Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
  - a) Belimo
  - b) Delta
  - c) Johnson Controls

#### K. FIELD DEVICES – GENERAL

1. Provide field devices for input and output of digital (binary), and analog, signals into PCUs and ASCs. Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.
2. It shall be the Contractor's responsibility to assure that all field devices are compatible with CU hardware and software.
3. Field devices specified herein are generally "two-wire" type transmitters, with power for the device expected to be supplied from the respective CU. If the CU provided is not equipped to provide this power, or is not designed to work with "two-wire" type transmitters, or if field device is to serve as input to more than one CU, the Contractor shall provide "four-wire" type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.
4. For field devices specified hereinafter that require signal interface to CU's, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.
5. Accuracy, as stated in this Section, shall include combined effects of nonlinearity, nonrepeatability and hysteresis.

#### L. TEMPERATURE SENSORS (TS)

1. Sensor range: When matched with A/D converter of PCU, or ASC, sensor range shall provide a resolution of no worse than 0.5°F.
2. Platinum RTD Sensors shall be 1000Ω two wire type unless provided with integral transmitter with current or voltage output.

3. Room temperature sensor shall be an element contained within a ventilated cover, suitable for wall mounting. The LAN broadcast of sensing values for control to multiple controllers is unacceptable. Provide slide setpoint adjustment, (2°F up and down), on all sensors except those located in locker rooms, corridors, auditoriums, gang toilets, and on all PRV's, CEF's, EWH's and ECH's. The following sensing elements are acceptable:
  - a. Sensing element – Platinum RTD, Thermistor, or integrated circuit, +/- 0.5°F accuracy at calibration point.
4. Single point duct temperature sensor shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph a) below. Sensor probe shall be 304 stainless steel. Probe length shall be selected so that the sensing point is minimum 8" from the center point of the medium being measured.
  - a. Sensing element – Platinum RTD, Thermistor, or integrated circuit, +/- 0.5°F accuracy at calibration point.
5. Averaging duct temperature sensor shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each square feet of coil face area. Temperature range as required for resolution indicated in paragraph a) below.
  - a. Sensing element – Platinum RTD, or Thermistor, +/- 0.5°F accuracy at calibration point.
6. Liquid immersion temperature sensors for hot, chilled and condenser water systems shall include stainless steel thermowell, sensor and connection head for wiring connections. Temperature range shall be as required for resolution indicated in paragraph a) below.
  - a. Sensing element – Platinum RTD, Thermistor, or integrated circuit, +/- 0.5°F accuracy at calibration point.
7. Pipe Surface Mount temperature sensor shall include metal junction box and clamps and shall be suitable for sensing pipe surface temperature and installation under insulation. Provide thermally conductive paste at pipe contact point. Sensors shall only be used where specifically called for or with prior approval of the Owner. Temperature range shall be as require for resolution indicated in paragraph a) below.
  - a. Sensing element – Platinum RTD, Thermistor, or integrated circuit, +/- 0.5°F accuracy at calibration point.

8. Outside air sensors shall consist of a sensor, sun shield, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as require for resolution indicated in paragraph a) below.
  - a. Sensing element – Platinum RTD, Thermistor, or integrated circuit, +/- 0.5°F accuracy at calibration point.

#### M. HUMIDITY TRANSMITTERS (H)

1. Units shall be suitable for duct, wall (room) or outdoor mounting. Unit shall be two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor. Unit shall produce linear continuous output of 4-20 mA for percent relative humidity (% rh). Sensors shall have the following minimum performance and application criteria:
  - a. Input Range: 0 to 100% rh.
    - 1) Accuracy (% rh): +/- 2% (when used for enthalpy calculation, dewpoint calculation, dehumidification or humidifier control) or +/- 3% (monitoring only) between 20-90% rh at 77°F, including hysteresis, linearity, and repeatability.
    - 2) Sensor Operating Range: as required by application
    - 3) Long Term Stability: Less than 1% drift per year.
2. Units shall be General Eastern, Microline, Hy-Cal HT Series, ACI or Vaisala HM Series. Provide one (1) Calibration Tool Kit per job.

#### N. CARBON DIOXIDE SENSORS (CO2)

1. Units shall be suitable for duct or wall (room) mounting. Unit shall be two or four wire transmitter utilizing a non-dispersive infrared sensor. The cover of the sensor shall be attached by tamperproof fasteners to the mounting box or plate. Sensor shall have a LED readout. Unit shall produce linear continuous output of 4-20 mA 0-5VDC or 0-10 VDC for parts per million (ppm) concentration. Sensors shall have the following minimum performance and application criteria:
  - a. Power: 24 VAC or VDC less than 3 VA
  - b. Input Range: 0 to 2000 ppm adjustable.
  - c. Output Range: 4-20 mA, 0-5 VDC or 0-10 VDC

- d. Accuracy:  $\pm 75$  ppm from 0 to 1500 ppm and  $\pm 5\%$  above 1500 ppm, including hysteresis, linearity, and repeatability.
  - e. Repeatability:  $\pm 8$  ppm
  - f. Pressure effect: 0.19% of reading per mm Hg
  - g. Long Term Stability: Less than  $\pm 20$  ppm drift per year.
  - h. Calibration Interval: Lifetime or self calibrating.
2. Units shall be ACI ESENSE- R-5-LCD (wall), or D-5-LCD-D (duct).
- O. DIFFERENTIAL PRESSURE TRANSMITTERS (DP)
1. General Purpose Water: Two or four wire transmitter, and shall produce linear continuous output of 4-20 mA 0-5VDC or 0-10VDC output with zero and span adjustments. Plus or minus 0.5% overall accuracy, 450 psig (3103 Kpa) maximum static pressure rating, 200 psid maximum overpressure rating for 6 through 60 psid range, 450 psid for 100 through 300 psid range. Kele & Associates Model W30 series with BVA-5 bypass valve assembly, Units manufactured by Veris Industries, Modus, or Setra are acceptable provided they are fully equal to the item specified.
  2. General Purpose Air: Units shall be suitable for duct or unit mounting. Unit shall be two or four wire transmitter and shall produce linear continuous output of 4-20mA, 0-5VDC or 0-10VDC.
    - a. Loop powered two wire differential capacitance cell type transmitter
    - b. Output: two wire 4-20 mA output with zero adjustment.
    - c. Overall accuracy: Plus or minus 1%
    - d. Minimum range: 0.1 in. w.c.
    - e. Maximum range: 10 inches w.c.
    - f. Housing: Polymer housing suitable for surface mounting.
    - g. Static sensing element: pitot type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
    - h. Range: Select for specified setpoint to be between 50% and 75% full scale.

- i. Manufacturer: Veris Industries PX Series Kele Model T30, Modus, or Setra.
  - j. Provide LCD Display.
- P. DIFFERENTIAL PRESSURE SWITCHES (DPS)
- 1. General Service Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide static pressure sensing tips similar to Dwyer model A-301 static pressure sensing tips and connecting tubing.
  - 2. General Service Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap acting form C contacts rated for the application. 60 psid minimum pressure differential range. 0°F to 160°F operating temperature range. Switch body pressure rating shall be at least 150 psig.
- Q. PRESSURE SWITCHES (PS)
- 1. Diaphragm or bourdon tube with adjustable setpoint and differential and snap acting form C contacts rated for the application. PS shall be capable of withstanding 150% of rated pressure.
  - 2. Acceptable manufacturers subject to meeting the specified requirements: Square D, ITT Neo-Dyn, ASCO, Penn, Honeywell, and Johnson.
- R. PIPE AND TUBING FOR PRESSURE SENSING AND CONTROL DEVICES
- 1. Piping for low pressure air sensing and control devices operating under 30 psig shall be instrument grade polyethylene tubing (plenum rated if used in plenums), ¼ inch OD, 120 psig working pressure assembled with brass barbed fittings or ¼ inch type 'L' soft copper tubing assembled with flared type fittings.
  - 2. Piping for water pressure sensing instruments shall be the same specification as the main piping up to the instrument isolation valve for connections ½ inch and larger. 3/8 and ¼ inch connections shall be made with standard weight threaded red brass pipe between the main piping and the instrument isolation valve where the main piping is steel. The instrument isolation valve shall be installed as close as practical to the main line where accessible, and shall be a ¼ inch minimum size bronze ball valve rated for 150 psig WOG with stainless steel ball, blowout proof stem, reinforced Teflon packing and seats. Tubing from the instrument isolation valve to the device shall be type 'L' soft copper tubing installed with brass flare type fittings.
- S. TRANSDUCERS

1. Pulse Width Modulating, Voltage or Current to Voltage or Current
  - a. Universal Electronic Analog Transducer for all three phase equipment and digital transducer for all single phase equipment
  - b. Electrical Power Supply: 24 VAC or 24 VDC
  - c. Input: 0-40 mA, 0-4 mA, 0-2 V, 0-20V, 100 $\Omega$  min to 10k $\Omega$  max., pulse width modulated or tri-state input.
  - d. Output Span: 0-18 VDC or 0-20 VDC – Jumper Selectable
  - e. Zero and Span: Adjustable to full range
  - f. Action: Direct or Reverse Acting – Jumper Selectable
  - g. Operating Humidity & Temperature: 5-95% non-condensing, 32°F to 150°F
  - h. Linearity: <0.1% of span
  - i. Enclosure: Polymer designed for surface or panel mount.
  - j. Manufacturer: Kele Model UAT-1, PWA-1A

T. AIR FLOW MEASURING STATIONS

1. Furnish where indicated on the drawings, insertion type, airflow traverse probes. Probes shall utilize multiple total and static pressure measurement points located along the length of the probe in accordance with ASHRAE standards and recommendations for duct traverses. The probes, and placement of the probes, shall provide measurement accuracy within +/- 2% of actual velocity. Probes shall be of cylindrical cross section and shall indicate no more than a +/-3% deviation from the centerline velocity at a yaw angle of 30 degrees. Probes shall be aluminum with a hard anodized or radiate finish. Probes shall be provided with integral mounting plate, 1/4 compression fitting connections, end mounting rod and be suitable to operate in ambient conditions off 300°F. The probe assemblies shall not have a pressure drop greater than 10% of the velocity pressure at the maximum design flow. The probes shall not amplify sound levels in the duct. Submit data indicating the developed differential pressure and pressure loss at the minimum and maximum design flows for each duct location. Provide differential pressure transmitter for measuring velocity, with a range selected to match the velocity of the maximum design flow for the duct served. The following schedule is the minimum probe quantities across either the width or height of the duct sections where the probes are being inserted:

| Insertion side | Qty |
|----------------|-----|
| 6-10 inches    | 1   |
| 11-20 inches   | 2   |
| 21-30 inches   | 3   |
| 31-45 inches   | 4   |
| 46-60 inches   | 5   |
| 61-84 inches   | 6   |
| 85-120 inches  | 7   |

Manufacturer: Tek-Air Model T-FP5000, or approved equal.

For outside air, return air or exhaust air measurement, the equipment manufacturer supplied device is acceptable provided this contractor can interface and control the device.

#### U. CURRENT SWITCHES

1. Clamp-On Design Current Operated Switch for Motor Status Indication
  - a. Range: 1.5 to 150 amps
  - b. Trip Point: Adjustable +/- 1 % of range
  - c. Switch: Solid state, normally open, 1 to 135 VAC or VDC, 0.3 amps. Zero off state leakage.
  - d. Lower Frequency Limit: 6 Hz.
  - e. Trip Indication: LED
  - f. Approvals: UL, CSA
  - g. Max. Cable Size: 350 MCM
  - h. Manufacturer: RE Technologies SCS1150A-LED or equal.
2. Wire Thru and Current Operated Switch for Motor Status Indication
  - a. Range: 0 to 200 A continuous amperage rating
  - b. Trip Point: Adjustable +/- 1 % of range
  - c. Switch: 8A @ 240 Vac resistive, 4A @ 120 Vac tungsten, 2A @ 240 Vac inductive (1/2 hp), load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A).
  - d. Manufacturer: Veris Industries, Inc.



- e. Current switches for fractional horsepower motors (terminal equipment, UV's FCU's PRV's ECH CEF's etc.) shall be Veris H120

V. CURRENT TRANSFORMERS (CT)

- 1. Clamp-On Design Current Transformer for Motor Current Sensing
  - a. Range: 50 amps minimum, 4000 amps maximum
  - b. Accuracy:  $\pm 1\%$
  - c. Manufacturer: KELE Model 500T or Veris Industries.

W. ELECTRIC CONTROL COMPONENTS

- 1. Limit Switches (LS): Limit switches shall be UL listed, with adjustable trim arm. Limit switches shall be as manufactured by Square "D", Allen Bradley; SPDT or DPDT type.
- 2. Smoke Detectors – Shall be furnished and wired to the fire alarm system under Division 16. They shall be installed under Division 15 and interlocked to their respective starters under this section. Fire alarm modules for unit shut down shall be provided and installed by the division 16 contractor, and interlocked to their respective starters under this division.
- 3. Control Relays: All control relays shall be UL listed, with contacts rated for the application. Relays shall be mounted inside of an approved electrical enclosure such as a control panel, equipment control enclosure, or separate enclosure meeting the requirements specified for control panels, unless noted otherwise below. Relays mounted in equipment control enclosures shall be neatly installed in accordance with the electrical code, securely fastened to the enclosure, and shall be accessible for maintenance without obstructing access to other equipment control components.
  - a. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
  - b. AC coil pull-in voltage range of +10%, -15% or nominal voltage.
  - c. Coil sealed volt amperes (VA) not greater than four (4) VA.
  - d. Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
  - e. Pilot light indication of power-to-coil and coil retainer clips.

- f. Coil rated for 50 and 60 Hz service.
  - g. Relays shall be KELE or Omron LY series.
  - h. Relays used for control (start/stop) of 120V motors, up to 1/3 HP, shall be rated to break minimum 10 Amps inductive load. Relays shall be RIB series and mounted externally to the starter or junction box.
  - i. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the CU interface if required by equipment manufacturer.
  - j. All relays for motor starters and variable frequency drives, electric heaters, inline pumps, exhaust fans and electric heat trace shall be RIB series and mounted externally to the starter, drive or junction box.
  - k. All RIB relays shall be mounted on the exterior of the electrical equipment.
4. General Purpose Power Contactors. NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, enclosure meeting requirements stated for control panels. Manufacturer shall be Square 'D', Cutler Hammer or Westinghouse.
5. Control Transformers: Control transformers shall be machine tool type, and shall be UL and CSA listed. Secondary sides shall have re-settable overcurrent protection in accordance with the NEC. Transformer shall be proper size for application, and mounted in minimum NEMA 1 enclosure. Transformers shall be UL listed and Rated Class 2 when installed in plenums. Transformers shall be manufactured by Westinghouse, Square "D" Veris, RIB or Jefferson.
6. Time Delay Relays (TDR): TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a dustproof enclosure.
- a. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.
  - b. TDRs shall be UL and CSA listed, Crouzet type.
7. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required.

Contacts shall be snap-action type, and rated for minimum 120 VAC operation. Switch shall be 800T type, as manufactured by Allen Bradley, Square 'D', Cutler Hammer or Westinghouse.

8. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen Bradley, Square 'D', Cutler Hammer or Westinghouse.
9. Electric Selector Switch (SS): Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 VAC operation. Switch shall be 800T type, as manufactured by Allen Bradley, Square 'D', Cutler Hammer or Westinghouse.
10. DIGITAL OVERRIDE TIMER - Override Timer: Digital time switch suitable for wall or panel mounting, 0-3 hour range, 24VAC/VDC, 12mA DC, 41mA AC, with LCD display. Switch shall be TSW-400-24 as manufactured by Wattstopper.
11. OVERRIDE TOUCH SCREEN- Configurable, high resolution, TFT override touch panel suitable for panel mounting as manufactured by Loytec model LVIS-3ME15-Gx or approved equal. Provide all mounting hardware.
12. INDUCTIVE ROTATION SENSOR – Proximity type sensor for rotation detection (Heat Recovery Wheel), 120-3000 cyc/min, 24..240VAC/DC, 10 mm nominal sensing range. Sensor shall be XSAV12801 as manufactured by Schneider Electric or approved equal. Include all manufacturers' recommended mounting hardware.

#### X. NAMEPLATES

1. Nameplates – Provide engraved phenolic or micarta nameplates for all equipment, panels, components, and field devices furnished. Each nameplate shall identify the items, such as "Main HW Flow-DI3". Nameplates shall be 1/8 thick, blue, with white center core, and shall be minimum 1" x 3", with minimum 1/4" high block lettering. Nameplates for devices smaller than 1" x 3" shall be attached to adjacent surface. Panels located in ceilings shall be identified with a nameplate screwed (1/4" self-taping), to the ceiling grid. Equipment identification shall be as shown in the equipment schedules on the drawings. Nameplates shall be applied to surfaces with mechanical fasteners. Each nameplate shall identify the function for each device. (Example: RTU-C1 ATC, PRV-4 ATC, Etc.) Labels for Terminal Equipment shall include the signage # of the room/space served. (Example VAV-RM100, FCU-RM201) The signage number shall be the final room number, not the room number from the construction documents.

2. Temperature Sensors – Provide labels on all temperature sensors to identify the equipment served and the location of the sensor. Abbreviations used to identify the equipment shall be as listed in paragraph 1.06 DEFINITIONS. Room numbers used to identify the locations of sensors shall be the same as those used for the approved signage schedule, not from construction documents, and shall be obtained from the Construction Manager, Design and Construction Services. (Example: VRF-RM 101 FCU-RM100, UV-RM103, etc). Sensors for equipment not located in classrooms, such as rooftop units, air-handling units, power roof ventilators, shall be labeled as shown in the equipment schedules on the drawings. (Example: RTU-C1, AHU-A3, PRV-4, etc.). Labels shall be BROTHER type “P-TOUCH”, clear tape with upper case letters, black printing and shall be on the outside of the sensor cover. The inside of the sensor cover shall also be identified with permanent marker.
3. Actuators – Provide labels on all zone damper actuators in multi-zone units to identify the room the damper serves. When more than one room is served by a zone damper, the room with the temperature sensor located in it shall be the referenced room. Room numbers shall be the same as those used for lockset keying purposes, not from construction documents, and shall be obtained from the Construction Manager, Design and Construction Services. The actuators shall be labeled with permanent markers.
4. Warning Labels – In addition to the above, each item of motorized equipment and associated starters, including air handling units, exhaust fans, return fans, supply fans, pumps, cooling towers, condensers and similar equipment shall be provided with a label with wording as follows:

**WARNING**

**EQUIPMENT IS REMOTELY CONTROLLED AND  
MAY STOP OR START UNEXPECTEDLY**

Lettering shall be red on white base with integral adhesive and peel-off backing for attaching to existing equipment and shall be minimum 1” x 3”. The Contractor shall submit a sample of the label material with the lettering sizes noted for approval prior to installation. Contractor shall thoroughly clean each item of motorized equipment and starters prior to application of labels.

Y. TESTING EQUIPMENT

1. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range).

## 2.03 DISTRIBUTED DIRECT DIGITAL CONTROLLERS AND CONTROL SYSTEM

- A. General: The functional intent of this specification is to allow application of manufacturer's standard products while maintaining the integrity and reliability of the control functions. A Primary Control Unit as specified below is generally fully featured and customizable whereas the Application Specific Controller refers to a more cost effect unit designed for lower end applications. Specific requirements indicated below are required for the respective application.
- B. Standalone Capability: Each Control Unit shall be capable of performing the required sequence of operation for the associated equipment. All physical point data and calculated values required to accomplish the sequence of operation shall originate within the associated IFID/CU with only the exceptions enumerated below. Listed below are physical point data and calculated values, which shall allowed to be obtained from, or stored by other IFIDs/Cus via LAN.

### 1. SYSTEM ARCHITECTURE

- a. The system provided shall incorporate hardware resources sufficient to meet the functional requirements of these Specifications. The Contractor shall include all items not specifically itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications.
- b. The system shall be configured as a distributed processing network(s) capable of expansion as specified below.
- c. The system architecture shall consist of a single Local Area Network (LAN) or multi-leveled LANs all which support Control Units, both local and Remote Operator Interfaces, and LAN Interface Devices, and Remote Communication Devices. The following indicates a functional description of the system structure.
  - 1) Host LAN: high speed LAN used for supervision, and communication between primary controlling LANs. This shall be the Owner's existing WAN. This network shall be used for communication between buildings only. This

contractor shall coordinate with division 16 contractor and owner to provide network connectivity as required. Modem connections to buildings are unacceptable. Communications within building shall be provided by contractor.

- 2) Primary Controller LAN: High-speed peer-peer LAN generally used to connect Primary Control Units (PCUs- which generally control central plant equipment, air handling units) and LANIDs. Acceptable technologies include: Arcnet (IEEE802.4), Ethernet (IEEE802.3), TP/FT-10 (LonTalk), ASHRAE 135-2004 (BACnet).
  - 3) Secondary Controller LAN: Polling or peer-peer LAN to support connection of Terminal Control Units/application specific controllers to LANIDs. Acceptable technologies include: ASHRAE 135-2004 (BACnet), Arcnet (IEEE8802.4), Ethernet (IEEE8802.3), MS/TP, TP/FT-10 (LonTalk), EIA-485 at a minimum speed of 19.2 kbps.
  - 4) Auto Answer/Auto Dial communications to remote operator interfaces shall be supported to allow communication with all levels of the system.
- d. Dynamic Data Access: Any data throughout any level of the network shall be available to and accessible by all other devices, IFIDs/Cus, LANIDs, and OI's, whether directly connected or connected remotely.
- e. The communication speed between the IFIDs/Cus, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. Contractor shall submit guaranteed response times with shop drawings including calculations to support the guarantee. In no case shall delay times between an event, request, or command initiation and its completion be greater than the following requirements. Contractor shall reconfigure LAN as necessary to accomplish these performance requirements.
- 1) 5 seconds between a Level 1 (critical) alarm occurrence and enunciation at operator workstation
  - 2) 10 seconds between a Level 2 alarm occurrence and enunciation at operator workstation
  - 3) 20 seconds between and a Level 3-5 alarm occurrence and enunciation at operator workstation

- 4) 10 seconds between an operator command via the operator interface to change a setpoint and the subsequent change in the controlling IFIDs/CU
  - 5) 5 seconds between an operator command via the operator interface to start/stop a device and the subsequent command to be received at the controlling IFIDs/CU
  - 6) 10 seconds between a change of value or state of an input and it being updated on the operator interface
  - 7) 10 seconds between an operator selection of a graphic and it completely painting the screen and updating at least 10 points
- f. Polling Secondary LANs shall operate at a minimum baud rate of 19200 BPS. Application and node restrictions for polling LANs based on application and communication speed are specified in "Distributed Direct Digital Controllers and Control System".
  - g. The operator interface shall provide for overall system supervision, operator interface, management report generation, alarm annunciation, remote monitoring and back up and loading of software and data to be stored in either Flash, EEPROM or EPROM Memory.
  - h. The primary and secondary control units shall monitor, control, and provide the field interface for all points specified. Each PCU or ASC shall be capable of performing all specified energy management functions, and all Distributed Digital Control (DDC) functions, independent of other PCUs or ASCs and operator interface devices as more fully specified in "Distributed Direct Digital Controllers and Control System".
  - i. Interruptions or fault at any point in the primary or secondary LAN shall not interrupt communications between other nodes on the network. If a primary LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted.
  - j. All line drivers, signal boosters, and signal conditioners etc. shall be provided as necessary for proper data communication.
- C. PRIMARY CONTROL UNITS (PCUs) ( PCU's shall control HW/CHW/CW systems, AHU, ERU,MAU and RTU equipment)
1. PCUs shall provide intelligent, standalone control of HVAC functions. Each unit shall have its own internal RAM, non-volatile memory, microprocessor, A/D converters, regulated power supply, power

conditioning equipment, wiring terminal strips, ports for connection of operating interface devices, and control enclosure. PCUs shall be programmable from an operator workstation, portable operators terminal, or hand held operating device. PCU shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.

2. PCUs shall communicate over the primary high speed, local area network. They shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices and perform all necessary mathematical and logical functions. The controller shall be a microprocessor. PCUs shall share information with the entire network of PCUs and ASCs for full global control. Each controller shall permit multi-user operation from multiple workstations and portable operator terminals connected either locally or over the Primary network.
3. Each PCU must be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, A to D conversion, real time clock/calendar and voltage transient and lightning protection devices. All PCUs shall be protected from any memory loss due to a loss of power by storing data using non-volatile memory.
4. The PCU shall provide for point mix flexibility and expandability. This requirement may be met via either a family of expander boards, modular input/output configuration, or a combination thereof. Any expansion devices shall connect directly to the microprocessor bus and receive the same functionality as that on the main board. Alternatively slave panels may be used for point expansion provided they are located immediately adjacent to the PCU.
5. All PCU point data, algorithms and application software shall be modifiable from the Operator Workstation.
6. Each PCU shall execute application programs, calculations, and commands via a microprocessor resident in the PCU. The database and all application programs for each PCU shall be stored in non-volatile or battery backed volatile memory within the PCU and shall be able to upload/download to/from the Operator Workstation. Application programs, calculations, and commands resident in other controllers, with the exception of global information (further defined in this specification), and transmitted to the PCU for execution is unacceptable.
7. PCU shall provide buffer for holding alarms, messages, trends etc.
8. Each PCU shall be connected to the Primary LAN communicating to/from other PCUs. Each PCU shall include self-test diagnostics, which allow



the PCU to automatically alarm any malfunctions, or alarm conditions that exceed desired parameters as determined by programming input.

9. Each PCU shall contain both software and hardware to perform full DDC/PID control loops.
10. Input-Output Processing
  - a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current, each configurable as normally open or normally closed. Each output shall have a HOA switch to allow for override and a LED to indicate the operating mode of the output. Position feed back to the controller shall be provided to indicate when the switches are not in the automatic mode. Status shall be monitored and will inform any time automatic control operation has been inhibited. Override activity shall be collected for reports. If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure. Each DO shall be discrete outputs from the PCU's board (multiplexing to a separate manufacturer's board is unacceptable). LCD displays at the PCU that incorporate output override capability shall be acceptable in lieu of HOA switches with LED's. Systems which require the use of a laptop computer to be connected to the device for override capability are not acceptable. Provide suppression to limit transients to acceptable levels.
  - b. Analog Inputs (AI): 0-5VDC, 0-10VDC; 0-20VDC, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the PCU's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 12 bits.
  - c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the PCU and shall be isolated from the main board. Software multiplexing of an AI and resistors may only be done in non-critical applications and only with prior approval of Architect/Engineer.
  - d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
  - e. Electronic Analog Outputs (AO): voltage mode, 0-5VDC and 0-10VDC; current mode (4-20 mA). Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO and transducer is acceptable unless stipulated

- otherwise for a given control loop. Transducer shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the PCU's board (multiplexing to a separate manufacturers board is unacceptable). D/A converters shall have a minimum resolution of 10 bits.
- f. Pulsed Inputs: Capable of counting up to 8 pulses per second with buffer to accumulate pulse count. Pulses shall be counted at all times.
  - g. A communication port for operator interface through a terminal shall be provided in each PCU. It shall be possible to perform all program and database back-up, system monitoring, control functions, and PCU diagnostics through this port. Standalone PCU panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers, or workstations.
  - h. Each PCU shall be equipped with loop tuning algorithm for precise, proportional, integral, derivative (PID) control. Loop tuning tools provided with the Operator workstation software are acceptable. In any case, tools to support loop tuning must be provided such that P, I, and D gains are automatically calculated.
  - i. All analog output points shall have a selectable failure setpoint. The PCU shall be capable of maintaining this failure setpoint in the event of a system malfunction that causes loss of PCU control, or loss of output signal, as long as power is available at the PCU. The failure setpoint shall be selectable on a per point basis.
  - j. Slope intercepts and gain adjustments shall be available on a per point basis.
11. PCU Power Loss:
- a. Upon a loss of power to any PCU, the other units on the network shall not in any way be affected.
  - b. Upon a loss of power to any PCU, the Direct Digital Control software, the database parameters, and all other programs and data shall be backed-up and stored in either Flash, EEPROM and EPROM memory.
  - c. Upon restoration of power within the specified battery backup period, the PCU shall resume full operation without operator intervention. The PCU shall automatically reset its clock such that proper operation of any time dependent function is possible

without manual reset of the clock. A return to normal message shall indicate the PCU is back under normal power. All monitored functions shall be updated.

12. PCU Failure:
    - a. Primary LAN Data Transmission Failure: PCU shall continue to operate in stand alone mode. PCU shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value. Peer PCU's shall recognize the loss, report alarm (level one) and reconfigure the LAN.
    - b. PCU Hardware Failure: PCU shall cease operation and terminate communication with other devices. All outputs shall go to their specified fail position.
  13. Each PCU shall be equipped with firmware resident self-diagnostics for sensors and be capable of assessing an open or shorted sensor circuit and taking an appropriate control action (close valve, damper, etc.).
  14. PCU's may include LAN communications interface functions for controlling secondary controlling LANs. Refer to System Communications Devices for requirements if this function is packaged with the PCU.
  15. A minimum of four levels of password protection shall be provided for direct connection to each PCU.
- D. APPLICATION SPECIFIC CONTROLLER (ASC) (ASCs shall control FCU, UV, FTR, VAV,EF, BCU, Terminal devices etc...)
1. ASCs shall include Unitary Controllers (UC), and Terminal Equipment Controllers (TEC), which provide intelligent, limited stand-alone control of HVAC equipment. Each unit shall have its own internal RAM, non-volatile memory and shall continue to operate all local control functions in the event of a loss of communications on the secondary LAN. Refer to stand alone requirements by application specified in Section 2.03. In addition, it shall be able to share information with every other PCU and ASC on the entire network.
  2. Each ASC shall include self-test diagnostics that allow the ASC to automatically relay to the PCU, LAN Interface Device or workstation, any malfunctions or abnormal conditions within the ASC or alarm conditions of inputs that exceed desired parameters as determined by programming input.

3. Application programs, calculations, and commands resident in other controllers, with the exception of global information (further defined in this specification), and transmitted to the ASC for execution is unacceptable.
4. Each ASC shall contain both software and hardware to perform full DDC/PID control loops.
5. Each ASC must be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, minimum 10 bit A to D conversion, voltage transient and lightning protection devices. All volatile memory shall have a battery backup of at least fifty (50) hrs with a battery life of five years.
6. All point data; algorithms and application software within an ASC shall be modifiable from the Operator Workstation, Portable Operators Terminal and Hand Held Device.
7. ASC Input-Output Processing
  - a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each configurable as normally open or normally closed. Each DO shall be discrete outputs from the ASC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
  - b. Analog Inputs (AI): 0-5VDC, 0-10VDC; 0-20VDC, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the SCU's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 10 bits.
  - c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the ASC and shall be isolated from the main board.
  - d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
  - e. Electronic Analog Outputs (AO) as required by the application: voltage mode, 0-5VDC and 0-10VDC; current mode (4-20 mA). Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO and transducer is acceptable unless stipulated otherwise for a given control loop. Transducer shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing.

Each AO shall be discrete outputs from the ASC's board (multiplexing to a separate manufacturers board is unacceptable). D/A converters shall have a minimum resolution of 8 bits.

## 2.04 SYSTEM COMMUNICATION DEVICES

### A. LOCAL AREA NETWORK Interface Devices (LANID)

1. The LANID shall be a microprocessor-based communications device, which acts as a gateway between the Host LAN, Primary LAN, Secondary LAN, an operator interface, or printer. These may be provided within a PCU or as a separate device. LANID shall automatically report alarm conditions, download trend data, etc. as required elsewhere in these specifications.
2. The LANID shall perform information translation between the Host LAN, Primary LAN, and the Secondary LAN, supervise communications on a polling secondary LAN, and shall be applicable to systems in which the same functionality is not provided in the PCU. In systems that the LANID is a separate device, it shall contain its own microprocessor, RAM, battery, real time clock, communication ports and, power supply as specified for a primary control unit. Each gateway shall be mounted in a lockable enclosure.
3. Each LANID shall support interrogation, full control, and all utilities associated with all PCU's on the Primary LAN, all ASCs connected to all secondary LANs under the Primary LAN, and all points connected to those PCUs and ASCs.
4. Upon loss of power to a LANID, all programs and data shall be stored in either Flash, EEPROM or EPROM memory.
5. LANIDs shall support communications to the remote OW and POT. LANID functionality shall support
  - a. Automatic dial out to report alarm conditions, download trend data, etc. as required elsewhere in these specifications.
  - b. multiple retries for unsuccessful connection
  - c. multiple number dial out
  - d. buffering of incoming and outgoing data
  - e. automatic answer
  - f. uploading and downloading of control unit programs

6. The LANID shall be transparent to control functions and shall not be required to control information routing on the Primary LAN

## 2.05 SYSTEM SOFTWARE AND PROGRAMMING

### A. CU SOFTWARE

1. PCU Software Residency: Each PCU as defined below shall be capable of control and monitoring of all points physically connected to it. All software including the following shall reside and execute at the PCU
  - a. Real Time Operating System software
  - b. Real Time Clock/Calendar and network time synchronization
  - c. PCU diagnostic software
  - d. LAN Communication software
  - e. Direct Digital Control software
  - f. Alarm Processing and Buffering software
  - g. Energy Management software
  - h. Data Trending, Reporting, and Buffering software
  - i. I/O (physical and virtual) database
  - j. Remote Communication Software unless its resident in a LANID on the primary LAN.
2. ASC Software Residency: Each ASC as defined below shall be capable of control and monitoring of all points physically connected to it. As a minimum, software including the following shall reside and execute at the ASC. Other software to support other required functions of the ASC may reside at the master PCU or LANID with the restrictions/exceptions per application provided in "Distributed Direct Digital Controllers and Control System".
  - a. Real Time Operating System software
  - b. Real Time Clock/Calendar and network time synchronization
  - c. ASC diagnostic software
  - d. LAN Communication software

- e. Direct Digital Control software
  - f. Control software applicable to the unit it serves shall support a single mode of operation
  - g. I/O (physical and virtual) database.
3. Stand Alone Capability: PCU/ASC shall continue to perform all functions independent of a failure in other PCUs/ASCs or other communication links to other PCUs/ASCs. Trends and runtime totalization shall be retained in memory. Runtime totalization shall be available on all digital input points that monitor electric motor status.
  4. Operating System: CU's shall include a real time operating system resident in ROM. This software shall execute independently from any other devices in the system. It shall support all specified functions. It shall provide a command prioritization scheme to allow functional override of control functions
  5. Network Communications: Each CU shall include software that supports the networking of CUs on a common communications trunk that forms the respective LAN. Network support shall include the following:
    - a. Primary LAN shall be a high speed peer to peer network designed and optimized for control system communication. If a Primary LAN communications trunk is severed, PCUs shall reconfigure into two separate LANs and continue operations without interruption.
    - b. CU communication software shall include error detection, correction, and re-transmission to ensure data integrity.
    - c. Operator/System communication software shall facilitate communications between other PCUs, all subordinate ASCs, gateways and LAN Interface Devices or Operator Workstations. Software shall allow point interrogation, adjustment, addition/deletion, and programming while the CU is on line and functioning without disruption to unaffected points. The software architecture shall allow networked CUs to share selected physical and virtual point information throughout the entire system.
  6. Point Database: Point/system database creation and modification shall be via a user friendly, menu driven program. System software shall support virtual or logic point (points not representing a physical I/O) creation. Software shall support virtual points with all services specified herein. Database software shall support definition of all parameters specified in Part III of this section for a given point type. If database does

not support all these parameters software module shall be created and attached to the points which accomplish the respective function.

7. Diagnostic Software: CU software shall include diagnostic software that checks memory and communications and reports any malfunctions.
8. Alarm/Messaging Software: CUs software shall support alarm/message processing and buffering software as more fully specified below.
9. Application Programs: CUs shall support and execute application programs as more fully specified below. All Direct Digital Control software, Energy Management Control software, and functional block application programming software templates shall be provided in a "ready-to-use" state, and shall not require (but shall allow) Owner programming. Line programs shall supply preprogrammed functions to support these energy management and functional block application algorithms. All functions shall be provided with printed narratives and/or flow diagrams to document algorithms and how to modify and use them. All programs shall reside in the controller serving the equipment being controlled.
10. Security: CU software shall support multiple level password access restriction as more fully specified below.
11. Direct Digital Control: CU shall support application of Direct Digital Control Logic. All logic modules shall be provided pre-programmed with written documentation to support their application. Provide the following logic modules as a minimum:
  - a. Proportional-Integral-Derivative (PID) Control with analog, PWM and floating output
  - b. Two Position control (Hi or Low crossing with deadband)
  - c. Single Pole double throw relay
  - d. Delay Timer (delay on make, delay on break, and interval)
  - e. Hi/Low Selection
  - f. Reset or Scaling Module
  - g. Logical Operators (And, Or, Not, Xor)
12. Psychrometric Parameters: CU software shall provide preprogrammed functions to calculated and present psychrometric parameters (given temperature and relative humidity) including the following as a minimum: Enthalpy, Wet Bulb Temperature,



13. Updating/Storing Application Data: Site specific programming residing in volatile memory shall be uploadable/downloadable from an operator interface connected either locally, to the primary LAN or remotely via Host LAN. Initiation of an upload or download shall include all of the following methods; manually, scheduled, and automatically upon detection of a loss or change.
14. Restart: System software shall provide for orderly shut down upon loss of power and automatic restart upon power restoration. Volatile memory shall be retained, outputs shall go to programmed fail (open, closed, or last) position. Equipment restart shall include a user definable time delay on each piece of equipment to stagger the restart. Loss of power shall be alarmed at operator interface indicating date and time.
15. Misc. Calculations: System software shall automate calculation of psychometric functions, calendar functions, kWh/kW and flow determination and totalization from pulsed or analog inputs, curve-fitting, look-up table, input/output scaling, time averaging of inputs and A/D conversion coefficients.
16. PID Loop Tuning: Contractor shall provide a software tool for tuning PID loops. This tool shall preferably be provided as an integral part of the system software or graphic software package. Loop response trends shall be used to calculate suggested P, I, and D gains in the units used in the manufacturers PID algorithms. The following are acceptable:
  - a. Manual Tuning that accepts either automatic or manual amplitude and response time inputs and calculates PID gains for automatic or manual entry into control module.
  - b. Self Tuning algorithm that periodically upsets the process and automatically adjusts the PID gains.
  - c. Adaptive Tuning that continuously monitors natural disturbances in the process and adjusts the PID gains accordingly. This algorithm must include a user definable noise band to inhibit adjustments.
17. Trending Software: CU software shall support alarm/message processing and buffering software as more fully specified below.

#### B. PROGRAMMING DESCRIPTION

1. The application software shall be user programmable.
2. This specification generally requires a programming convention that is logical, easy to learn, use, and diagnose. General approaches to

application programming shall be provided by one, or a combination, of the following conventions:

- a. Database Creation: provide templates customized for point type, to support input of individual point information.
  - b. Graphical Block Programming: Manipulation of graphic icon “blocks”, each of which represents a subroutine, in a functional/logical manner forming a control logic diagram. Blocks shall allow entry of adjustable settings and parameters via pop-up windows. Provide a utility that shall allow the graphic logic diagrams to be directly compiled into application programs. Logic diagrams shall be viewable either off-line, or on-line with real-time block output values.
  - c. Functional Application Programming: Pre-programmed application specific programs that allow/require-limited customization via “fill in the blanks” edit fields. Typical values would be setpoints gains, associated point names, alarm limits, etc.
  - d. Line Programming: Text programming in a language similar to BASIC or FORTRAN designed specifically for HVAC control. Subroutines or functions for energy management applications, setpoints, and adjustable parameters shall be customizable, but shall be provided preprogrammed and documented.
3. Provide a means for testing and/or debugging the control programs both off-line and on-line.

#### C. ENERGY MANAGEMENT APPLICATIONS

1. System shall perform all of the following energy management routines via preprogrammed function blocks or template programs.
  - a. Time of Day Scheduling
  - b. Calendar Based Scheduling
  - c. Holiday Scheduling
  - d. Countywide Schedules
  - e. Individual Building Schedules
  - f. Snow Day Schedules and Override Schedules
  - g. Custom Group/Area/Zone Scheduling

- h. Temporary Schedule Overrides
  - i. Optimal Start/Optimal Stop-based on space temperature offset, outdoor air temperature, and building heating and cooling capacitance factors as a minimum
  - j. Night Setback and Morning Recovery Control with ventilation only during occupancy.
  - k. Night Purge ventilation cycle to use the cool night/morning air to pre-cool the space prior to occupancy.
  - l. Economizer Control (enthalpy)
  - m. Peak Demand Limiting / Load Shedding
  - n. Dead Band Control
2. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow operator customization. All programs shall reside in the controller serving the equipment being controlled.

#### D. PASSWORD PROTECTION

- 1. Multiple-level password access protection shall be provided to allow the Owners authorized BAS Administrator to limit workstation control, display and database manipulation capabilities as he deems appropriate for each user, based upon an assigned user name with a unique password.
- 2. Passwords shall restrict access to all control units
- 3. Each user name shall be assigned to a discrete access level. A minimum of four levels of access shall be supported. Alternatively, a comprehensive list of accessibility/functionality items shall be provided for enabling/disabling for each user. See Section 3.07.C.
- 4. A minimum of 100 user names shall be supported.
- 5. Operators shall be able to perform only those commands available for the access level assigned to their user name.
- 6. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving interface device software on-line.

#### E. ALARM/MESSAGE REPORTING

1. Alarm management shall be provided to monitor, buffer, and direct alarms and messages to operator devices and memory files. Each PCU shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall a PCU's ability to report alarms be affected by either operator activity at an Operator Workstation or local handheld device or by communications with other panels on the network. To eliminate nuisance and invalid alarms and messages, alarms and messages shall not be reported if the software algorithm or point is inactive. See section 3.06 paragraph E line 9 for alarms during the construction and warranty period.
  - a. Alarm Descriptor: Each alarm or point change shall include the point's English language description, and the time and date of occurrence. In addition to the alarm's descriptor and the time and date, the user shall be able to print, display and store an alarm message to more fully describe the alarm condition or direct operator response.
  - b. Alarm Prioritization: The software shall allow users to define the handling and routing of each alarm by their assignment to discrete priority levels. A minimum of five priority levels shall be provided. For each priority level, users shall have the ability to enable or disable an audible tone whenever an alarm is reported and whenever an alarm returns to normal condition. Users shall have the ability to manually inhibit alarm reporting for each individual alarm and for each priority level.
  - c. Alarm Report Routing: Each alarm priority level shall be associated with a unique user-defined list of operator devices including any combination of local or remote workstations, printers and workstation disk files. All alarms associated with a given priority level shall be routed to all of the operator devices on the user-defined list associated with that priority level. For each priority level, alarms shall be automatically routed to a default operator device in the event that alarms are unable to be routed to any operator device assigned to the priority level.
  - d. Auto-Dial Alarm Routing: For alarm priority levels that include a remote workstation (accessed by modem) or alpha-numeric pagers as one of the listed reporting destinations, the PCU shall initiate a call to report the alarm, and shall terminate the call after alarm reporting is complete. System shall be capable of multiple retries and buffer alarms until a connection is made. If no connection is made, system shall attempt connection to an alternate dial-up workstation. System shall also be able to dial multiple pagers upon alarm activation.

- e. Alarm Acknowledgment: For alarm priority levels that are directed to a workstation screen, an indication of alarm receipt shall be displayed immediately regardless of the application in use at the workstation, and shall remain on the screen until acknowledged by a user having a password that allows alarm acknowledgment. Upon acknowledgment, the complete alarm message string (including date, time, and user name of acknowledging operator) shall be stored in a selected file on the workstation hard disk.

## F. TRENDING

1. The software shall be capable of displaying historical data in both a tabular or graphical format. The requirements of this trending capability shall include the following:
  - a. All points listed in the Input/Output summaries and all physical points and calculated variables shall be trended.
  - b. In the graphical format, the trend shall plot at least 4 different values for a given time period superimposed on the same graph. The 4 values shall be distinguishable by using unique colors. In printed form the 4 lines shall be distinguishable by different line symbology. Displayed trend graphs shall indicate the engineering units for each trended value.
  - c. The time period for each trend shall be for a minimum of seven days and shall be user selectable.
  - d. The trended value range shall be user selectable.
  - e. All points shall be included in series for commissioning purposes.
2. Control Loop Performance Trends: CUs incorporating PID control loops shall also provide high resolution sampling capability in less than six second increments for verification of control loop performance.
3. Data Storage and Archiving: Trend data shall be stored at the CU, and uploaded to hard disk storage when archival is desired. Uploads shall occur based upon user-defined interval, manual command, or when the trend buffers become full. Trended data shall include one row of descriptive column headings with all subsequent data in a contiguous stream. All trend data shall be available one of the following disk file formats:
  - a. Quote and Comma separated text
  - b. Microsoft ACCESS database

- c. Microsoft EXCEL spreadsheet.

#### G. TOTALIZATION

1. The software shall support totalizing analog, digital, and pulsed inputs and be capable of accumulating, storing, and converting these totals to engineering units used in the documents. These values shall generally be accessible to the Operator Interfaces to support management reporting functions.
2. Totalization of electricity use/demand shall allow application of totals to different rate periods, which shall be user definable.

#### H. EQUIPMENT SCHEDULING

1. Provide a graphic utility for user-friendly operator interface to adjust equipment operating schedules.
2. Scheduling feature shall include multiple seven-day master schedules, plus holiday schedule, each with start time and stop time. Features shall also include countywide schedules, individual building schedules, custom group schedules within a building consisting of multiple pieces of equipment, snow day schedules, and override schedules. All schedules shall be individually editable for each day and holiday.
3. Scheduling feature shall allow for each individual equipment unit to be assigned to one of the master schedules.
4. Timed override feature shall allow an operator to temporarily change the state of scheduled equipment. An override command shall be selectable to apply to an individual unit, all units assigned to a given master schedule, or to all units in a building. Timed override shall terminate at the end of an operator selectable time, or at the end of the scheduled occupied/unoccupied period, whichever comes first. A password level that does not allow assignment of master schedules shall allow timed override features.
5. A yearly calendar feature shall allow assignment of holidays and automatic reset of system real time clocks for transitions between daylight savings time and standard time.

#### I. OPERATOR INTERFACE GRAPHIC SOFTWARE (Graphical User Interface)

1. Graphic software shall facilitate user friendly interface to all aspects of the System Software specified above as well as in sections 3.07 and 3.08 (System Software And Programming). The intent of this specification is to require a graphic package that provides for intuitive operation of the systems without extensive training and experience. Graphic software

shall make maximum use of colors, graphics, icons, embedded images and dynamic symbols. It shall facilitate logical and simple system interrogation, modification, configuration, and diagnosis. This interface shall provide the web browser the same view of the system, in terms of graphics, schedules, calendars, logs, trends, point override etc., and the same interface methodology. Functions of this interface shall be identical when accessed via the web based browser and shall not require the use of proprietary software.

2. The home screen of the graphic software shall have a "button icon" which shall provide a Web gateway to the VRF control software in the VRF central controller.
3. Graphic software shall support multiple simultaneous screens to be displayed and resizable in a "Windows" like environment and shall include a tree view (similar to "Windows Explorer"). All except text entry functions shall be executable with a mouse.
4. Graphic software shall provide for multitasking such that third party programs can be used while the Operator Workstation Software is on line. Provide the ability to alarm graphically even when operator is in another software package.
5. Operating system software shall be Windows, the latest release and version supported by the manufacturer.
6. The software shall allow for Owner creation of user defined, color graphic displays of geographic maps, building plans, floor plans and mechanical and electrical system schematics. These graphics shall be capable of displaying all point information from the database including any attributes associated with each point (e.g., engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse. The user shall have the ability to import AutoDesk AutoCAD Release 2006 (or newer version) generated files as background displays.
7. Screen Penetration: The operator interface shall allow users to access the various system graphic screens via a graphical penetration scheme by using the mouse to select from menus or "button" icons. Each graphic screen shall be capable of having a unique list of other graphic screens that are directly "linked" through the selection of a menu item or button icon.
8. Dynamic Data Displays: Dynamic physical point values shall automatically updated at a minimum frequency of 3 updates per minute without operator intervention. Point value fields shall be displayed with a color code depicting normal, abnormal, override and alarm conditions.

9. Point Override Feature: Each displayed point shall be individually enabled/disabled to allow mouse driven override of digital points or changing of analog points. Such overrides or changes shall occur in the control unit, not just in the workstation software. The graphic point override feature shall be subject to password level protection. Points that are overridden shall be reported as an alarm, and shall be displayed in a coded color. The alarm message shall include the operator's user name. A list of points that are currently in an override state shall be available through menu selection.
10. Dynamic Symbols: Provide a selection of standard symbols, which change in appearance based on the value of an associated point.
- a. Analog symbol: Provide a symbol that represents the value of an analog point as the length of a line or linear bar.
  - b. Digital symbol: Provide symbols such as switches, pilot lights, rotating fan wheels, etc. to represent the value of digital input and output points as appropriate. Animation for any operating machinery shall only represent digital inputs, and not outputs, in order to provide an accurate equipment status.
  - c. Point Status Color: Graphic presentations shall indicate different colors for different point statuses. (For instance, green = normal, red = alarm, gray (or???) for non-response.
  - d. Use dynamic zone background colors (thermograph) to indicate thermal comfort based on temperature offset from setpoint on the zone graphic display screens. The colors are as follows:

|            |                                |
|------------|--------------------------------|
| Red        | 5 DEG F or more below setpoint |
| Dark Blue  | 4 DEG F below setpoint         |
| Light Blue | 2 DEG F below setpoint         |
| Green      | Satisfied                      |
| Yellow     | 2 DEG F above setpoint         |
| Orange     | 4 DEG f above setpoint         |
| Red        | 5 DEG F or more above setpoint |
11. Graphics Definition Package: Graphic generation software shall be provided to allow the user to add, modify, or delete new or existing system graphic displays.
- a. The contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), mechanical system components (e.g., pumps, chillers, cooling towers, boilers, etc.),



complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.

- b. The graphic development package shall use a mouse to allow the user to perform the following:
  - 1) Define symbols
  - 2) Position items on graphic screens
  - 3) Attach physical points, virtual points or setpoints to a graphic
  - 4) Define background screens
  - 5) Define connecting lines and curves
  - 6) Locate, orient and size descriptive text
  - 7) Define and display colors for all elements
  - 8) Establish correlation between symbols or text and associated system points or other displays.
  - 9) Create hot spots or link triggers to other graphic displays or other functions in the software.

#### J. WORKSTATION DATA REPORTING AND STORAGE

- 1. Workstation software shall support Microsoft Dynamic Data Exchange (DDE) and Object Linking and Embedding (OLE) to facilitate historical data access from popular spreadsheet and database programs (e.g., Microsoft EXCEL and ACCESS). Data storage format shall be directly importable to the application without manual parsing. Programs external to the graphic software are acceptable to meet this requirement.

#### K. REMOTE PERSONAL COMPUTER WORKSTATION GRAPHIC SOFTWARE

- 1. Remote graphic operator software shall provide all the functionality specified for the local graphic software. It shall communicate with the Primary and Host LAN via a hardwired connection.
- 2. Software shall not require graphic images to be sent across the Host LAN or phone lines. Graphic images shall reside on the remote operator workstation hard drive. Terminal emulation software such as PC Anywhere, Carbon Copy, ProComm, PolyPM II, etc. are not acceptable.

3. Software shall be capable of connecting to the Host LAN or initiating phone calls to the primary LAN, upon user command, to perform all specified functions. Software shall be capable of connecting to the primary LAN in accordance with user-programmed time schedules to upload trend and report data. Software shall be capable of receiving calls or connections from the primary LAN in accordance with user-programmed time schedules to report alarms and upload trend and report data. Software shall automatically terminate the connection whenever all applications requiring communication are closed.
4. The combination of Remote Personal Computer Workstation Software, PCU software, and LAN Interface Device software shall provide the ability for seamless automatic upload of trend data and reports to the remote workstation. The feature shall allow for disk storage of continuous historical trend and report data without gaps or duplications.

L. TAB & CX PORTABLE OPERATORS TERMINAL

1. Contractor shall provide a portable operator's terminal or hand held device to facilitate TAB and calibration. This device shall support all functions and allow querying and editing of all parameters required for proper calibration and start up.
2. Connections shall be provided local to the device being calibrated. For instance, for VAV boxes, connection for the operator's terminal shall be at the wall sensor.

M. SOFTWARE MAINTENANCE

1. During warranty period, contractor shall be responsible to maintain, change, modify, correct, and optimize all software upon request by the Owner. During this period, when software problems cause comfort or equipment problems, contractor shall implement corrective measures within two hours of notification by Owner.

**PART 3. EXECUTION**

3.01 GENERAL

A. INSPECTION

1. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

B. INSTALLATION OF CONTROL SYSTEMS

1. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.
2. Refer to additional requirements in other sections of this specification.
3. On projects which have phased construction the BAS for each phase shall be functional prior to completion and turnover of the phase, network connectivity shall be established and graphics shall be remotely available. If the location of the master IFID/CU is not yet established a protected temporary location will be chosen in which to mount the master IFID/CU until such time that the permanent location is established. A temporary network connection will be provided (coordinate with owner).

C. IFID/CU QUANTITY AND LOCATION

1. Individual Digital Control Stations (DCS) are referenced to indicate allocation of points to each DCS and DCS location. Digital control stations shall consist of one or multiple IFIDs/CUs to meet requirements of this specification.
2. Where a DCS is referenced, Contractor shall provide at least one IFID/CU, and additional IFIDs/Cus as required, in sufficient quantity to meet the requirements of this Specification. Restrictions in applying CUs are specified in "Distributed Direct Digital Controllers and Control System" (Section 15900, Paragraph 2.03B & 2.03C). If the control contractor wishes to further distribute panels to other locations, control contractor is responsible for extending power to that location. Furthermore, Contractor is responsible for ensuring adequate locations for the panels that do not interfere with other requirements of the project and maintain adequate clearance for maintenance access and to comply with local codes. DCS's shall be installed in locations, as specified in Section 15900, Paragraph 2.03.E, CONTROL PANELS. DSC's provided by the equipment manufacturer and factory installed within the equipment control enclosure are acceptable. Locate panels for roof top units in areas shown on the drawings. Locate panels in ceilings for unit ventilators, fan coil units, fin tube radiation, terminal devices, and heating coils. Panels located in ceilings shall be identified with a nameplate attached with 1/4" head, self-tapping screw to the ceiling grid or access door identifying the equipment. Mounting control panels for VAV boxes on the VAV box itself is acceptable. See additional identification requirements in Section 15900, Paragraph 2.02 x, NAMEPLATES. No DCS's may be located in other areas without prior approval of the Owner.
3. Stand Alone Functionality: Provide IFIDs/CUs so that all points associated with and common to one air handling unit or other complete stand alone system/equipment shall reside within a single control unit. See related restriction in "Distributed Direct Digital Controllers and Control System". When referring to the IFID/CU as pertains to the standalone

functionality, reference is specifically made to the processor. One processor shall execute all the related functions. I/O point expander boards may be added to expand the point capacity of the IFID/CU. Where any I/O point expansion devices are connected to the main controller board via a communication sub LAN, that communication sub LAN shall be dedicated to that controller and include no other devices including secondary controllers. The sub-LAN communication speed shall be the same or higher than the main controller LAN.

4. Contractor shall locate DCSs as referenced. It is the Contractor's responsibility to provide enough IFIDs/Cus to ensure a completely functioning system, according to the point list and sequence of operations.
5. Contractor shall provide a minimum of the following:
  - a. One DCS (including at least one PCU) in the central control panel.
  - b. One IFID/CU for each air handler located in applicable mechanical room.
  - c. One IFID/CU shall be provided for each terminal unit unless indicated otherwise.
6. IFID/CU Mounting – see Section 15900, paragraph 2.02F
  - a. IFIDs/CUs that control equipment located above accessible ceilings shall be mounted in an enclosure or on the equipment and shall be rated for plenum use within a suitable enclosure.
  - b. IFIDs/CUs that control equipment located in occupied spaces shall be mounted above the ceiling and shall be rated for plenum use within a suitable enclosure or factory mounted on unit.
  - c. IFIDs/CUs that control equipment mounted in a mechanical room may either be mounted on the equipment or on the wall of the mechanical room within a locking enclosure.
  - d. IFIDs/CUs that control equipment mounted outside shall be located in a mechanical/utility space within a locking enclosure.
  - e. IFIDs/CUs shall be suitable for operation in the ambient temperatures that may be encountered in the location they are installed. CU's located in ambient conditions must be approved by the Owner. CU's that are not suitable shall be replaced and at no cost to the Owner.

- f. IFIDs/CUs mounted above ceilings shall be mounted no higher than 12" above the ceiling grid to the bottom of the control enclosure. All IFIDs/CUs mounted above ceilings shall have a nameplate attached to the ceiling grid.

#### D. SURGE PROTECTION

1. The Contractor shall furnish and install power supply surge protection, filters, etc. for proper operation and protection of all PCUs, SCUs operator interfaces, printers, and other hardware and interface devices. All equipment shall be capable of handling voltage variations 10% above or below measured nominal value, with no affect on hardware, software, communications, and data storage.

#### E. CONTROL POWER SOURCE AND SUPPLY

1. Power wiring from dedicated circuit breaker at each 120 Volt panel to a junction box shall be provided by the Division 16 Contractor. Electrical circuits for use by the BAS Contractor are shown on the electrical drawings. This Contractor is responsible for all power wiring from this junction box to control panels, devices, controllers and components for a complete and operating system. If the control contractor wishes to further distribute panels to other locations, control contractor is responsible for extending power to that location. Furthermore, contractor is responsible for ensuring adequate locations for the panels that do not interfere with other requirements of the project and maintain adequate clearance for maintenance access.
2. All other electrical wiring, conduit, devices, transformers, components, etc. required for a complete BAS system including interlocking of controllers, equipment etc. shall be provided under this Section. Mechanical equipment supplied power transformers may be utilized if they are factory furnished and designed to be used with the control system. Mechanical equipment supplied power transformers shall not be utilized for non factory supplied control systems.

### 3.02 BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

#### A. INSPECTION

1. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

#### B. INSTALLATION OF CONTROL SYSTEMS

1. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install

electrical components and use electrical products complying with requirements of National Electric Code and all local codes.

2. Control Wiring: The term “control wiring” is defined to include providing of wire, cable, conduit and miscellaneous materials as required for mounting and connection of electric control devices.
  - a. Wiring System: Install complete wiring system for electric control systems. Conceal wiring except in mechanical rooms and areas where other conduit and piping are exposed. Wiring run in walls shall be run in electrical metallic tubing (EMT). Install in accordance with National Electrical Code and Division 16 of this Specification. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly. Wiring shall be run without splices. Any and all junction box covers shall be marked “ATC”. Relays controlling equipment located above ceiling shall be located a maximum of 6” above acoustical ceiling tile. In areas without acoustical ceilings, relays shall be located a maximum 12’ above finished floor. Wiring terminations which do not terminate at a terminal strip shall be made using insulated compression type connectors. Wiring terminations which do not terminate at a terminal strip shall be made using insulated compression type connectors.
  - b. Control Wiring Conductors: Install control wiring conductors, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code and Division 16 of this Specification.
  - c. Communication wiring, signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at IFID/CU end only, as recommended by the IFID/CU manufacturer.
  - d. Primary LAN Communication wiring shield shall be terminated as recommended by IFID/CU manufacturer and owners active hub manufacturer.
  - e. Communication wiring shall be run without splices.
  - f. Install all control wiring external to panels in electric metallic tubing or raceway. However, communication wiring, signal wiring and low voltage control wiring may be run without conduit in concealed, accessible locations if noise immunity is ensured. Accessible locations are defined as areas inside mechanical equipment enclosures, such as heating and cooling units,

- instrument panels etc.; suspended ceilings with easy access. Tie and support conductors neatly on "J" hooks. Conductors shall be pulled tight and be installed as high as practically possible in ceiling cavities. Conductors shall not be installed between the top cord of a joist or beam and the bottom of roof decking. Contractor shall be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.
- g. Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.
  - h. Provide power disconnect switch in the interior for all main control panels.
3. Electric conduit ( EMT/IMC ect.) shall not be run exposed on the floor slab.
  4. Control Valves: Install so that actuators and wiring and tubing connections are accessible. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal, if in accordance with manufacturer's written recommendation. Do not install valves with stem below horizontal, or down. Adjust and verify proper valve stroke operation to assure proper shut-off and full flow.
  5. Liquid immersion wells shall be installed on or below the horizontal axis of the pipe. Temperature sensor shall be installed with thermally conductive paste within the well.
  6. Space Sensors: Install in accordance with the manufacturers recommendations. The cover of the sensor shall be attached by tamperproof fasteners to the recessed mounting box or plate. Provide insulated base. Classrooms shown with multiple units shall have one room sensor except those with folding partitions shall have separate sensors for each unit. Mount all sensors at 4'-0" AFF. Sensors located in Cafeterias, Gymnasiums, storage rooms and electric rooms shall be mounted at 5'-6" AFF. Sensors in corridors and group bathrooms shall be mounted at 6'-8" AFF. Provide welded wire enclosures securely mounted to the wall in gymnasiums, locker rooms, gang toilets, and corridors, for all temperature, humidity and CO<sub>2</sub>sensors. Sensors located in storage rooms and electric rooms, provide a locking metal enclosure. Submit a sample space sensor for approval prior to installation.
  7. Averaging Temperature Sensors: Cover no more than one square feet per linear foot of sensor length. Adequately support with coil clips.

8. Relative humidity sensors: Provide element guard as recommended by manufacturer for high velocity installations.
9. Provide pressure snubbers for water pressure sensing devices and switches where necessary to eliminate pressure transients causing unwanted control signal noise or switch operation.
10. Differential Pressure Switch (Air & Water): Adjust switches as recommended by the manufacturer and so that setpoint is within the operating range of the device being sensed.
11. Differential Pressure Transmitters: Provide four valve bypass arrangement to protect against over pressure damaging the transmitter. Provide pressure gauges after the isolation valves, but before the transmitter device to assist in device calibration.
12. Flow Switches: Where possible, install in a straight run of pipe at least 6 diameters in length to minimize false indications.
13. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current.
14. Air Flow Measuring Stations (AFM) shall be installed under the applicable air distribution or air handling equipment section under the direction of Section 15900 Contractor who shall be fully responsible for the proper installation of the AFM. Contractor shall comply with the manufacturer's suggested installation requirements and recommendations. The AFM shall be installed in an unobstructed straight length of duct (except those installations specifically designed for installation in fan inlet). Any deviations from the recommended minimum installation requirements shall be approved by the Owner prior to installation.
15. Supply Duct / Building Pressure Transmitters:
  - a. General: Install pressure tips, per manufacturer's installation instructions, or with at least 4 "round equivalent" duct diameters of straight duct with no takeoffs upstream. Install static pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions. Locate the transmitter within a weather tight section of the equipment served at an accessible location to facilitate service / calibration. Extend piping from transmitter to pickup device.
  - b. VAV System 'Down-Duct' Transmitters: Locate static pressure tips approximately 2/3 of the way to the most remote terminal in the air system with no branch takeoffs within five feet. Locate the transmitter within a weather tight section of the equipment served



at an accessible location to facilitate service / calibration. Extend piping from transmitter to pickup device.

- c. Building Static Transmitter: Locate static remote pickup as shown or within zone away from any appurtenance which could affect reading. Locate the transmitter within a weather tight section of the equipment served at an accessible location to facilitate service / calibration. Extend piping from transmitter to pickup device.

### 3.03 SYSTEM OPERATOR INTERFACES

#### A. INSTALLATION

1. Set up and configure Operator Workstations at the school and at the Energy Management Department Offices, Sideburn Maintenance Support Facility and the Edison Maintenance Support Facility. Install all software and verify that the systems are fully operational via Host LAN.
2. Set up portable operator terminals and configure them as remote and/or local workstations. Install all software and verify that the systems are fully operational via Host LAN and dial-up connection from a remote location, as well as directly connected at IFIDs/Cus.
3. Install systems and materials in accordance with manufacturer's instructions.

### 3.04 SEQUENCE OF OPERATION

#### A. General:

1. Provide the operating sequence described in detail in the following paragraphs. The sequence shall not be deviated from unless a proposed change is submitted with justifying reasons approved by FCPS and a Change Order is issued. Inability of the proposed control system logic to produce the desired sequence is not grounds for approval of a change. Furnish adequate programming capability for the sequence outlined below.
2. Equipment Response Time – Operating program shall be arranged so that system components such as valve, damper and VAV box operators shall require no more than 12 minutes elapse time to complete a totally closed to totally open position cycle if space conditions are such that continued movement in one direction is necessary.
3. System operation printouts shall be accurate and sufficiently detailed to establish that the specified sequence is being affected.

4. Control shall be direct digital Owner programmable microprocessor located in the field, unless otherwise specified.
5. Equipment listed in the following Input/Output Summaries shall have the necessary electric and electronic equipment, material and supplies added to accomplish the indicated actions. Present time clock functions shall be done by the IFID.
6. Provide all equipment listed in the following input/output summaries with individual override switches located in the custodians office or as shown on drawings.
7. All points indicated in the Input/Output summaries shall be displayed on the proper computer graphic display screen.
8. Scheduling Terminology: When control zones are scheduled throughout the day, the following defines the terminology used:
  - a. Day or Occupied Period: period of time when the building is in use and occupied. This period is defined as follows:

Elementary Schools – 6:00 a.m. to 4:30 p.m. Monday – Friday  
SACC zone – 6:00a.m. to 6:30 p.m. Monday - Friday

Middle Schools – 6:00 a.m. to 4:30 p.m. Monday – Friday

High and Secondary Schools  
With Adult ED – 6:00 a.m. to 10:00 p.m. Monday – Friday  
Without Adult ED – 6:00 a.m. to 6:00 p.m. Monday – Friday

Exclude all County holidays. Systems shall be fully operational throughout this period and ventilation air shall be continuously introduced.
  - b. Night or Unoccupied period: period of time when the building or zone is not in use and unoccupied. Ventilation air shall not be introduced. Systems shall be off except to maintain a night setting.
  - c. Occupancy During Construction: New equipment shall run during the period of time when spaces are turned over. This period is defined as follows:
  - d. All Schools – 6:00 a.m. to 12:00 p.m. Monday – Saturday.
  - e. Systems shall be fully operational throughout this period and ventilation air shall be continuously introduced.

9. Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the BAS start commands shall be staggered by 5 second (adj.) intervals to minimize inrush current.
10. Alarm messages specified throughout the sequences are assigned to discrete priority levels. Priority levels dictate the handling and destination of alarm reports, and are defined in Section 3.07.E.
11. All setpoints, deadbands, PID gains, throttling ranges, requests etc. shall be adjustable and shall be easily modifiable, with the proper password level, from the operator interface or via a function block menu. For all setpoints, deadbands, throttling ranges, requests etc., it is unacceptable to have to modify programming statements to change the setpoint.
12. Each analog output shall include, as an integral function, a ramp control algorithm that limits the rate of change of an output on an increase in value or a decrease in value. These values shall be adjustable from the graphic screen.
13. Where reset action is specified in a sequence of operation, but a reset schedule is not indicated on the drawings, one of the following methods shall be employed:
  - a. Contractor shall determine a proportional (P) fixed reset schedule, which shall result in stable operation and shall maintain the primary variable within the specified maximum allowable variance. Reset range maximum and minimum values shall limit the setpoint range.
  - b. A floating reset (utilizing integral (I)) algorithm shall be used which increments the secondary variable setpoint (setpoint of control loop being reset) on a periodic basis to maintain primary variable setpoint. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance. Reset range maximum and minimum values shall limit the setpoint range.
  - c. Primary variable shall control the devices directly using a PID feedback control loop without resetting the secondary variable. However, the control devices shall still modulate as necessary to maintain upper and lower limits on the secondary variable. Proportional band, integral gain, and derivative term shall be selected to maintain the primary variable within the specified maximum allowable tolerance while minimizing overshoot and setting time. Reset range maximum and minimum values shall limit the setpoint range. Contractor shall gain prior approval for implementing this method of reset.

14. A floating reset algorithm shall be used which increments the secondary variable (e.g., supply air temperature or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. space temperature) setpoint. The reset increment shall be determined by the quantity of “need heat” or “need cool” requests from individual ASC’s. An ASC’s “need heat” virtual point shall activate whenever the zone’s space temperature falls below the currently applicable (occupied or unoccupied) heating setpoint minus a fixed value that is adjustable. An ASC’s “need cool” virtual point shall activate whenever the zone’s space temperature rises above the currently applicable (occupied, unoccupied, or economy) cooling setpoint plus a fixed value that is adjustable. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and setting time. Reset range maximum and minimum values shall limit the setpoint range.
15. Where a supply air temperature, duct pressure, or differential water pressure setpoint is specified to be reset by valve or damper position of the zone or zones calling for the most cooling/heating, the following method shall be employed:
  - a. A floating reset algorithm shall be used which increments the secondary variable (e.g., supply air temperature, pipe or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. cooling valve, heating valve, damper position) setpoint of 85% open. The reset increment shall be calculated based on the average position of the quantity of the worst (most open valve/damper) zone(s) as specified. The recalculation time, reset increment and control device position influence shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and setting time. The BAS analog output value shall be acceptable as indicating the position of the control device.
  - b. Rather than continuously calculating the average of the quantity of worst valve/damper positions, a method similar to the one described above may be employed whereby the “need heat” or “need cool” virtual point shall increment by one unit each time a zone’s valve/damper position rises to greater than 95%. The quantity of “need heat” or “need cool” points shall then be the basis for reset.
16. Where “prove operation” of a device (generally controlled by a digital output) is indicated in the sequence, it shall require that the BAS shall, after an adjustable time delay after the device is commanded to operate (feedback delay), confirm that the operational via the status input. If the status point does not confirm operation after the time delay or thereafter for an adjustable time delay (debounce delay) while the device is

commanded to run, an alarm shall be enunciated audibly and via an alarm message at the operator interface and print at the alarm printers. A descriptive message shall be attached to the alarm message indicating the nature of the alarm and actions to be taken. Contractor shall provide messages to meet this intent.

17. Program adjustable maximum rates of change for increasing and decreasing output from the following analog output points:
  - a. Speed control of variable speed drives (acceleration 0 to 100 percent speed in 30 seconds, deceleration 100 to 0 percent speed in 10 seconds, unless noted otherwise)
  - b. Chiller supply water setpoint reset (limit to  $\pm 1^{\circ}\text{F}$  per 5 minutes unless noted otherwise)
  - c. Chiller demand limit to 10% per minute unless noted otherwise)
18. Wherever a value is indicated to be dependent on another value (i.e.: setpoint plus  $5^{\circ}\text{F}$ ) BAS shall use that equation to determine the value. Providing a virtual point that the operator must set is unacceptable. In this case, three virtual points shall be provided: One to store the parameter ( $5^{\circ}\text{F}$ ); one to store the setpoint; and one to store the value that is the result of the equation.
19. Sequenced Heating and Cooling: BAS shall control the heating and cooling coils, mechanical cooling and heating and air side economizer as detailed for the particular equipment. Program logic shall directly prohibit the mechanical cooling and heating to be energized as well as the heating source to be energized and economizer damper to be open (or above minimum) simultaneously unless specifically noted. This does not apply to cooling and reheat valves that are used simultaneously for dehumidification.
20. Mixed Air Low Override: BAS shall override the signal to the OA damper via a proportional only loop to maintain a minimum mixed air temperature of  $45^{\circ}\text{F}$  (adj.) (loop shall output 0% at  $45^{\circ}\text{F}$  which shall be passed to the output via a software programmed low selector).
21. Smoke Safety: Upon indication of smoke by a smoke detector, the mechanical unit shall be de-energized by a hardwired interlock. OA dampers cooling valve and heating valve shall spring to the failsafe position.
22. Abbreviations used in the input/output summaries and sequences:

ACWC

AIR COOLED WATER CHILLER

|      |  |
|------|--|
| AHU  | AIR HANDLING UNIT (INCLUDES CONSTANT VOLUME AND VARIABLE VOLUME) |
| AHS  | AIR HANDLING SYSTEM  |
| BCU  | BLOWER COIL UNIT   |
| CEF  | CABINET OR CEILING EXHAUST FAN                                   |
| CHW  | CHILLED WATER  |
| CONF | CONFIRMATION   |
| C.R. | CLASSROOM  |
| CT   | COOLING TOWER  |
| CU   | CONDENSING UNIT  |
| CUH  | CABINET UNIT HEATER  |
| CZ   | CONTROL ZONE   |
| DAT  | DISCHARGE AIR TEMPERATURE  |
| DPS  | DIFFERENTIAL PRESSURE SENSOR                                     |
| ECON | ECONOMIZER   |
| EF   | EXHAUST FAN  |
| ERU  | ENERGY RECOVERY UNIT   |
| EBB  | ELECTRIC BASE BOARD HEATER                                       |
| ECH  | ELECTRIC CABINET UNIT HEATER                                     |
| EDH  | ELECTRIC DUCT HEATER   |
| EWB  | ELECTRIC WALL HEATER   |
| EW   | ENTHALPY WHEEL   |
| FTR  | FIN TUBE RADIATOR  |
| FCU  | FAN COIL UNIT  |

|         |  |
|---------|--|
| FZ STAT | FREEZESTAT   |
| HEX     | HEAT EXCHANGER   |
| HW      | HOT WATER  |
| HRW     | HEAT RECOVERY WHEEL  |
| IFID    | INTELLIGENT FIELD INTERFACE DEVICE                             |
| MAU     | MAKE-UP AIR UNIT   |
| O.A.    | OUTSIDE AIR  |
| OAT     | OUTSIDE AIR TEMPERATURE  |
| PRV     | POWER ROOF VENTILATORS   |
| RAHU    | ROOFTOP AIR HANDLING UNIT                                      |
| RAT     | RETURN AIR TEMPERATURE   |
| RTU     | ROOFTOP UNIT (INCLUDES CONSTANT VOLUME AND<br>VARIABLE VOLUME) |
| RTW     | ROOFTOP UNIT WITH ENTHALPY WHEEL                               |
| RWC     | REMOTE HOT WATER COIL  |
| SF      | SUPPLY FAN   |
| SC      | SELF-CONTAINED AIR CONDITIONING UNIT                           |
| TEMP    | TEMPERATURE  |
| TW      | TOWER WATER  |
| TWU     | THRU-WALL UNIT   |
| UH      | UNIT HEATER  |
| UV      | UNIT VENTILATOR  |
| UV      | UTILITY VENT SET   |
| VAL     | VALANCE  |

|       |                            |
|-------|----------------------------|
| VAVTU | VAV TERMINAL UNIT          |
| VFD   | VARIABLE FREQUENCY DRIVE   |
| VRF   | VARIABLE REFRIGERANT FLOW  |
| WCWC  | WATER COOLED WATER CHILLER |
| WSHP  | WATER SOURCE HEAT PUMP     |

## Notes:

- 1) Provide the required number of inputs and outputs in each classroom or space to comply with the sequence of operations specified in Part 3, Execution, Paragraph 3.04 whether or not they are shown in the summaries.
- 2) When equipment is supplied and wired by the factory as a complete product, the factory points shall be acceptable for monitoring and control provided that all aspects of this specification and sequences are met.
- 3) The setpoints listed in the following sequences are recommended values. All setpoints shall be field adjusted during the commissioning period to meet the requirements of the actual field conditions.



| <b>ACTION ANALOG INPUTS</b> | <b>SPACE/EQUIP</b>   | <b>LOCATION</b>      | <b>RESPONSE</b>       | <b>REMARKS</b> |
|-----------------------------|--|----------------------|-----------------------|----------------|
| 1.                          | NORTH WALL   | O. A.                | TEMP/HUMIDITY         | NOTE #5        |
| 2.                          | BOILER ROOM  | HW SUPPLY            | TEMPERATURE           | NOTE #1        |
| 3.                          | BOILER ROOM  | HW RETURN            | TEMPERATURE           | NOTE #1,13     |
| 4.                          | BOILER   | HW SUPPLY            | TEMPERATURE           | NOTE #3        |
| 5.                          | BOILER ROOM  | CHW SUPPLY           | TEMPERATURE           | NOTE #1,17     |
| 6.                          | BOILER ROOM  | CHW RETURN           | TEMPERATURE           | NOTE #1,17     |
| 7.                          | BOILER ROOM  | TW SUPPLY            | TEMPERATURE           | NOTE #1,3      |
| 8.                          | BOILER ROOM  | TW RETURN            | TEMPERATURE           | NOTE #1,3      |
| 9.                          | SPACE TEMP.  | 1 EACH ROOM          | TEMPERATURE           | NOTE #2        |
| 10.                         | HYDRONIC LOOP  | SUPPLY               | TEMPERATURE           | NOTE #19       |
| 11.                         | HYDRONIC LOOP  | RETURN               | TEMPERATURE           | NOTE #20       |
| 12.                         | HYDRONIC LOOP  | PIPING (2 LOCATIONS) | DIFF PRESS            | NOTE #16       |
| 13.                         | SPACE TEMP.  | 1 EACH ROOM          | TEMP. ADJUST          | NOTE #2        |
| 14.                         | MAU/ERU  | RETURN DUCT          | HUMIDITY              | NOTE #3        |
| 15.                         | RTW/RTU/AHU/MAU/<br>KFP/UV/FCU/ERU/ RWC/<br>BCU/VAV TERMINAL UNIT/<br>WSHP | SUPPLY AIR           | TEMPERATURE           | NOTE #3        |
| 16.                         | RTU/AHU/RTW  | RETURN AIR           | TEMPERATURE           | NOTE #3        |
| 17.                         | RTU/AHU/RTW  | MIXED AIR            | TEMPERATURE           | NOTE #3        |
| 18.                         | AHU/RTU  | SUPPLY AIR           | STATIC PRESS          | NOTE #3        |
| 19.                         | RTW/RTU/AHU/MAU/MZU/<br>ERU  | FAN STARTER          | FLOW CONF.            | NOTE #3 18     |
| 20.                         | BOILER ROOM  | PUMPS                | FLOW CONF.            | NOTE #4        |
| 21.                         | RTU/MAU/CT   | FAN STARTER          | FLOW CONF.            | NOTE #3        |
| 22.                         | CT   | PUMP STARTER         | FLOW CONF             | NOTE #3        |
| 23.                         | GYM/CAFETERIA<br>AUDITORIUM /LECTURE                                       | ON WALL              | CO <sub>2</sub> CONC. | NOTE #3,6      |

|     |                              |  |  |            |
|-----|------------------------------|--|--|------------|
| 24. | AHU/ RTU/RTW                 | OUTSIDE AIR                                    | FLOW                                   | NOTE #3    |
| 25. | RTW/RTU/MAU/ERU              | HOT GAS RE-HEAT<br>DISCHARGE AIR               | TEMPERATURE                            | NOTE #3    |
| 26. | RTW/RTU/MAU/ERU              | HOT GAS RE-HEAT COIL                           | PERCENTAGE OF<br>MODULATION CAPABILITY | NOTE #3    |
| 27. | RTW/RTU/MAU/ERU              | EVAPORATOR COIL                                | LEAVING EVAPORATOR<br>COIL TEMPERATURE | NOTE #3    |
| 28. | RTU                          | DUCT HEATER                                    | DISCHARGE AIR<br>TEMPERATURE           | NOTE #3    |
| 29. | RTW/MAU/ERU                  | COMPRESSOR                                     | PERCENTAGE OF<br>MODULATION CAPABILITY | NOTE #3    |
| 30. | RTW/MAU/ERU                  | GAS VALVE                                      | PERCENTAGE OF<br>MODULATION CAPABILITY | NOTE #3    |
| 31. | VRF SYSTEM                   | EACH ROOM                                      | TEMPERATURE                            | NOTE #21   |
| 32. | EBB/EWH,ECH,EDH, PRV,<br>CEF | ON WALL  | TEMPERATURE                            | NOTES#3,22 |
| 33. | COMM ROOM                    | ON WALL  | TEMPERATURE                            | NOTE #8    |
| 34. | WALK-IN-REFRIGERATOR         | ON WALL  | TEMP/ALARM                             | NOTE #9    |
| 35. | WALK-IN-FREEZER              | ON WALL  | TEMP/ALARM                             | NOTE# 10   |
| 36. | CT BASIN                     | TOWER BASIN                                    | TEMP/ALARM                             | NOTE#3,16  |
| 37. | RTW/RTU                      | ON WALL  | HUMIDITY                               | NOTE#3     |
| 38. | AHU                          | RETURN AIR                                     | HUMIDITY                               | NOTE#3     |
| 39. | RTW/AHU/ERU                  | EXHAUST AIR                                    | TEMP.                                  | NOTE#3     |
| 40. | RTW/AHU/ERU                  | ENTHALPY WHEEL<br>DISCHARGE (TWO<br>LOCATIONS) | TEMP.                                  | NOTE#3     |
| 41. | ERU/RTW                      | ENTHALPY WHEEL<br>INLET (TWO<br>LOCATIONS)     | TEMP.                                  | NOTE #3    |
| 42. | HW / CHW SYSTEM              | RECIRCULATING<br>PUMP INLET                    | DIFF PRESS                             | NOTE#16    |
| 43. | VAV TERMINAL UNIT            | IN BOX   | CFM                                    | NOTE#3     |
| 44. | BLDG STATIC PRESS.           |  | STATIC PRESS                           | NOTE #3    |
| 45. | DOMESTIC HOT WATER           | PIPING SYSTEM                                  | TEMP                                   | NOTE #1    |

|     |                          |         |                      |         |
|-----|--------------------------|---------|----------------------|---------|
|     | (TEMPERED AND HOT WATER) |         |                      |         |
| 46. | AT IFID                  | SPARES  | (5% OF TOTAL POINTS) |         |
| 47. | HUMIDIFIER               | ON WALL | HUMIDITY             | NOTE #3 |

**NOTES:**

1. BOILER RM. OR MECHANICAL ROOM SEE PLANS.
2. ONE PER CLASSROOM OR SPACE.
3. ONE PER UNIT.
4. TRANSDUCER – ONE PER PUMP.
5. MOUNT ON SHADED WALL WITH SHIELD.
6. READOUT IN PARTS PER MILLION WITH 4-20 mA SIGNAL.
7. MZU'S SHALL HAVE ONE PER EACH ZONE.
8. SPACE TEMPERATURE MONITOR.
9. ANNUNCIATE A LEVEL 1 ALARM IF TEMPERATURE RISES ABOVE 40°F (ADJ.) FOR MORE THAN 30 MINUTES (ADJ.).
10. ANNUNCIATE A LEVEL 1 ALARM IF TEMPERATURE RISES ABOVE 15°F (ADJ.) FOR MORE THAN 30 MINUTES (ADJ.).
11. PROVIDE THE REQUIRED NUMBER OF INPUTS AND OUTPUTS IN EACH CLASSROOM OR SPACE TO COMPLY WITH THE SEQUENCE OF OPERATION SPECIFIED IN PART 3, EXECUTION, PARAGRAPH 3.04.
12. ALL RELAYS WITH THE EXCEPTIONS OF BOILERS, HOT WATER PUMPS, DOMESTIC HOT WATER PUMPS, AND HEAT TRACE, SHALL BE WIRED NORMALLY OPEN.
13. LOCATE ON SYSTEM SIDE OF 3-WAY VALVE.
14. LOCATE SENSOR 2/3 DISTANCE OF LONGEST DUCT RUN.
15. ANNUNCIATE A LEVEL ONE ALARM IF BASIN TEMPERATURE DROPS BELOW 32DEG F FOR MORE THAN FIFTEEN MINUTES.
16. AS SHOWN ON DRAWINGS.
17. PROVIDE FOR PRIMARY SYSTEM, SECONDARY SYSTEM AND ALL ZONES.
18. ONE PER FAN (SUPPLY, EXHAUST).
19. LOCATE IN THE DISCHARGE OF RECIRCULATING PUMPS.
20. LOCATE IN RETURN TO BOILER ROOM, BEFORE BOILERS OR COOLING TOWER.

21. THROUGH BACnet INTERFACE TO EACH VRF UNIT.
22. FOR PRV AND CEF UNITS LABELLED "SENSOR" ON EQUIPMENT SCHEDULE.

| <b>ACTION ANALOG OUTPUTS</b> | <b>SPACE/EQUIP</b>          | <b>LOCATION</b>        | <b>RESPONSE</b>      | <b>REMARKS</b> |
|------------------------------|-----------------------------|------------------------|----------------------|----------------|
| 1.                           | BOILER ROOM                 | 3 WAY HW VALVE         | MODULATION           | NOTE #1        |
| 2.                           | BOILER SYSTEM CONTROL PANEL | HEATING WATER SETPOINT | MODULATION           | NOTE #1        |
| 3.                           | RTU/AHU/MAU/ERU             | HW VALVE               | MODULATION           | NOTE #1        |
| 4.                           | AHU/MAU/ERU                 | CHW VALVE              | MODULATION           | NOTE #1        |
| 5.                           | FCU/UV/BCU/VAL              | HW VALVE               | MODULATION           | NOTE #1        |
| 6.                           | FCU/UV/BCU/VAL              | CHW VALVE              | MODULATION           | NOTE #1        |
| 7.                           | FTR/ RWC                    | HW VALVE               | MODULATION           | NOTE #1        |
| 8.                           | BOILER ROOM                 | 3 WAY TW VALVE         | MODULATION           | NOTE #1        |
| 9.                           | VAV                         | DAMPER                 | MODULATION           | NOTE #1        |
| 10.                          | RTW/RTU/MAU/AHU/ERU         | O. A. DAMPER           | MODULATION           | NOTE #2        |
| 11.                          | RTW/RTU/MAU                 | RELIEF DAMPER          | MODULATION           | NOTE #2        |
| 12.                          | AHU/RTU                     | VFD                    | MODULATION           | NOTE #1        |
| 13.                          | VAVTU                       | HW VALVE               | MODULATION           | NOTE #1        |
| 14.                          | VFD                         | EF/PUMP/CT FAN/HRW     | MODULATION           | NOTE#1         |
| 15.                          | AHU/ERU                     | OA BYPASS              | MODULATION           | NOTE#1         |
| 16.                          | AHU/ERU                     | EX AIR BYPAS           | MODULATION           | NOTE#1         |
| 17.                          | RTW/RTU/MAU/ERU             | HOT GAS REHEAT VALVE   | MODULATION           | NOTE#1         |
| 18.                          | RTW/RTU/ERU/KFP             | GAS HEAT               | MODULATION           | NOTE#1         |
| 19.                          | RTW/ERU/MAU                 | COMPRESSOR             | MODULATION           | NOTE#1         |
| 20.                          | VRF SYSTEM                  | EACH ROOM              | TEMP SETPOINT        | NOTE #5        |
| 21.                          | ACWC/WCWC                   | CHILLER RETURN TEMP    | RESET                | NOTE#1         |
| 22.                          | AT IFID                     | SPARES                 | (5% OF TOTAL POINTS) |                |

|     |         |  |            |         |
|-----|---------|--|------------|---------|
| 23. | ERU/RTW | ENTHALPHY<br>WHEEL                         | ENABLE     | NOTE #1 |
| 24. | ERU/RTW | ENTHALPY WHEEL<br>SUPPLY FAN<br>RETURN FAN | MODULATION | NOTE #1 |

**NOTES:**

1. ONE PER UNIT AND DEVICE. BOILER ROOM OR MECHANICAL ROOM. SEE DRAWINGS.
2. ONE PER UNIT ECONOMIZE CYCLE.
3. PROVIDE THE REQUIRED NUMBER OF INPUTS AND OUTPUTS IN ECAH CLASSROOM OR SPACE TO COPLY WITH THE SEQUENCE OF OPERATION SPECIFIED IN PART 3, EXECUTION, PARAGRAPH 3.04.
4. ALL RELAYS WITH THE EXCEPTIONS OF BOILERS, HOT WATER PUMPS, AND HEAT TRACE SHALL BE WIRED NORMALLY OPEN.
5. THROUGH BACNet INTERFACE TO EACH VRF UNIT.

| <b>ACTION<br/>DIGITAL<br/>INPUTS</b> | <b>SPACE/EQUIP</b>                                 | <b>LOCATION</b>                         | <b>RESPONSE</b> | <b>REMARKS</b> |
|--------------------------------------|--|---|-----------------|----------------|
| 1.                                   | BOILER ROOM  | BOILERS                                 | STATUS          | NOTE #1        |
| 2.                                   | MAIN IFID  | ZONEOVERRIDE                            | STATUS          | NOTE #3        |
| 3.                                   | MAIN IFID  | BOILERS                                 | ALARM           | NOTE #4,5      |
| 4.                                   | MAIN IFID  | ACWC                                    | ALARM           | NOTE #4        |
| 5.                                   | MAIN IFID  | WCWC                                    | ALARM           | NOTE #4        |
| 6.                                   | MAIN IFID  | CZ                                      | ALARM           | NOTE #3        |
| 7.                                   | UV/FCU/BCU/<br>PRV's/CEF's/<br>ECH/EWH/EBB/<br>EDH | FAN/UNIT                                | STATUS          | NOTE #4        |
| 8.                                   | MAIN IFID  | CHILLER/ACWC/<br>WCWC                   | PUMP<br>REQUEST | NOTE #4        |
| 9.                                   | UTILITY<br>VENTSET                                 | FAN                                     | STATUS          | NOTE #4        |
| 10.                                  | CHILLER  | CHILLER/ACWC/<br>WCWC                   | STATUS          | NOTE#4         |
| 11.                                  | EW/HRW   | HEAT RECOVERY<br>WHEEL MOTION<br>SENSOR | ROTATION        | NOTE#4         |
| 12.                                  | AHU/RTU/MAU/<br>ERU/WSHP                           | HW COIL FZSTAT                          | ALARM           | NOTE#4         |
| 13.                                  | AHU/RTU/MAU/<br>ERU/WSHP/RTW                       | CONDENSATE<br>OVERFLOW<br>SWITCH        | ALARM           | NOTE#4         |
| 14.                                  | CHW PUMP   | SELECTOR<br>SWITCH                      | STATUS          | NOTE#4         |

|     |                                 |   |                         |            |
|-----|---------------------------------|---|-------------------------|------------|
| 15. | TW PUMP                         | SELECTOR SWITCH                           | STATUS                  | NOTE#4     |
| 16. | MAU/<br>ERU/WSHP/<br>BOILERS/CT | SHUT OFF OR<br>BYPASS VALVE<br>END SWITCH | STATUS                  | NOTE#4     |
| 17. | RTU/MAU/ERU                     | COMPRESSOR                                | STATUS                  | NOTE #8    |
| 18. | KW                              | ELEC. METER<br>SWITCHEGER                 | PULSE                   | NOTE#4     |
| 19. | DOMESTIC<br>RECIRC PUMP         | PUMP                                      | STATUS                  | NOTE#4     |
| 20. | VRF SYSTEM                      | SYSTEM                                    | ON/OFF<br>STATUS        | NOTE#9     |
| 21. | VRF SYSTEM                      | SYSTEM                                    | MODE STATE              | NOTE#9     |
| 22. | VRF SYSTEM                      | SYSTEM                                    | FAN SPEED<br>STATE      | NOTE#9     |
| 23. | VRF SYSTEM                      | SYSTEM                                    | AIR DIRECTION<br>STATE  | NOTE#9     |
| 24. | VRF SYSTEM                      | SYSTEM                                    | ALARM SIGNAL            | NOTE#9     |
| 25. | VRF SYSTEM                      | SYSTEM                                    | HIGH ROOM<br>TEMP ALARM | NOTE#9     |
| 26. | VRF SYSTEM                      | SYSTEM                                    | LOW ROM<br>TEMP ALARM   | NOTE#9     |
| 27. | VRF SYSTEM                      | SYSTEM                                    | ERROR CODE              | NOTE#9     |
| 28. | AT IFID                         | SPARES                                    | (5% OF TOTAL<br>POINTS) |            |
| 29. | VRF SYSTEM                      | SYSTEM                                    | ALARM                   | NOTE #10   |
| 30. | VRF SYSTEM                      | COND. UNIT                                | ALARM                   | NOTE #4, 5 |



**NOTES:**

1. ONE PER UNIT, BURNER STATUS ON/OFF. BOILER ROOM OR MECHANICAL ROOM. SEE PLANS.
2. ONE PER IFID.
3. ONE PER CONTROL ZONE.
4. ONE PER UNIT.
5. ANY ALARM.
6. PROVIDE THE REQUIRED NUMBER OF INPUTS AND OUTPUTS IN EACH CLASSROOM OR SPACE TO COMPLY WITH THE SEQUENCE OF OPERATION SPECIFIED IN PART 3, EXECUTION, PARAGRAPH 3.04.
7. ALL RELAYS WITH THE EXCEPTIONS OF BOILERS, HOT WATER PUMPS, AND HEAT TRACE SHALL BE WIRED NORMALLY OPEN.
8. ONE PER COMPRESSOR. FOR UNITS WITH MULTIPLE COMPRESSORS.
9. THROUGH BACnet INTERFACE TO EACH VRF UNIT.
10. DIGITAL INPUT TO FIRE ALARM SYSTEM TO SHUT DOWN ERU AND ASSOCIATED VRF UNITS.

| <b>ACTION<br/>DIGITAL<br/>OUTPUTS</b> | <b>SPACE/EQUIP</b>          | <b>LOCATION</b>                  | <b>RESPONSE</b> | <b>REMARKS</b>  |
|---------------------------------------|-----------------------------|----------------------------------|-----------------|-----------------|
| 1.                                    | BOILER                      | PUMPS                            | STOP/START      | NOTE #1         |
| 2.                                    | ACWC                        | UNIT                             | STOP/START      | NOTE #1         |
| 3.                                    | WCWC                        | UNIT                             | STOP/START      | NOTE #1         |
| 4.                                    | CT                          | FAN                              | STOP/START      | NOTE #1         |
| 5.                                    | CT                          | SPRAY PUMP                       | STOP/START      | NOTE #1         |
| 6.                                    | CT                          | DAMPER                           | STOP/START      | NOTE #1         |
| 7.                                    | RTU/AHU/MAU/<br>ERU/KFP/RTW | FANS: SUPPLY /RETURN<br>/EXHAUST | STOP/START      | NOTES<br>#1,4,5 |
| 8.                                    | WSHP/MAU/ERU                | SHUT OFF or BYPASS<br>VALVE      | OPEN/CLOSE      | NOTE #1         |
| 9.                                    | BOILERS/CT                  | BYPASS VALVE                     | OPEN/CLOSE      | NOTE #1         |
| 10.                                   | CZ                          | PRV/UVS/EF                       | STOP/START      | NOTE #2, 6      |
| 11.                                   | CZ                          | FCU/TWU                          | STOP/START      | NOTES #2,4      |
| 12.                                   | CZ                          | UV                               | STOP/START      | NOTES #2,4      |
| 13.                                   | CZ                          | FAN                              | STOP/START      | NOTE #2         |
| 14.                                   | ECH,<br>EDH/EBB/EWH/<br>EUH | UNIT                             | STOP/START      | NOTE#1          |
| 15.                                   | RTU/RTW/ERU                 | HEAT                             | CYCLE           | NOTE #3,11      |
| 16.                                   | RTU/RTW/ERU                 | COOL                             | CYCLE           | NOTE #3,11      |
| 17.                                   | CU                          | COOL                             | CYCLE           | NOTE #3,11      |
| 18.                                   | RTU/AHU/MAU/<br>ERU/RTW     | O. A. DAMPER                     | OPEN/CLOSE      | NOTE #1         |
| 19.                                   | RTU/AHU/MAU/<br>ERU/RTW     | O. A. DAMPER                     | LOCKOUT         | NOTE #1         |
| 20.                                   | EUH, ECH, EWH,<br>EDH/EBB   | UNIT                             | LOCKOUT         | NOTE #1         |

|     |                         |                        |                                     |          |
|-----|-------------------------|------------------------|-------------------------------------|----------|
| 21. | RTU/AHU/MAU/<br>ERU/RTW | RELIEF AIR VENT        | OPEN/CLOSE                          | NOTE #1  |
| 22. | ACWC/CT                 | HEAT TRACE             | ON/OFF                              |          |
| 23. | HRW                     | HEAT RECOVERY<br>WHEEL | ON/OFF                              | NOTE#1   |
| 24. | HEX                     | 3-WAY HEX VALVE        | OPEN/CLOSE                          | NOTE#1   |
| 25. | AT IFID                 | SPARES                 | SECURITY<br>ALARM                   | NOTE#7   |
| 26. | DOMESTIC<br>RECRIC.PUMP | PUMP                   | STOP/START                          | NOTE#1   |
| 27. | VRF SYSTEM              | SYSTEM                 | ON/OFF                              | NOTE#10  |
| 28. | VRF SYSTEM              | SYSTEM                 | SET MODE                            | NOTE#10  |
| 29. | VRF SYSTEM              | SYSTEM                 | PROHIBIT<br>ON/OFF AT RM<br>CONTROL | NOTE#10  |
| 30. | VRF SYSTEM              | SYSTEM                 | PROHIBIT<br>MODE AT RM<br>CONTROL   | NOTE#10  |
| 31. | AT IFID                 | SPARES                 | (5% OF TOTAL<br>POINTS)             |          |
| 32. | HUMIDIFIER              | UNIT                   | STOP/START                          | NOTE #1  |
| 33. | VRF SYSTEM              | UNIT                   | SHUTDOWN                            | NOTE #13 |

**NOTES:**

- ONE PER UNIT. BOILER ROOM OR MECHANICAL ROOM. SEE PLANS.
- EQUIPMENT WITHIN ZONE PER ZONE.
- PROVIDE A DIGITAL OUTPUT POINT FOR EACH HEATING AND COOLING STAGE. CONNECT TO FACTORY BUILT-IN CONTROLS.
- RTU/AHU FAN LOCKOUT BY SMOKE DETECTOR SHALL BE INDEPENDENT OF IFID CONTROL.
- PROVIDE THREE DIGITAL OUTPUT POINTS FOR SECURITY. (SECURITY 1 – COMM RM; SECURITY 2 – ALARM FOR WALK-IN FREEZER; SECURITY 3- ALARM FOR WALK-IN REFRIGERATOR)

6. PROVIDE THE REQUIRED NUMBER OF INPUTS AND OUTPUTS IN EACH CLASSROOM OR SPACE TO COMPLY WITH THE SEQUENCE OF OPERATION SPECIFIED IN PART 3, EXECUTION, PARAGRAPH 3.04.
  7. ALL RELAYS WITH THE EXCEPTIONS OF BOILERS, HOT WATER PUMPS, DOMESTIC HOT WATER PUMPS, AND HEAT TRACE, SHALL BE WIRED NORMALLY OPEN.
  8. THROUGH BACnet INTERFACE TO EACH VRF UNIT.
  9. PROVIDE A DIGITAL OUTPUT POINT FOR EACH HEATING STAGE.
  10. FOR EACH UNIT CONTROLLED BY A SPACE SENSOR.
  11. SHUT DOWN UPON FIRE ALARM ACTIVATION.
- B. For renovation projects Existing equipment - Shall be replaced and in first class operating condition to function as outlined below. Refer to drawings for mechanical equipment to remain.
- C. Boiler-Burner Unit - The boiler with burners shall be manually selected for operation and shall remain in constant operation during the heating season. Burner shall cycle to maintain water temperature setting of the built-in aquastat. The system hot water supply temperature shall be controlled by the boiler by-pass three-way valve. Valve shall be modulated by the local indoor/outdoor controller with 1 1/2 to 1 reset ratio. Controller shall reset the supply water temperature in response to changes in outside temperatures at 20°F outside = 180°F Boiler Water.
- D. Hot Water Heating Zone Control
1. Pump shall be controlled through the time clock function and energized when the outside air temperature drops below 62°F through the central control panel. The outside air sensor bulb shall be on a shaded wall, insulating mounting and shall be protected by a sunshield. The outside air sensor shall be wired directly to the master controller or the heating controller.
  2. Time Clock Operation
    - a. Day or Occupied Clock Position - Heating pump or pumps shall be energized and operate constantly.
    - b. Night or Unoccupied Clock Position - Heating pump shall be de-energized.

- c. In the night position, when any sensor falls below its setting of 55°F, it shall override the time clock function and return the heating pump to operation until the sensor setting is satisfied.
    - d. All hot water valves shall reference the associated heating water pump run status and shall be enabled when pump status is active. All hot water valves shall remain disabled when associated heating water pump status is not active.
  3. Freeze Protection unoccupied mode
    - a. If the outside air temperature falls below 40Deg F the heating pump shall energize to circulate heating water throughout the building. Roof top air handling equipment heating valves shall cycle to maintain a mixed air temperature of 45 Deg F (adj), the fans shall remain off with the outside air dampers closed.
    - b. On a continued fall of the outside air temperature to at or below 20 Deg F a programmed override shall run the building in the day heating mode with all outside air dampers closed. Make up air units shall remain off.
  4. Manual Operation - Timer override switches, one for each building control zone, shall be indexed to move the heat pump or pumps to day operation. This position shall override the time clock.
  5. Space temperature controls shall operate while pump is running.
  6. System Failures:
    - a. Upon loss of communication associated equipment shall maintain space temperature.
    - b. Should any type of hot water system failure occur (i.e. boilers, pumps, hot water reset) all outside air dampers shall close, all exhaust fans, PRV's and 100% Outside Air units shall turn off.
    - c. When any unit is off, all spring return chill water valve and outside air damper actuators shall fail closed, all hot water valve actuators shall fail open via a hard wired interlock thru the supply fan auxiliary contacts. All hot water valve actuators for rooftop air handling units shall remain active to maintain a mixed air temperature of 45\* (adj.) when the outside air temperature is at or below 40\* deg F.

The time delay for pump changeover shall be one minute.

7. The two primary pumps shall operate utilizing a lead/lag strategy. The lead pump shall run first. On failure of the lead pump, the lag pump shall run and the lead pump shall remain active. For systems equipped with VFD's On decreasing differential pressure, the lag pump shall stage on and run in unison with the lead pump to maintain differential pressure setpoint. The Fail Safe of the VFD driven hot water pumps shall be accomplished by wiring the Stop / Start relay normally closed. The signal shall be from 0 volt to 10 volts with 0 volt equals pump minimum speed (Adj.). The designated lead pump shall rotate upon one of the following conditions: manually through a software switch, if pump runtime is exceeded, daily, weekly, monthly.
8. Central Hot Water Heating System

(to be used for atmospheric modular boilers, engineer to edit)

- a. General: BAS shall control the Central Hot Water Heating System including boilers, boiler primary pumps, secondary hot water pumps and secondary pump VFDs, as well as provide monitoring and diagnostic information for management purposes.

- b. Heating Enable:

- 1) The heating shall enable when:

- a) The outside air temperature is below the Heat Lockout setpoint of 62°F (adj.) AND when any heating request is received from any zone served by the central HW heating system continuously for 5 min. (adj.)
- b) Anytime the outside air temperature is below the continuous run setpoint of 40°F (adj).
- c) Whenever manually enabled by the operator locally via a graphic icon. The graphic icon shall also be capable of Overriding the System Off.

- 2) The Heating System shall be disabled when:

- a) All the zones served by the Heating System have shut down as scheduled AND the OA temp is above the continuous run OA setpoint plus 2°F.
- b) The outside air rises above the OA Heat Lockout setpoint plus 2°F.

- 3) Secondary Heating Water (Building Loop) Pump Control

- a) The lead secondary hot water pump shall start and run continuously when heating is enabled.
  - b) BAS shall prove operation of the lead secondary hot water pump via a current transducer. If, after 30 seconds, the pump fails to start or fails at any time thereafter, the BAS shall generate an alarm and start the lag pump. The request for the failed pump shall stay active. The pump shall be considered failed when the signal from the current transducer reading the pump amps is less than 50% of the signal when the pump is running at minimum speed. The pump shall also be considered failed if the system differential pressure signal is 25% below the signal at setpoint for more than 30 minutes in which case the lag pump shall start while the lead pump signal remains active.
  - c) The lead pump shall continue to run for 15 min. (adj.) after the heating system has been disabled. The pumps shall remain off for at least three minutes before being allowed to restart.
  - d) The lead/lag pump sequence shall rotate weekly.
  - e) For pumps with variable frequency drives (VFDs), the BAS shall receive a system differential pressure signal from a pressure transducer located as shown on the drawings, if not indicated on the drawings; locate approximately 75% to the farthest point in the system from the pump. The BAS shall modulate the operating pump speed signal to maintain the differential setpoint (adjustable). A separate output start/stop and speed signal from the BAS shall be provided for each pump VFD. A VFD minimum speed of 20 Hz. shall be programmed in to each VFD.
- 4) Secondary Hot Water Supply Temperature (building loop) setpoint Control
- a) The secondary hot water supply temperature setpoint shall be reset based on outdoor air temperature with all values being adjustable from the graphic. The setpoint shall be reset from 135°F to 180 ° F as the O/A temperature falls from 60°F to 20°F or below.

- 5) Boiler Burner Temperature Control
  - a) The BAS shall only enable and disable a boiler to run. When a boiler is enabled the boiler shall run on internal controls to maintain its operating temperature of 180°F.
- 6) Boiler Enable and Rotation Sequence
  - a) Boilers Enable: When the Central Heating System is Enabled the BAS shall sequence the boilers on and off to maintain the secondary hot water temperature setpoint as follows:
    - (1) If the Secondary Hot Water temperature is at least 2 degrees F (Adjustable) below the secondary hot water supply temperature setpoint, enable the lead boiler primary pump, confirm pump flow via a current switch input to the BAS, after a 30 second delay, enable the lead boiler. Once the lead boiler is enabled, it shall remain enabled for at least 30 minutes to prevent short cycling.
    - (2) If after a five minute delay from the time the lead boiler is enabled the Secondary Hot Water Supply temperature is at least 2 degrees F below the secondary hot water supply temperature setpoint continuously for five minutes, enable the second boiler primary pump, confirm pump flow via a current switch input to the BAS, after a 30 second delay, enable the second boiler. Once the second boiler is enabled, it shall remain enabled for at least 15 minutes to prevent short cycling.
    - (3) Continue to add additional boilers in the same manner.
  - b) Boilers Disable:
    - (1) If the Secondary Hot Water Supply temperature is at least 2 degrees F above the secondary hot water supply temperature setpoint continuously for at least 15 minutes, disable the last boiler that was



enabled (unless that boiler is in its minimum run time delay in which case it shall continue to run until the delay expires), after a 5 minute delay, disable the boiler's primary pump. Once a boiler is disabled, it shall remain disabled for at least 15 minutes to prevent short cycling.

- (2) If after a five minute delay, the Secondary Hot Water Supply temperature remains at least 2 degree F above the secondary hot water supply temperature setpoint continuously for at least 15 minutes, disable the second to last boiler that was enabled (unless that boiler is in its minimum run time delay in which case it shall continue to run until the delay expires), after a 5 minute delay, disable the primary pump. Once a boiler is disabled, it shall remain disabled for at least 15 minutes to prevent short cycling.
- (3) Continue to disable boilers in the same manner until all boilers including the lead boiler are disabled.

c) Boiler Rotation:

- (1) The BAS shall rotate the lead boiler every 24 hours. Each boiler shall be in the rotation.
- (2) The lead boiler rotation shall take place only when the plant is disabled and only if all boilers are disabled. Should the plant be enabled for more than 24 hours continuously, the lead rotation shall be delayed until the next time the plant is disabled. Additional boilers shall stage on in numerical order starting from the lead boiler.

7) Boiler and Primary Pump Alarm

- a) The BAS shall monitor the boiler alarm point from each boiler burner control and if active, generate a "Boiler #X Failure" alarm. Should a boiler alarm point be active, the BAS shall continue to keep the signal to the boiler enabled (no lock-out) and continue through the enable/ disable sequence.

- b) Should a boiler primary pump fail to start or fails while running, the BAS shall continue to keep the signal to the pump enabled (no lock-out) but shall disable the boiler and continue through the enable/disable sequence. Should the failed pump start while the BAS is attempting to enable the boiler, then the boiler shall be allowed to start.
- 8) Boiler Plant monitoring and alarming
- a) Each boiler shall have a boiler supply/discharge temperature sensor which shall be displayed on the graphic for monitoring purposes. The sensors shall be located between the boiler and the connection to the primary loop as close to the boiler as practical.
  - b) The secondary hot water supply (building loop) shall have temperature sensor located downstream of the last boiler connection which shall be displayed on the graphic. Should the secondary hot water supply temperature be below the secondary hot water supply temperature setpoint by 10 degrees continuously for more than 30 minutes while the plant is enabled, then activate an alarm.
  - c) The secondary hot water return (building loop) shall have a temperature sensor located upstream of the first boiler connection which shall be displayed on the graphic for monitoring purposes.
- 9) General
- a) All points, and commands for the Central Hot Water system shall be displayed on the graphic.
  - b) All points, and commands for the Central Hot Water system shall be trended by the BAS. Digital points shall be set up to trend on a change of state. Analog points shall trend every 10 minutes.
  - c) Failsafe wiring: All primary pumps, secondary pump VFDs and boiler enable points shall be controlled using normally closed contacts so that a failure of the controller will enable the pumps and boilers. Control relays coils shall be energized to disable equipment and de-energized to enable equipment.

## E. Heat Pump Water System Controls

1. General: BAS shall control the heat pump water system and equipment and provide monitoring and diagnostic information for management purposes.
2. Cooling/Heating Modes: Cooling mode and heating mode shall be determined by the BAS based on outside air temperature and HPW temperatures as defined below:
  - a. Heat Mode Shall Be Enabled When: Outside air temperature falls below 60°F (adj.) or HPWR temperature falls to within 5°F (adj.) of the boiler HPWS setpoint (60°F, adj.).
  - b. Cool Mode Shall Be Enabled When: Outside air temperature rises above 65°F (adj.) or HPWS temperature rises to within 5°F (adj.) of the cooling tower HPWS setpoint (90°F, adj.).
3. HPW Pump Control: BAS Shall Control the Pumps as Follows:
  - a. Start/Stop: Lead pump shall run continuously during occupied, during unoccupied when setback setpoints are exceeded and during freeze protection mode. Lead pump designation shall be rotated by the BAS on a weekly basis.
  - b. Proof: BAS Shall prove pump operation and use the status indication to accumulate runtime. Upon failure of the lead pump, BAS shall enunciate an alarm and enable the standby pump.
  - c. VFD Control: BAS shall control the output of the active pump VFD per a Ra Pid Loop to maintain the lowest of two HPW remote differential pressure (RDP) sensors at setpoint (determined by TAB; initially 10 Psid). On start and stop, the VFD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. Boiler Control and Staging: When Heat Mode Is Active, as Defined Above:
  - a. BAS shall command boiler isolation valve open to the boilers and prove open valve status.
  - b. BAS shall then enable the Boiler Management System.
  - c. The Boiler Management System, by others, shall sequence the boilers as required to maintain the temperature at an adjustable setpoint.

- d. BAS shall send adjustable boiler setpoint signal (initially 60°F) to the Boiler Management System. BAS contractor shall be responsible for coordinating point configuration with Boiler Management System supplier.
5. Cooling Tower Control: When Cool Mode Is Active, as Defined Above:
    - a. BAS shall command cooling tower isolation valve open to the tower and prove open valve status.
    - b. BAS shall start cooling tower spray pump and prove status.
    - c. BAS shall enable tower fan when cooling is enabled, spray pump status is proven, and HPWS temperature rises above cooling HPWS setpoint with a 3°F (adj.) cycle differential.
    - d. BAS shall prove tower fan operation and use the status indication to accumulate runtime.
    - e. Whenever the tower fan is enabled, BAS shall control the output of the fan VFD per a DA PID loop to maintain heat pump water supply temperature cooling setpoint of 90°F (adj.). On start and stop, the VFD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
  6. Tower Freeze Protection:
    - a. When outside air temperature falls below 35°F (adj.), BAS shall command cooling tower isolation valve open to the tower regardless of the active system mode. Dampers on the tower shall be closed. Heat pump water pump shall be energized.
    - b. When outside air temperature falls below 35°F (adj.), BAS shall enable the tower heat tracing and basin heater.
- F. Classroom Water Source Heat Pumps
1. The unit shall be controlled by a field mounted DDC controller and room thermostat furnished and installed by the controls contractor. Unit shall be started and stopped by a time schedule in the DDC controller. Any unit manufacturer device that is furnished with a factory DDC controller shall use appropriate protocol to provide seamless integration and control from the BMS.

Individual heat pumps shall monitor the status of the heat pump water pump. Individual heat pumps shall not be indexed to run unless the heat pump water pump is running.

2. Occupied Cycle: When indexed to the occupied mode by the DDC system, the unit fan shall run continuously. A heat pump compressor fan off delay shall provide a programmable delay which must time out after the heat pump's compressor turns off before the fan is shut off. The reversing valve transition point shall be halfway between the occupied heating setpoint and the occupied cooling setpoint. When the space temperature is above the reversing valve transition point, the reversing valve shall be in the cooling position. When the space temperature is below the reversing valve transition point, the reversing valve shall be in the heating position.
3. Occupied Heating Cycle: The heat pump's compressor(s) shall be off between the adjustable heating and cooling setpoints. As the space temperature falls below the heating setpoint, the DDC system shall open the two position isolation valve. Once the valve is proven open (via the endswitch), then the DDC shall place the reversing valve in the heating position and energize the required number of stages of mechanical heating to satisfy the space temperature set point. The compressor's on and off times shall vary depending on the difference between the space temperature and the heating setpoint. The heat pump compressor's cycle time shall be subject to minimum on and off times (adj.) to prevent short cycling of the compressor when the space temperature is slightly below the heating setpoint.
4. Occupied Cooling Cycle: The heat pump's compressor(s) shall be off between the adjustable heating and cooling setpoints. As the space temperature rises above the cooling setpoint, then the DDC system shall open the two position isolation valve. Once the valve is proven open (via the endswitch), then the DDC shall place the reversing valve in the cooling position and energize the required number of stages of mechanical cooling to satisfy the space temperature set point. The heat pump compressor's cycle time shall be subject to minimum on and off times (adj.) to prevent short cycling of the compressor when the space temperature is slightly above the cooling setpoint.
5. Unoccupied Cycle: The fan shall cycle with a call for heating or cooling during the unoccupied cycle. The fan off delay shall be in effect during the unoccupied cycle. The heat pump compressor shall turn on, with its changeover valve in the heating position, and the fan shall start whenever the space temperature falls below the unoccupied heating setpoint. Likewise, the heat pump compressor shall turn on, with its changeover valve in the cooling position, and the fan shall start whenever the space temperature rises above the unoccupied cooling setpoint.
6. Morning Warmup/Cooldown: The DDC system shall determine the optimum morning warmup or cooldown start. During the morning warmup/cooldown, the individual heat pump units shall be energized as

required to reach the occupied space temperature setpoint prior to being indexed to the occupied mode. During this time, the reversing valve shall be placed in the appropriate position, and the two position outside air damper shall be closed. If the space is out of temperature range (i.e., above cooling space temperature setpoint, or below heating space temperature setpoint), then the isolation valve shall be opened and the compressor commanded to run. The DDC system shall determine if the first or second stage of compressor operation is required to reach space temperature setpoint. Once the majority of spaces within the zone are within temperature setpoint, then the zone shall be commanded to operate under the occupied mode and the respective ventilation air rooftop heat pump unit shall be commanded to run.

7. Safeties: Upon sensing a no air or water flow condition after a command to start the fan, the DDC system shall turn the heat pump compressor off and the fan off. Upon sensing a change of state in the heat pump common alarm contact, the DDC system shall turn the fan and the heat pump compressor off. Upon sensing a low return water temperature below 34DEG F (adj.), the DDC system shall function to shut down the heat pump's compressor and fan. The heat pump compressor shall be able to be locked out through the use of Heating, Cooling and Compressor Lockout Interlocks which will be functional in both the occupied and unoccupied modes. The heat pump manufacturer provided microprocessor based controls shall retain the alarm code through the LED light display.
  - a. Condensate Overflow Switch: A condensate overflow switch shall be installed in the drain pan by the unit manufacturer. The condensate overflow switch shall lock out the compressors under an "alarm" condition. The DDC system shall monitor the condensate overflow alarm and indicate an alarm condition on the graphics page for each unit.
8. A supply air temperature sensor shall be provided for use in verifying compressor and reversing valve operation. A current switch shall be furnished and installed to monitor and verify fan operation.
9. Each heat pump unit shall have a 2-way normally closed ball valve, as further defined herein, to shut down water flow to the unit whenever the compressor is off. The DDC system shall control the 2-position valves, via a separate Digital Output point, to open whenever the compressor runs and close whenever the compressor is off. An end switch shall verify actuator position. The DDC system shall not turn the compressor on until the end switch proves the valve open. An alarm shall be generated if the end switch fails to prove the valve position command.
10. In addition, when the VFDs for the system loop are at minimum speed and on a rise in the remote system differential pressure above normal

setpoint, the DDC system shall then sequence open the control valves on these units, regardless if the compressors are indexed to operate or not, in order to maintain system set point and maintain minimal system water flow.

11. Each heat pump unit shall have a motor operated 2-position volume control damper installed in the outside air ductwork to the unit. This damper shall be operated by the DDC system and be controlled via the respective occupied/unoccupied signal. When the zone is occupied the damper shall be open, when the zone is un-occupied the damper shall be closed. The damper shall remain closed under any unoccupied cycle override. The control damper shall be positioned by the balancing subcontractor to provide minimum airflow rates as listed on the schedule when opened during normal occupied mode.

G. Variable Refrigerant Flow System

1. On/Off Control: the indoor units shall be commanded ON/OFF by the BAS. If all indoor units are off, the outdoor unit shall turn off. With the Night Setback Function/Mode, the system shall cycle on during unoccupied periods as needed to maintain unoccupied temperature setpoint of 55F (adjustable).
2. Space Temperature Control: the indoor unit shall modulate its internal linear expansion valve (LEV) to maintain the temperature setpoint via the indoor unit's internal controls.
  - a. The setpoint is provided and adjustable through the BAS interface.
  - b. The temperature setpoint provided through the BAS interface shall additionally be adjustable to a maximum of  $\pm 2F$  from that setpoint using the room controller.
3. Mode Control
  - a. Auto Mode:
    - 1) The indoor unit shall determine whether it should be in auto-heat mode or auto-cool mode based on space temperature relative to temperature setpoint. If the indoor unit is in auto-heat mode, the indoor unit control board shall follow the heat mode sequence. If the indoor unit is in auto-cool mode, the indoor unit control board shall follow the cool mode sequence.
    - 2) The indoor unit shall switch from auto-heat to auto-cool when the space temperature rises above and remains

above the temperature setpoint plus the dead band for 3 minutes.

3) The indoor unit will switch from auto-cool to auto-heat when the space temperature drops below and remains below the temperature setpoint minus the dead band for 3 minutes.

b. Heating Mode: the indoor unit shall modulate its linear expansion valve (LEV) to maintain temperature setpoint of 71F (adjustable).

c. Cooling Mode: the indoor unit shall modulate its linear expansion valve (LEV) to maintain temperature setpoint of 74F (adjustable).

#### H. Water Chillers - Air Cooled

1. When a request for cooling requires the chiller to start, the following sequence shall occur:

a. Command the chiller to start under its own control.

b. Start CHWP based on chiller pump request. Verify CHWP pump is operating (prove operation).

c. Monitor chiller status and prove operation. If status is not indicated within 15 minutes (ADJ.) of a command to start, enunciate an alarm.

2. The chiller shall be hard wired interlocked with its chilled water pump and with a flow sensor so it cannot operate unless the pump is in operation and a flow sensor switch proves water flow in the chilled water line.

3. With the chilled water flow proved the compressors shall be cycled on and off and loaded and unloaded by a built-in return water thermostat either with multiple stages or controlling a step controller through the required number of stages of control or an approved factory controlled method.

4. Chiller control and crankcase heater circuit and electric heat tracing circuit shall remain on constantly during all seasons. Heat tracing circuit shall be cycled off during mild weather by outside air sensor sensing outside air temperature.

5. This contractor shall interface with the chiller supplied network interface card. The points listed in the input/output summaries as well as those listed below shall be the minimum acceptable.

a. Chilled water pump request.



- b. Chilled water setpoint.
  - c. Chiller enable/disable.
  - d. Chiller current draw.
  - e. Entering water temperature.
  - f. Leaving water temperature.
  - g. Compressor starts.
  - h. Compressor run time.
  - i. Alarm.
  - j. Present operating mode.
- I. Chilled Water Cooling Zone Control
- 1. Zone shall be controlled though the time clock function and when the outside air temperature rises to 50°F and a call for cooling is present through the central control panel.
  - 2. In the day occupied mode In addition to the outside air sensor, if any four rooms on the chilled water system call for cooling, for fifteen minutes or more it shall over ride the outside air sensor and allow the cooling to operate below 50°F.
  - 3. Time Clock Operation
    - a. Day or Occupied Clock Position - Cooling pump or pumps shall operate when requested by the chiller.
    - b. Night or Unoccupied Clock Position - Cooling pump or pumps shall be de-energized.
    - c. In the night position, when any four sensors rise above its setting of 85°F, it shall override the time clock function and return the chiller and cooling pump to operation until the sensor setting is satisfied.
    - d. All chilled water valves shall remain inactive when the associated chilled water pumps are not enabled.

4. Manual Operation - Timer override switches one for each building control zone, shall enable chiller and chilled water pumps for day operation. This position shall override the time clock.
  5. Space temperature controls shall operate while the pump is running.
  6. The two primary pumps shall operate utilizing a lead/lag strategy. The lead pump shall run first. On failure of the lead pump, the lag pump shall run and the lead pump shall remain active. For systems equipped with VFD's On decreasing differential pressure, the lag pump shall stage on and run in unison with the lead pump to maintain differential pressure setpoint. The designated lead pump shall rotate upon one of the following conditions: manually through a software switch, if pump runtime is exceeded, daily, weekly, monthly. Pumps shall stop only after the chiller has been disabled and shall have an adjustable delay on stop feature which will allow for the orderly shutdown of the chilled water system.
- J. Unit Ventilators and Fan Coil Units without outside air – 4 Pipe
1. With respective system pumps in occupied operation the combination heating-cooling room control shall modulate space located controls as described below. Each unit shall have a complete set of control components (see item 6 below).
  2. Heating
    - a. Control shall modulate fan coil unit or unit ventilator hot water valve to maintain its setting (71°F). Unit's fan shall operate constantly during the occupied heating mode.
    - b. During clock unoccupied position, heating pump shall be de-energized. When the reduced setting night control returns the pump to operation, the equipment shall operate as described above until the night setting (55°F) is satisfied.
  3. Cooling
    - a. Fan coil unit or unit ventilator fans shall operate constantly during the occupied cooling mode. Heating-cooling room control shall modulate unit chilled water valve to maintain its setting (74°F).
    - b. During clock unoccupied position, the chiller and cooling pump shall be de-energized. When the increased night setting control returns the chiller and cooling pump to operation, the equipment shall operate as described above until the night setting of 85°F is satisfied.

4. Provide zone warm-up cycle with setpoint (68°F).
5. During clock unoccupied position, during morning warm-up and when unit fan is turned off the respective make-up air unit shall be de-energized.
6. Rooms shown with two units shall have control components of both units controlled by one room control, except classrooms with folding partitions shall have individual controls for each unit.

K. Split System - AHU/CU

1. Heating - With heating pump in constant occupied operation through time clock function and outside air sensor, space shall be controlled as described below.
2. Heating/Cooling - With Air Handling Unit Fan in constant occupied operation. Room control located as shown shall cycle compressors and heating valve to maintain their settings, heating 71°F - cooling 74°F. Compressors shall be hardwired interlocked with the air-handling unit so they cannot be energized unless the fan is in operation. When air handling unit starts, two position spring return outside air damper shall open. When unit is de-energized outside air damper shall be closed.
3. Heating Setback - During clock unoccupied position, heating pump shall be de-energized. When the reduced setting night control returns the pump to operation the equipment shall operate as described above until the night setting (55°F) is satisfied. O.A. dampers shall be closed.
4. Cooling Setback – During clock unoccupied position, provide cooling night control set at 85°F, to cycle cooling to maintain setting, with O.A. damper closed.
5. Provide morning warm-up cycle with O.A. damper closed and setpoint (68°F). The morning warm –up sensor shall be located in the space served.

L. Variable Air Volume Rooftop Units

1. General - The rooftop unit shall be controlled through its factory controls via interface and the timing function by the central control panels operating program reacting to space and system temperature and static pressure conditions.
2. Fan
  - a. When the IFID timing function energizes the system the supply fan shall run constantly. The modulating low leakage outside air damper shall be internally interlocked with the fan to open to its

- minimum position with the return air damper closing a corresponding amount.
- b. The RTU controller will modulate the fan speed by an output signal to the supply VFD to maintain the setpoint of the duct mounted static pressure sensor.
  - c. The Ventilation Control Module shall be linked to the air handling unit microprocessor-based controller. Using a velocity pressure sensing ring, the ventilation control module shall monitor and control the quantity of fresh air entering the unit. The building automation system shall send the CFM set point to the unit and shall then monitor that setpoint to ensure that it is maintained.
  - d. The fresh outdoor air shall enter the air handling unit through the air flow monitor station/damper sensor assembly and shall be measured by velocity pressure flow rings. The velocity pressure flow rings shall be connected to a pressure transducer/solenoid assembly. The ventilation control module shall utilize the velocity pressure input, the outdoor air temperature input, and the minimum outdoor CFM setpoint to modify the volume (CFM) of fresh air entering the unit as the measured airflow deviates from setpoint.
3. Occupied Operation - Warm-Up
- a. When the unit is initially energized and controlled by the timed start/stop function the fan shall be energized and the control system shall be activated to the warm up mode.
  - b. During the warm up mode the static pressure control system shall be activated, the remaining controls shall remain in their respective night positions with O. A. damper closed and the space VAV boxes shall be held open. The VAV box reheat shall be disabled during periods of morning warm up. The system shall remain in the warm up mode until the return air rises above 68°F if after a one hour time period the warm up sensor has not reached 68DEG F the outside air damper will be indexed to the occupied position. The Warm up temperature sensor shall be located in return air duct at the unit.
4. Occupied Operation - Cooling
- a. When the warm up mode ends the outside air dampers shall open to their adjustable minimum positions with the return air damper closing a corresponding amount. If the outside air enthalpy is less than the return air enthalpy the discharge temperature sensor shall cause modulation of the outside and return air dampers to

maintain its setting. If the outside air enthalpy is greater than the return air enthalpy the dampers shall remain in their minimum positions. Power exhaust fans/relief dampers shall be energized/modulate when outside air damper exceeds 50% open or the respective building static pressure controller exceeds its setting (adj) When the unit is de-energized the outside air damper and relief damper shall close.

- b. In addition to the dampers the discharge air temperature sensor signals shall cause modulation of the cooling and heating system to maintain its setting. Compressors and heating section shall be hardwired interlocked internally so that they cannot operate unless the unit fan is running. The discharge air temperature sensor shall also act as a low limit control. The sensor shall be located per the manufactures recommendation. The setting of the discharge air temperature sensor shall be reset through the factory electronic control system by field-supplied controls.
  - c. The unit shall be capable of Discharge Temperature Control and the discharge temperature shall be reset from 55 degrees to 65 degrees as the return air temperature falls from 78 degrees to 74 degrees with all values being adjustable. When the unit is energized for setback heating during the unoccupied period, the discharge setpoint shall be 75 degrees. When the unit is energized for morning cool-down, night purge or setback cooling, the discharge setpoint shall be the warmest zone temperature minus 15 degrees.
5. Unoccupied Operation - When the unit is de-energized the controls shall assume their night position. The supply air fan shall be de-energized; the outside air damper and static control dampers shall close, and the return air damper shall open.

M. Variable Air Volume AHU with Heat Wheel

1. Supply Fan Control

- a. The supply fan will operate continuously whenever the BAS commands the mode of the unit controller to be either occupied or optimal start. The supply fan will be off whenever:
  - 1) The BAS commands the mode of the unit controller to be unoccupied.
  - 2) The freezestat has tripped.
  - 3) A high duct static condition exists.

- 4) The discharge air temperature sensor fails.
2. Supply Fan Speed
    - a. The speed of the supply fan will be modulated by the unit controller to maintain duct static pressure.
    - b. If the duct static pressure sensor fails, the unit controller will alarm and the fan will be shut down.
  3. Economizer Operation
    - a. When the outside air temperature rises above 56DEG F(adj) the ECON will be locked out and mechanical cooling will be used.
    - b. When the outside air temperature is 56DEG F(adj) or below, mechanical cooling will be locked out and ECON cooling will be used. The outside air damper will modulate to maintain a mixed air temperature of 56DEG F(adj).
    - c. A mixed air low limit will activate mechanical cooling and modulate the outside air damper if the mixed air temperature drops below 50 DEG F(adj).
  4. Outside Air Damper
    - a. When the unit controller is unoccupied, or in the unoccupied portion of morning warm-up, the outside air damper (OADAMPER) will be closed.
    - b. During the occupied portion of morning warm-up, the outside air damper (OADAMPER) will modulate to maintain its minimum flow setpoint.
    - c. The Ventilation Control Module shall be linked to the air handling unit microprocessor-based controller. Using a velocity pressure sensing ring, the ventilation control module shall monitor and control the quantity of fresh air entering the unit. The building automation system shall send the CFM set point to the unit and shall then monitor that setpoint to ensure that it is maintained.
    - d. The fresh outdoor air shall enter the air handling unit through the air flow monitor station/damper sensor assembly and shall be measured by velocity pressure flow rings. The velocity pressure flow rings shall be connected to a pressure transducer/solenoid assembly. The ventilation control module shall utilize the velocity pressure input, the outdoor air temperature input, and the minimum outdoor CFM setpoint to modify the volume (CFM) of

fresh air entering the unit as the measured airflow deviates from setpoint.

- e. A password protected graphic icon (button) shall be incorporated in the graphics which, when enabled, will globally reset the outside air dampers to 10% of minimum flow. This icon shall be labeled "summer ventilation mode".

5. Return Air Damper

- a. The position of the return air damper (RADAMPER) will be proportionate to the outside air damper ( as the outside air damper opens the RADAMPER will close a corresponding amount).

6. Chilled Water Valve

- a. The chilled water valve will modulate in order to maintain discharge air temperature as determined by a discharge air sensor.
- b. The cooling shall be enabled whenever:
  - 1) the outside air temperature is greater than 50 DEG F (adj),
  - 2) AND the economizer is disabled or fully open,
  - 3) AND the supply fan status is on,
  - 4) AND the heating is not active.

7. Heating Water Valve

- a. The controller shall measure the supply air temperature and modulate the heating coil valve to maintain its setpoint.
- b. The heating coil valve shall be enabled whenever:
  - 1) Outside air temperature is less than 62°F (adj),
  - 2) AND the fan status is on,
  - 3) AND the cooling is not active.
- c. The heating coil valve shall open to 100% (adj) whenever:
  - 1) Supply air temperature is less than 35°F (adj),
  - 2) OR the freezestat is tripped or in alarm.

8. Discharge Air

- a. The setting of the discharge air temperature sensor shall be reset thru the control system. The discharge air shall be reset from 55 DEG F(adj) to 65 DEG F(adj) as the return temperature falls from 78DEG F to 74 DEG F. with all values being adjustable. When the unit is energized for setback heating during the unoccupied period, the discharge setpoint shall be 75 degrees. The O/A dampers, exhaust fan and any associated remote relief devices shall remain in the unoccupied position. The return air by-pass damper shall fully open and the hot water valve shall modulate to maintain setpoint. When the unit is energized for morning cool-down, night purge or setback cooling, the discharge setpoint shall be the warmest zone temperature minus 15 degrees.

9. Heat Wheel Operation

a. Cooling Recovery Mode

If the OAT is greater than the ECON setpoint temperature (55F adj.) and the OAT is greater than the RAT the heat wheel is on. The OAD is at its minimum position and the return air damper is fully open. The outside/ exhaust air recovery bypass dampers are closed and the cooling valve is active.

b. Cooling No Recovery

If the OAT is greater than the ECON setpoint temperature and the OAT is less than the RAT the heat wheel is off. The outside/exhaust air recovery bypass dampers are open and the cooling valve is active.

c. Cooling Economizing Mode

If the OAT is less than the ECON setpoint temperature and the OAT is less than the RAT the heat wheel is off. The outside air damper and the return air damper will modulate to maintain the discharge air temperature. The outside/exhaust air recovery bypass dampers are open and the heating and cooling valves are not active.

d. Heating Recovery

1) Heating Stage 1

If the OAT is less than both the ECON setpoint temperature and the RAT, and the DAT is less than the



discharge air setpoint temperature, the heat wheel is on. The outside air damper is at its minimum position, the outside/exhaust air recovery dampers are open and the heating valve is not active.

2) Heating Stage 2

If the OAT is less than both the ECON setpoint temperature and the RAT and the DAT is less than the discharge setpoint temperature, the heat wheel is on. The outside air damper is at minimum. The exhaust air recovery damper will modulate to maintain the DAT and the outside air recovery bypass damper is closed. The heating valve is not active.

3) Heating Stage 3

If the OAT is less than both the ECON setpoint temperature and the RAT the heat wheel is on. The outside air damper is at its minimum position, the return air damper is at its maximum position and the outside/exhaust air recovery bypass dampers are closed. The heating valve is active.

10. Exhaust Fan Control

- a. The exhaust fan will operate continuously whenever the BAS commands the unit controller to either the occupied mode or the optimal start mode.
- b. The exhaust fan will be off under any of the following conditions:
  - 1) The unit controller is in the unoccupied mode.
  - 2) The supply fan has failed.
  - 3) The freezestat has tripped.
  - 4) The discharge air temperature sensor has failed.
  - 5) The exhaust fan status indicates a failure.

11. Exhaust Fan Speed

- a. The speed of the exhaust fan will be modulated by the unit controller to maintain the differential building pressure at 0.05 (adj.) in WC.

12. Safeties

- a. The unit controller will shut down the unit when:
  - 1) The unit controller is in the unoccupied mode.
  - 2) The discharge air temperature sensor has failed.
  - 3) The freezestat is tripped.
  - 4) A high duct static condition exists.

### 13. Alarms

- a. The unit controller will generate an alarm if:
  - 1) The supply fan has failed.
  - 2) The discharge air temperature sensor has failed.
  - 3) The duct static pressure sensor has failed.
  - 4) The outside airflow sensor has failed.
  - 5) The freezestat has tripped.
  - 6) A high duct static condition exists.

## N. Constant Volume AHU with Heat Wheel

### 1. Supply Fan Control

The supply fan will operate continuously whenever the BAS commands the mode of the unit controller to be either occupied or optimal start. When the unit is energized The supply fan will be off whenever:

- a. The BAS commands the mode of the unit controller to be unoccupied.
- b. The freezestat has tripped.
- c. A high duct static condition exists.
- d. The supply fan status indicates a failure.

### 2. Economizer operation

- a. When the outside air temperature is 56 DEG F(adj) or below cooling will be provided by modulating the outside air damper to maintain the space temperature setpoint.

- b. A mixed air low limit will activate mechanical cooling and modulate the outside air damper if the mixed air temperature drops below 50 DEG F(adj).
- 3. Outside Air Damper
  - a. When the unit controller is unoccupied, or in the unoccupied portion of morning warm-up, the outside air damper (OADAMPER) will be closed.
  - b. During the occupied portion of morning warm-up, the outside air damper (OADAMPER) will modulate to maintain its minimum flow setpoint.
- 4. Return Air Damper
  - a. The position of the return air damper (RADAMPER) will be equal to 100% open minus the position of the outside air damper.
- 5. Chilled Water Valve
  - a. The chilled water valve will modulate in order to maintain its setting of 74 DEG F (adj.)
  - b. The cooling shall be enabled whenever:
    - 1) The outside air temperature is greater than 50 DEG F (adj),
    - 2) AND the economizer is disabled or fully open,
    - 3) AND the supply fan status is on,
    - 4) AND the heating is not active
- 6. Heating Water Valve
  - a. The heating water valve will modulate in order to maintain its setting of 71 DEG F (adj).
  - b. The heating coil valve shall be enabled whenever:
    - 1) Outside air temperature is less than 62°F (adj),
    - 2) AND the fan status is on,
    - 3) AND the cooling is not active.

- c. The heating coil valve shall open to 100% (adj) whenever:
  - 1) Supply air temperature is less than 35°F (adj),
  - 2) OR the freezestat is tripped or in alarm.
  
- 7. Heat Wheel Operation
  - a. Cooling Recovery Mode
    - 1) If the OAT is greater than the ECON setpoint temperature (55F adj.) and the OAT is greater than the RAT the heat wheel is on. The OAD is at its minimum position and the return air damper is fully open. The outside/ exhaust air recovery bypass dampers are closed and the cooling valve is active.
  - b. Cooling No Recovery
    - 1) If the OAT is greater than the ECON setpoint temperature and the OAT is less than the RAT the heat wheel is off. The outside/exhaust air recovery bypass dampers are open and the cooling valve is active.
  - c. Cooling Economizing Mode
    - 1) If the OAT is less than the ECON setpoint temperature and the OAT is less than the RAT the heat wheel is off. The outside air damper and the return air damper will modulate to maintain the discharge air temperature. The outside/exhaust air recovery bypass dampers are open and the heating and cooling valves are not active.
  
- 8. Heating Recovery
  - a. Heating Stage 1

If the OAT is less than both the ECON setpoint temperature and the RAT , and the DAT is less than the discharge air setpoint temperature, the heat wheel is on. The outside air damper is at its minimum position, the outside/exhaust air recovery dampers are open and the heating valve is not active.
  - b. Heating Stage 2

If the OAT is less than both the ECON setpoint temperature and the RAT and the DAT is less than the discharge setpoint temperature, the heat wheel is on. The outside air damper is at minimum. The exhaust air recovery damper will modulate to

maintain the DAT and the outside air recovery bypass damper is closed. The heating valve is not active.

c. Heating Stage 3

If the OAT is less than both the ECON setpoint temperature and the RAT the heat wheel is on. The outside air damper is at its minimum position, the return air damper is at its maximum position and the outside/exhaust air recovery bypass damper is closed. The heating valve is active.

9. Exhaust Fan Control

a. The exhaust fan will operate continuously whenever the BAS commands the unit controller to either the occupied mode, the optimal start mode or the morning warm up mode.

b. The exhaust fan will be off under any of the following conditions:

- 1) The unit controller is in the unoccupied mode.
- 2) The supply fan has failed.
- 3) The freezestat has tripped.
- 4) The exhaust fan status indicates a failure.

10. Safeties

a. The unit controller will shut down the unit when:

- 1) The unit controller is in the unoccupied mode.
- 2) The exhaust fan has failed.
- 3) The freezestat is tripped.

11. Alarms

a. The unit controller will generate an alarm if:

- 1) The supply fan has failed.
- 2) The outside air temperature has failed.
- 3) The exhaust fan has failed.
- 4) The exhaust airflow sensor has failed.

- 5) The freezestat has tripped.
  - 6) The energy wheel is not rotating when controlled on.
- O. Valances – 4 Pipe
1. With respective system pumps in occupied operation the combination heating-cooling room control shall modulate space located controls as described below. Each unit shall have a complete set of control components (see item 5 below).
  2. Heating
    - a. Control shall modulate valance hot water valve to maintain its setting (71°F).
    - b. During clock unoccupied mode, heating pump shall be de-energized. When the reduced setting night control returns the pump to operation, the equipment shall operate as described above until the night setting (55°F) is satisfied.
  3. Cooling
    - a. Heating-cooling room control shall modulate valance chilled water valve to maintain its setting (74°F).
    - b. During clock unoccupied position, cooling pump shall be de-energized. When the increased night setting control returns the pump to operation, the equipment shall operate as described above until the night setting of 85°F is satisfied.
  4. Provide zone warm-up cycle with setpoint (68°F).
  5. Rooms shown with two units shall have control components of both units controlled by one room control, except classrooms with folding partitions shall have individual controls for each unit.
- P. Fan Powered VAV Boxes, with Hot Water Coils or Electric Heat
1. General
    - a. Controls, damper operators and linkages furnished and installed under this section for constant volume terminal units shall be as described in section 15870. Coordinate with unit manufacturer for requirements. Operators and linkages shall be compatible with units.

- b. Unit shall be controlled by the control panel program reacting to temperature signals transmitted from individual room sensors located where shown and rooftop unit controls. Valve and damper operators shall be electronic.
  2. Occupied Mode - With fan operating constantly during occupied hours (fans are to start prior to the starting of the parent AHU/RTU) and the individual room sensor transmitting a temperature signal to the IFID lower than the programmed heating setting of 71°F the fan powered box primary air damper shall close to its minimum air flow and the electronic controlled normally open heating coil hot water valve or duct heater shall modulate to maintain the heating setting. As the space temperature rises above the programmed setting the valve shall modulate closed. or the duct heater shall turn off. As the space temperature continues to rise above the programmed cooling setting of 74°F the primary damper shall modulate toward the open position. On a fall in space temperature the reverse sequences shall occur. Units which incorporate electric duct heaters shall lockout heating if the outside air temperature is above 62Deg F(adj), units which incorporate hot water reheat coils shall lock out heating if the heating water pump is not running. A password protected graphic icon (button) shall be incorporated on the graphics which, when enabled, will override the above lockout and allow heating above 62Deg F (adj) for units using electric duct heaters.
  3. Unoccupied Mode
    - a. The constant volume terminal unit shall be fully de-energized during unoccupied hours. The primary air damper shall be in its normally closed position.
    - b. Heating - The fan and hot water coil valve respond to the IFID to meet the programmed night setting of 55°F.
    - c. Cooling – The fan and damper respond to the IFID to meet the programmed night setting of 85°F.
  4. Warm-Up Mode - with the associated rooftop unit start-up the terminal unit hot water valve shall fully open the constant volume terminal unit fan shall operate and its primary damper shall be 100% open. The cycle shall continue until the warm-up sensor located in the return air duct reaches the setting of 68°F, or when the schedule allows the system shall enter the occupied mode.
  5. Engineer designated space sensors shall, in addition to the above, be used to reset the discharge air setpoint as described in the VAV Rooftop unit sequence.
- Q. VAV Box with Hot water coils

1. General
    - a. Controls, damper operators and linkages furnished and installed under this section for terminal units shall be as described in section 15870. Coordinate with the unit manufacturer for requirements. Operators and linkages shall be compatible with units.
    - b. Unit shall be controlled by the control panel program reacting to temperature signals transmitted from individual room sensors located where shown and air handling unit controls.
  2. Occupied mode- With the individual room sensor transmitting a temperature signal to the IFID lower than the programmed heating setting of 71\* Deg F the primary air damper shall open to its maximum air flow and the heating coil hot water valve shall modulate to maintain the heating setting. As the space temperature rises above the programmed setting the valve shall modulate closed and the primary air damper shall close to its minimum position. As the space temperature continues to rise above the programmed cooling setting of 74\*Deg F the primary air damper shall modulate toward the open position. On a fall in space temperature the reverse shall occur. Heating shall be locked out if the associated heating water pump is not running.
  3. Unoccupied mode- The primary air damper and the hot water valve shall be in their normally open position.
  4. Warm-up Mode- With the associated air handling unit start-up the terminal unit hot water valve shall fully open and the primary air damper shall be 100% open. The cycle shall continue until the warm-up sensor reaches the setting of 68\*Deg F at which time the system shall enter the occupied mode.
- R. Rooftop Units - Single Zone with Economizer Cycle
1. General - Rooftop unit shall be controlled through the IFID timing function by the IFID operating program reacting to space temperature signals from the room sensor located where shown. The IFID shall actuate control relays, which will start and stop the unit and open or close circuits for the fan, heating or cooling operation. Compressors and heating section shall be hardwired interlocked internally so that they cannot operate unless the unit fan is running. When the unit is de-energized the outside air damper shall close.
  2. Fan - When the IFID timing function energizes the system, the program shall cause the supply fan to run constantly using the factory built-in control circuitry. The modulating electrically operated low leakage outside



air damper shall be internally interlocked with the fan to open to its preset minimum position with the return air damper closing a corresponding amount.

### 3. Heating

- a. Occupied Mode - The IFID shall cause modulation or cycling of the heating to maintain the space programmed heating setting of 71°F. Whenever the unit is energized, BAS shall enable the heater and use a DA PID loop to control its output via the unit mounted heater management system to maintain space temperature at setpoint, through a step control logic function utilizing dead bands with a 2°F (ADJ.) throttling range. Heating shall remain off if the outside air temperature is above 62°F (ADJ.).
- b. Unoccupied Mode - The IFID shall close the outside air damper and stop the fan. When the space temperature falls below the programmed reduced night temperature of 55°F, the IFID shall return the system to operation as described above until the programmed setting is reached. During night setback heating operation the outside air damper shall remain closed.
- c. Morning Warm-Up - When the IFID returns the equipment to the occupied mode it shall start in a morning warm-up configuration. The fan shall run, the heat shall cycle and the outside air damper shall remain closed until the space temperature signal transmitted to the IFID reaches the programmed setting of 68°F. If after a one hour time period the space temperature has not reached 68 DEG F the outside air damper will be indexed to the occupied position.

### 4. Cooling

- a. Occupied Mode
  - 1) The IFID shall close the cooling control circuits to the rooftop unit in noted stages causing the controls to operate the cooling cycle to maintain the IFID programmed cooling setting of 74° F.
  - 2) Mechanical Cooling - When the unit panel operates the cooling controls and the outside air enthalpy is above the built-in enthalpy sensor set point the economizer mode is locked out and the outside air dampers remain at their minimum position. Cooling is done mechanically by the compressors.

- 3) Economizer Cooling - When the unit panel operates the cooling controls and the outside air enthalpy is below the setting of the built-in enthalpy sensor the economizer mode operates under built-in thermostatic control. The outside air dampers modulate toward their open position while the return air dampers modulate toward closed correspondingly. The economizer mode acts as the first stage of cooling using outside air. In this mode as the outside air damper modulates to the 50% open point and an end switch on the damper shall close the circuit to the relief air means described below. If the outside air alone cannot satisfy the cooling requirements of the conditioned space economizer cooling is integrated with mechanical cooling. Compressors working simultaneously with the economizer mode will be staged on to meet the cooling load. As the conditioned space temperature approaches the set point the mechanical stages cycle off, last stage first. After all stages of mechanical cooling are off as the discharge air temperature drops below 62°F the outside air damper will modulate toward its minimum setting. At a discharge air temperature of 50°F the outside air damper will be at its minimum position.
- 4) During the economizer cycle building air shall be relieved through the rooftop unit using barometric dampers, powered exhaust or remote relief dampers sized at 100%.
  - b. Unoccupied Mode - The IFID shall de-energize the controls and rooftop unit. The outside air dampers shall close. When the space temperature sensor rises above the programmed night temperature of 85°F, the IFID shall return the system to operation as described above until the programmed setting is reached. During the night setback cooling operation, the outside air damper shall remain closed.
5. Rooftop Unit Nos. (select) to (select) - In addition to the above sequence the following shall apply.
  - a. The rooftop units shall operate an equal amount of time each week. During normal occupancy only one primary unit shall operate. A different unit shall be the primary unit each day. Should one unit serve a dedicated space, this unit will be designated the primary unit. The primary unit shall be determined by the owner.
  - b. The change from normal occupancy to high occupancy shall be through a carbon dioxide sensor located in the space adjacent to the room sensor. Normal occupancy shall be below 900 parts per

- million or less and high occupancy shall be above 900 parts per million.
- c. Ventilation - When the changeover is made to high occupancy, additional units shall be staged on to provide ventilation as the CO<sub>2</sub> level in the space rises from 900 ppm to 1100 ppm so that all rooftop units are energized at a CO<sub>2</sub> level of 1100 ppm. Upon a fall in CO<sub>2</sub> level, the reverse shall occur. Units shall run for a minimum of one hour when brought on by CO<sub>2</sub>.
  - d. The BAS shall prove fan status of the primary unit. If a fan failure occurs in the primary unit, appropriate alarms will annunciate and the next unit in sequence shall be energized to maintain space temperature.
  - e. During normal occupancy, should the primary unit be unable to maintain space temperature at setpoint, additional unit(s) shall be enabled. Heating and cooling shall cycle using step control logic with a 2 Deg F (adj) throttling range. The outside air damper shall remain closed. Unit(s) shall run for a minimum of one hour when brought on by this sequence.
6. Demand Ventilation Control (engineer to use for spaces served by a single unit).
- a. Minimum damper position for Co2 control: The outside air damper shall be initially positioned to provide 25% (adj.) of the scheduled outside air flow, this will be considered the base level ventilation rate and shall be provided during all occupied times.
  - b. Maximum damper position for Co2 control: The outside air damper shall be positioned to the outside air flow value listed in the mechanical equipment schedule.
  - c. As the Co2 level, measured at the room Co2 sensor, increases above setpoint, 700ppm (adj.) the outside air damper shall modulate proportionally towards the maximum damper position so as not to allow the Co2 level to exceed 1100ppm (adj.).
- S. Rooftop Units - Single Zone with minimum outside air
1. General - Rooftop unit shall be controlled through the IFID timing function by the IFID operating program reacting to space temperature signals from the room sensor located where shown. Compressors and heat shall be hardwired interlocked so that they cannot operate unless the unit fan is running. IFID shall provide thermostatic functions to cause the unit to operate with its built-in control and protective circuits. When the unit is de-energized the outside air damper shall close.

2. Fan - When the IFID energizes the system the program shall cause the fan to run constantly using the factory built-in control circuitry. The two-position spring return electric motor operated outside air damper shall be internally interlocked to open to its preset minimum position.
  3. Heating
    - a. Occupied Mode - The IFID shall cause the heat to operate through the factory-designed controls to maintain the space programmed heating setting of 71°F. When the unit is energized, BAS shall enable the heater and use a DA PID loop to control its output via the unit mounted heater management system to maintain space temperature at setpoint, through a step control logic function utilizing dead bands with a 2°F (ADJ.) throttling range. Heating shall remain off if the outside air temperature is above 62°F (ADJ.).
    - b. Unoccupied Mode - The IFID shall de-energize the heating, stop the fan and close the outside air damper. When the space temperature falls below the programmed reduced night temperature of 55°F the IFID shall return the system to operation as described above until the programmed setting is reached. During night setback operation the outside air damper shall remain closed.
    - c. Morning Warm-Up - When the IFID returns the equipment to the occupied mode it shall start in a morning warm-up configuration. The fan shall run, the heat shall operate and the outside air damper shall remain closed until the space temperature signal transmitted to the IFID by the sensor reaches the programmed setting of 68°F. If after a one hour time period the space temperature has not reached 68 DEG F the outside air damper will be indexed to the occupied position.
  4. Cooling
    - a. Occupied Mode - The IFID shall cause the compressors and condensing fans to operate through the factory designed controls to maintain the individual space programmed cooling setting of 74° F. Cooling stages shall be per the equipment furnished.
    - b. Unoccupied Mode - The IFID shall stop the compressor and fans and close the outside air damper. When the space temperature sensor rises above the programmed night temperature of 85°F the IFID shall return the system to operation as described above until the programmed setting is reached. During the night setback cooling operation, the outside air damper shall remain closed.
- T. Rooftop Units with Enthalpy Wheel

1. The unit shall be controlled by a field mounted DDC controller, discharge air sensor, space temperature and humidity sensor furnished and installed by the controls contractor. Unit shall be started and stopped by a time schedule in the DDC controller. Any unit manufacturer device that is furnished with a factory DDC controller shall use EIA standard 709.1.
2. When a zone is in the unoccupied mode, warm-up mode or cool-down mode of operation, the rooftop unit serving that zone shall remain de-energized. When any associated zone is in the occupied mode the rooftop unit shall be energized to operate.
3. Unit Start Command
  - a. Factory mounted and wired outdoor air and exhaust air damper actuators are powered.
  - b. Exhaust fan starts after a 10 second delay (adjustable).
  - c. Supply fan starts 5 seconds (adjustable) after the exhaust fan.
  - d. Heating, cooling, and wheel operation as follows.
4. Unit Stop Command (or de-energized)
  - a. Supply fan, exhaust fan, tempering options, and wheel are de-energized.
  - b. Outdoor air and exhaust air damper actuators are de-energized and dampers spring return closed.
5. Cooling Sequence
  - (1) Occupied Mode
    - (a) The IFID shall close the cooling control circuits to the rooftop unit in noted stages causing the controls to operate the cooling cycle to maintain the IFID programmed cooling setting of 74°F.
    - (b) Mechanical Cooling - When the unit panel operates the cooling controls and the outside air enthalpy is above the built-in enthalpy sensor set point the economizer mode is locked out and the outside air dampers remain at their minimum position. Cooling is done mechanically by the compressors.
    - (c) Economizer Cooling - When the unit panel operates the cooling controls and the outside air enthalpy is below the setting of the built-in enthalpy sensor the economizer mode operates under built-in thermostatic control. The outside air dampers modulate toward their open position while the return air dampers modulate toward closed correspondingly. The economizer mode acts as the

first stage of cooling using outside air. In this mode as the outside air damper modulates open the variable frequency drive on the exhaust fan shall increase the fan speed. If the outside air alone cannot satisfy the cooling requirements of the conditioned space economizer cooling is integrated with mechanical cooling. Compressors working simultaneously with the economizer mode will be staged on to meet the cooling load. As the conditioned space temperature approaches the set point the mechanical stages cycle off, last stage first. After all stages of mechanical cooling are off as the discharge air temperature drops below 62°F the outside air damper will modulate toward its minimum setting. At a discharge air temperature of 50°F the outside air damper will be at its minimum position.

- (2) Unoccupied Mode - The IFID shall de-energize the controls and rooftop unit. The outside air dampers shall close. When the space temperature sensor rises above the programmed night temperature of 85°F, the IFID shall return the system to operation as described above until the programmed setting is reached. During the night setback cooling operation, the outside air damper shall remain closed.

#### 6. Energy Wheel Sequence

- (1) Wheel shall turn at full speed when supply fan is energized and unit is not in economizer.
- (2) Economizer
  - (a) Modulate Wheel - When economizer mode is enabled and there is a signal for cooling, the wheel VFD modulates wheel speed to maintain the discharge temperature setpoint.
  - (b) The economizer will be locked out when: the outside air is less than 40°F (adj); the unit is operating in dehumidification mode; or there is a call for heating.

#### 7. Heating Sequence

- (1) Occupied Mode - The IFID shall cause modulation of the heating to maintain the space programmed heating setting of 71°F. Whenever the unit is energized, BAS shall enable the heater and use a DA PID loop to control its output via the unit mounted heater management system to maintain space temperature at setpoint, through a step control logic function utilizing dead bands with a 2°F (ADJ.) throttling range. Heating shall remain off if the outside air temperature is above 62°F (ADJ.).

- (2) Unoccupied Mode - The IFID shall close the outside air damper and stop the fan. When the space temperature falls below the programmed reduced night temperature of 55°F, the IFID shall return the system to operation as described above until the programmed setting is reached. During night setback heating operation the outside air damper shall remain closed, the exhaust fan shall remain off, and the return air damper shall be open.
  - (3) Morning Warm-Up - When the IFID returns the equipment to the occupied mode it shall start in a morning warm-up configuration. The fan shall run, the heat shall cycle and the outside air damper shall remain closed until the space temperature signal transmitted to the IFID reaches the programmed setting of 68°F. If after a one hour time period the space temperature has not reached 68°F the outside air damper will be indexed to the occupied position.
8. Unoccupied Mode - When all associated zones are in the unoccupied, cool-down, or warm-up modes of operation, the rooftop unit shall be completely de-energized. The outside air damper shall be closed, the enthalpy wheel shall be disabled, and the return fan shall be disabled.
9. Rooftop Unit Nos. RTU-1 and RTU-2 (Cafeteria) - See sequence H. above for CO2 sequence. **(Engineer to edit RTU numbers to make job specific.)**
10. Hot Gas Reheat Dehumidification
  - (1) Space Humidity Control - A space mounted relative humidity sensor shall be provided for de-humidification control. Should the relative humidity rise above 60% RH (adjustable), the DDC system shall index the first stage of compressor operation on to maintain the space relative humidity setpoint. The space temperature sensor shall control the hot gas reheat to maintain space temperature.
11. Energy Wheel Sequence
  - (1) Wheel shall turn at full speed when supply fan is energized and unit is not in economizer. When unit is in economizer, wheel shall stop.
12. Safeties
  - (1) The DDC system shall shut down operation of the rooftop unit and alarm whenever enthalpy wheel discharge air temperature drops below 35°F (adj.) (supply air temperature between the enthalpy wheel and refrigerant coil).
  - (2) Condensate Overflow Switch - A condensate overflow switch shall be installed in the drain pan by the unit manufacturer. The condensate overflow switch shall shut down the unit under an "alarm" condition. The

DDC system shall monitor the condensate overflow alarm and indicate an alarm condition on the graphics page for each unit. The unit shall resume operation automatically once this device returns to normal.

- (3) Supply and Exhaust Air Alarm - Provide switch on each blower and display an alarm in case of blower failure.

U. Variable Air Volume Air Handling Units with chilled and hot water.

1. General – Units shall be controlled through the factory mounted controls and by the central control panels. The fan shall be energized through the control system, and shall run constantly. The modulating low leakage outside air damper shall be internally interlocked with the fan to open to its minimum position with the return air damper closing a corresponding amount.
2. Occupied Operation – Warm-Up
  - a. During the warm up mode the static pressure control system shall be activated, the remaining controls shall remain in their respective night positions with the outside air damper closed and the space VAV boxes shall be held open. The system shall remain in the warm up mode until the return air temperature rises above 68°F. If after a one hour time period the space temperature has not reached 68 DEG F the outside air damper will be indexed to the occupied position the unit shall then be indexed to the occupied mode. Warm up temperature sensor shall be located in the return air duct.
  - b. When the warm up mode ends the outside and remote relief air dampers shall open to their adjustable minimum positions with the return air damper closing a corresponding amount. If the outside air enthalpy is less than the return air enthalpy the discharge temperature sensor shall modulate the outside, return and remote relief air dampers to maintain its setting. If the outside air enthalpy is greater than the return air enthalpy the dampers shall remain in their minimum positions.
  - c. The Ventilation Control Module shall be linked to the air handling unit microprocessor-based controller. Using a velocity pressure sensing ring, the ventilation control module shall monitor and control the quantity of fresh air entering the unit. The building automation system shall send the CFM set point to the unit and shall then monitor that setpoint to ensure that it is maintained.
  - d. The fresh outdoor air shall enter the air handling unit through the air flow monitor station/damper sensor assembly and shall be measured by velocity pressure flow rings. The velocity pressure



flow rings shall be connected to a pressure transducer/solenoid assembly. The ventilation control module shall utilize the velocity pressure input, the outdoor air temperature input, and the minimum outdoor CFM setpoint to modify the volume (CFM) of fresh air entering the unit as the measured airflow deviates from setpoint.

- e. A password protected graphic icon (button) shall be incorporated in the graphics which, when enabled, will globally reset the outside air dampers to 10% of minimum flow. This icon shall be labeled "summer ventilation mode".
3. Occupied Cooling and Heating - In addition to the dampers the discharge air temperature sensor shall modulate the cooling coil valve to maintain its setting of 55°F. The discharge air temperature sensor shall also act as a low limit control by modulating the heating coil valve to maintain its setting of 52°F. The sensor shall be located per the manufacturers recommendation. The setting of the discharge air temperature sensor shall be reset from 55 DEG F (adj) to 65 DEG F (adj) as the return air temperature falls from 78 DEG F (adj) to 74 DEG F (adj). When the unit is energized for setback heating during the unoccupied period, the discharge setpoint shall be 75 degrees. When the unit is energized for morning cool-down, night purge or setback cooling, the discharge setpoint shall be the warmest zone temperature minus 15 degrees.
  4. A static pressure sensor, located a minimum of 2/3 the distance of the total duct run, as measured from the unit, shall modulate the variable frequency drive (VFD) to maintain its setting.
  5. Unoccupied Mode - the unit is de-energized and the controls shall assume their night positions. The supply air fan shall be de-energized; through a hardwired interlock the outside air damper, remote relief air damper, and cooling coil valve shall close, and the return air damper and heating coil valve shall open.
    - a. Heating – When the reduced setting night control returns the pump to operation, the equipment shall operate as described above until the night setting of 55°F is satisfied. O.A. damper shall be closed.
    - b. Cooling – When the increased night setting control returns the pump to operation, the equipment shall operate as described above until the night seating of 85°F is satisfied. O.A. damper shall be closed.
- V. Single Zone Air Handling with chilled and hot water.
1. Occupied Mode - the unit is energized and controlled by the timed start/stop function. The fan shall be energized through the control system

- activated to the warm up mode. When the unit is de-energized the O.A. damper shall close.
2. During the warm up mode the controls shall remain in their night position with O. A. damper closed until the space temperature rises above its setting of 68°F. When scheduling permits, the unit shall then be indexed to the occupied mode. Warm up temperature sensor shall be located in the space served.
  3. During the day mode the outside and remote relief air dampers shall open to their adjustable minimum position with the return air damper closing a corresponding amount. A room temperature sensor shall, through the IFID controller, modulate the heating coil valve to maintain its programmed setting of 71°F and the cooling coil valve to maintain its programmed setting of 74°F. If the outside air enthalpy is less than the return air enthalpy the room temperature sensor shall also cause the modulation of the outside, return and remote relief air dampers to maintain its programmed setting of 74° F. A mixed air low limit temperature sensor shall override the room temperature sensor and close the outside and relief air dampers if its programmed setting of 55°F is reached.
  4. Unoccupied Mode – when the unit is de-energized, or manually turned off the controls shall assume their night positions. The fan shall stop; the outside air damper, remote relief air damper and cooling coil valve shall close, and the return air damper and heating coil valve shall open.
    - a. Heating – When the reduced setting night control returns the pump to operation, the equipment shall operate as described above until the night setting of 55°F is satisfied. O.A. damper shall be closed.
    - b. Cooling – When the increased setting night control returns the pump to operation, the equipment shall operate as described above until the night setting of 85°F is satisfied. O.A. damper shall be closed.
- W. 100% Roof Top Make-up Air Units with chilled and hot water coils
1. Occupied Mode - the unit is energized and controlled by the timed start/stop function. The fan shall be energized through the control system activated to the occupied mode, the heating valve shall not be indexed until fan status is proven. When the unit is de-energized the O.A. damper shall close.
  2. During the day mode the outside air damper shall open fully. A duct discharge air temperature sensor shall, through the IFID controller, modulate the heating coil valve to maintain its programmed setting of

70°F heating mode shall be enabled when the outside air is below 62° F. In the cooling season, the space humidity sensor shall, through the IFID controller, modulate the chilled water coil valve to maintain its programmed setting of 55% relative humidity. Cooling coil leaving temperature setpoint shall be reset based on humidity. Setpoint shall be reset based on a RA PID loop outputting a setpoint of 75°F to 55°F as the space humidity rises from 60% RH to 70% RH all adjustable. In addition, the duct discharge air temperature sensor shall, through the IFID controller, modulate the cooling coil valve to prevent the supply air temperature from rising above 75°F or below 55°F. In the event of a unit freeze stat alarm, through a hardwired interlock the unit dampers and valves shall return to the failsafe position.

3. Unoccupied Mode - the unit is de-energized, the controls shall assume their night positions. The fan shall stop; and through a hardwired interlock the outside air damper and cooling coil valve shall close and heating coil valve shall open.

X. Energy Recovery Units with chilled and hot water coils

1. Occupied Mode - the unit is energized and controlled by the timed start/stop function. The supply and exhaust fans shall be energized through the control system activated to the warm up mode, the heating valve shall not be indexed until fan status is proven. When the unit is de-energized the O.A. damper shall close.
2. During the occupied mode the outside air damper shall open fully. A duct discharge air temperature sensor shall, through the IFID controller, modulate the heating coil valve to maintain its programmed setting of 70°F heating mode shall be enabled when the outside air is below 62°F. In the cooling season, cooling coil leaving temperature setpoint shall be reset based on humidity. Setpoint shall be reset based on a RA PID loop outputting a setpoint of 75°F to 55°F as the space humidity rises from 60% RH to 70% RH all adjustable. In addition, the duct discharge air temperature sensor shall, through the IFID controller, modulate the cooling coil valve to prevent the supply air temperature from rising above 75°F or below 70°F.
3. Unoccupied Mode - the unit is de-energized, the controls shall assume their night positions. The fan shall stop; the outside air damper and cooling coil valve shall close and heating coil valve shall open.
4. Freeze Protection: The energy recovery unit will operate as described in Section 15774, Energy Recovery Units, to defrost the heat exchanger. Also, if the hot water coil entering air temperature is below 40 degrees F, the heating coil valve will modulate fully open.

- Y. Energy Recovery Units with chilled and hot water coils with bypass dampers.
1. Occupied Mode - the unit is energized and controlled by the timed start/stop function. The supply and exhaust fans shall be energized through the control system activated to the warm up mode, the heating valve shall not be indexed until fan status is proven. When the unit is de-energized the O.A. damper shall close.
  2. During the warm up mode the controls shall remain in their night position with O. A. damper closed until the return air temperature rises above its setting of 68°F. When scheduling permits, the unit shall then be indexed to the occupied mode. Warm up temperature sensor shall be located in the return air duct.
  3. During the day mode the outside and remote relief air dampers shall open to their adjustable minimum position with the return air damper closing a corresponding amount. A room temperature sensor shall, through the IFID controller, modulate the heating coil valve to maintain its programmed setting of 71°F and the cooling coil valve to maintain its programmed setting of 74°F. If the outside air enthalpy is less than the return air enthalpy the room temperature sensor shall also cause the modulation of the outside, return and remote relief air dampers to maintain its programmed setting of 74° F. A mixed air low limit temperature sensor shall override the room temperature sensor and close the outside and relief air dampers if its programmed setting of 55°F is reached.
  4. Unoccupied Mode - the unit is de-energized, the controls shall assume their night positions. The fan shall stop; the outside air damper, remote relief air damper and cooling coil valve shall close, and the return air damper and heating coil valve shall open.
    - a. Heating – When the reduced setting night control returns the pump to operation, the equipment shall operate as described above until the night setting of 55°F is satisfied. O.A. damper shall be closed.
    - b. Cooling – When the increased setting night control returns the pump to operation, the equipment shall operate as described above until the night setting of 80° 85°F is satisfied. O.A. damper shall be closed.
  5. Freeze Protection: The energy recovery unit will operate as described in Section 15774, Energy Recovery Units, to defrost the heat exchanger. Also, if the hot water coil entering air temperature is below 40 degrees F, the heating coil valve will modulate fully open.
- Z. Energy Recovery Unit (enthalpy wheel)

1. The unit shall be controlled by a field mounted DDC controller, discharge air and humidity sensor, space temperature and humidity sensor furnished and installed by the controls contractor. Unit shall be started and stopped by a time schedule in the DDC controller. Any unit manufacturer device that is furnished with a factory DDC controller shall use EIA standard 709.1.
2. When a zone is in the unoccupied mode, warm-up mode or cool-down mode of operation, the energy recovery unit serving that zone shall remain de-energized. When any associated zone is in the occupied mode the energy recovery unit shall be energized to operate and provide tempered ventilation air as required.
3. Occupied Heating Mode: The outside air damper shall be open, supply and exhaust fan shall run, and the enthalpy wheel shall be energized. A damper end switch shall be used to verify damper position and start the supply air and exhaust air fans once the damper has been proven open. A current switch shall verify run status of each fan. When the discharge dew point temperature of the enthalpy wheel is below 54°F (adj.) and the dry bulb discharge temperature of the enthalpy wheel falls below 68°F (adj.), the unit's compressors shall be indexed on, and the hot gas reheat valve shall be modulated to maintain the unit's discharge dry bulb temperature of 68°F (adj.). Manufacturer will have a factory preprogrammed compressor on/off time build into their safeties and the DDC system shall provide the required programming that does not exceed a total combined 5 minute (adj.) on and a 5 minute (adj.) off time for the compressors. Failure to achieve run status shall be alarmed.
4. Occupied Cooling Mode: The outside air damper shall be open, supply and exhaust fan shall run, and the enthalpy wheel shall be energized. A damper end switch shall be used to verify damper position and start the supply air and exhaust air fans once the damper has been proven open. A current switch shall verify run status of each fan. When the discharge dew point temperature of the enthalpy wheel rises above 54°F (adj.), the unit's compressors shall be indexed on and the hot gas reheat valve shall be modulated to maintain the unit's discharge dew point temperature and dry bulb temperature of 54°F (adj.) and 68°F (adj.), respectively. When the discharge dew point temperature of the enthalpy wheel is below 54°F (adj.) and the dry bulb discharge temperature of the enthalpy wheel rises above 68°F (adj.), the unit's compressors shall be indexed on and the hot gas reheat valve shall be modulated to maintain the unit's discharge dew point temperature and dry bulb temperature of 54°F (adj.) and 68°F (adj.), respectively. Manufacturer will have a factory preprogrammed compressor on/off time built into their safeties and the DDC system shall provide the required programming that does not exceed a total combined 5 minute (adj.) on and a 5 minute (adj.) off time for the compressors. Failure to achieve run status shall be alarmed.

5. Unoccupied Mode: When all associated zones are in the unoccupied, cool-down or warm-up modes of operation, the energy recovery unit shall be completely de-energized. The outside air damper shall be closed, the enthalpy wheel shall be disabled, the return fan shall be disabled and the mixed air damper shall be indexed to the bypass mode. The unit fan shall be cycled in conjunction with the compressors and hot gas reheat valve to maintain the unoccupied space temperature cooling setpoint of 80°F (adj.), and unoccupied space temperature heating setpoint of 65°F (adj.). There shall be a 5°F (adj.) temperature dead band.
6. Safeties
  - a. The two position isolation valve shall fail close under loss of power or any other alarm shutdown scenario.
  - b. The DDC system shall shut down operation of the energy recovery unit and alarm whenever enthalpy wheel discharge air temperature drops below 35°F (adj.) (supply air temperature between the enthalpy wheel and refrigerant coil).
  - c. Condensate Overflow Switch: A condensate overflow switch shall be installed in the drain pan by the unit manufacturer. The condensate overflow switch shall lock out the compressors under an "alarm" condition. The DDC system shall monitor the condensate overflow alarm and indicate an alarm condition on the graphics page for each unit. The unit shall resume operation automatically once this device returns to normal.
  - d. Isolation Valve Control: Each unit shall have a 2-way normally open ball control valve, as further defined herein, to shut down water flow to the unit whenever the compressor is off. The DDC system shall control the 2-position valves, via a separate Digital Output point, to open whenever the compressor runs and close whenever the compressor is off. An end switch shall verify actuator position. The DDC system shall not turn the compressor(s) on until the end switch proves the isolation valve open. An alarm shall be generated if the end switch fails to prove the valve position command.
- AA. Energy Recovery Unit (Self contained with enthalpy wheel and hot gas reheat for demumidification).
  1. The unit shall be controlled by a field mounted DDC controller, discharge air sensor, space temperature and humidity sensor furnished and installed by the controls contractor. Unit shall be started and stopped by a time schedule in the DDC controller. Any unit manufacturer device that is furnished with a factory DDC controller shall use EIA standard 709.1.

2. When a zone is in the unoccupied mode, warm-up mode or cool-down mode of operation, the energy recovery unit serving that zone shall remain de-energized. When any associated zone is in the occupied mode the energy recovery unit shall be energized to operate and provide tempered ventilation air as required.
3. Unit Start Command
  - a. Factory mounted and wired outdoor air and exhaust air damper actuators are powered.
  - b. Exhaust fan starts after a 10 second delay (adjustable).
  - c. Supply fan starts 5 seconds (adjustable) after the exhaust fan.
  - d. Heating, cooling, and wheel operation as follows.
4. Unit Stop Command (or de-energized)
  - a. Supply fan, exhaust fan, tempering options, and wheel are de-energized.
  - b. Outdoor air and exhaust air damper actuators are de energized and dampers spring return closed.
5. Cooling sequence
  - a. The cooling is controlled to maintain the 68°F (adj.) supply temperature setpoint. The mechanical cooling will be locked out when the outside air is less than 55°F, adjustable.
  - b. Packaged DX Cooling: Compressor shall modulate to maintain the supply air setpoint. This signal will come wired to the factory provided condensing section.
6. Energy Wheel Sequence
  - a. Wheel shall turn at full speed when supply fan is energized and unit is not in economizer.
  - b. Economizer.
    - 1) Modulate Wheel - When economizer mode is enabled and there is a signal for cooling, the wheel VFD modulates wheel speed to maintain the discharge temperature setpoint.

- 2) The economizer will be locked out when: the outside air is less than 40°F (adj); the unit is operating in dehumidification mode; or there is a call for heating.
7. Dehumidification sequence
    - a. The cooling is controlled to maintain the cooling coil setpoint. The dehumidification sequence will be locked out when the outside air is less than 10°F above the cold coil setpoint.
    - b. The controller will adjust the cold coil leaving air temperature set point between the minimum (50°F) and maximum (55°F) set points, to satisfy the room relative humidity set point (60% adjustable).
    - c. Reheat Sequence - While the unit is in dehumidification mode, the supply air shall be reheated using modulating hot gas reheat. The controller shall modulate the hot gas reheat valve to maintain the supply temperature set point.
  8. Heating Sequence
    - a. The heating is controlled to maintain the supply temperature setpoint. The heating will be locked out when the outside air is above 70°F, adjustable.
    - b. Modulating Gas Furnace – DDC will operate the modulating gas furnace to maintain the 68°F supply temperature setpoint (adj).
  9. Unoccupied Mode: When all associated zones are in the unoccupied, cool-down, or warm-up modes of operation, the energy recovery unit shall be completely de-energized. The outside air damper shall be closed, the enthalpy wheel shall be disabled, and the return fan shall be disabled.
  10. Safeties
    - a. The DDC system shall shut down operation of the energy recovery unit and alarm whenever enthalpy wheel discharge air temperature drops below 35°F (adj.) (supply air temperature between the enthalpy wheel and refrigerant coil).
    - b. Condensate Overflow Switch: A condensate overflow switch shall be installed in the drain pan by the unit manufacturer. The condensate overflow switch shall lock out the compressors under an "alarm" condition. The DDC system shall monitor the condensate overflow alarm and indicate an alarm condition on the graphics page for each unit. The unit shall resume operation automatically once this device returns to normal.



- c. Supply and Exhaust Air Alarm - Provide switch on each blower and display an alarm in case of blower failure.
- BB. Energy Recovery Unit (enthalpy wheel and hydronic heat pump)
1. The unit shall be controlled by a field mounted DDC controller, discharge air sensor, space temperature and humidity sensor furnished and installed by the controls contractor. Unit shall be started and stopped by a time schedule in the DDC controller. Any unit manufacturer device that is furnished with a factory DDC controller shall use EIA standard 709.1.
  2. When a zone is in the unoccupied mode, warm-up mode or cool-down mode of operation, the energy recovery unit serving that zone shall remain de-energized. When any associated zone is in the occupied mode the energy recovery unit shall be energized to operate and provide tempered ventilation air as required.
  3. Unit Start Command.
    - a. Factory mounted and wired outdoor air and exhaust air damper actuators are powered.
    - b. Exhaust fan starts after a 10 second delay (adjustable).
    - c. Supply fan starts 5 seconds (adjustable) after the exhaust fan.
    - d. Heating, cooling, and wheel operation as follows.
  4. Unit Stop Command (or de-energized)
    - a. Supply fan, exhaust fan, tempering options, and wheel are de-energized.
    - b. Outdoor air and exhaust air damper actuators are de energized and dampers spring return closed.
  5. Cooling and Heating Sequence
    - a. The outside air damper shall be open, supply and exhaust fans shall run, and the enthalpy wheel shall be energized.
    - b. A damper end switch shall be used to verify damper position and start the supply air and exhaust air fans once the damper has been proven open. A current switch shall verify run status of each fan.
    - c. Compressors shall modulate to maintain supply air temperature setpoint of 68°F (adj). Supply air discharge shall have a 55°F low

limit; the air leaving the DX coil shall have a 45°F low limit. The lead compressor operation shall be rotated to achieve even run time. The manufacturer's controller shall control the refrigeration circuits, refrigeration / water heat exchanger (head pressure control), refrigerant system safeties and override EMS operations to protect the equipment. When the ERU is running, the EMS condenser water valve shall open to the ERU when a compressor is commanded on. The ERU manufacturer-furnished head pressure control condenser water valves shall modulate / cycle with the compressors. The ERU fans shall continue to operate unless shut down by the low temperature limit. If the ERU is off, and the outdoor air temperature is below 40°F (adj.), the EMS and manufacturer's valves shall be open to allow flow through the refrigerant / water heat exchanger.

6. Energy Wheel Sequence
  - a. Wheel shall turn at full speed when supply fan is energized and unit is not in economizer.
  - b. Economizer
    - 1) Modulate Wheel - When economizer mode is enabled and there is a signal for cooling, the wheel VFD modulates wheel speed to maintain the discharge temperature setpoint.
    - 2) The economizer will be locked out when: the outside air is less than 40°F (adj); the unit is operating in dehumidification mode; or there is a call for heating.
7. Dehumidification Sequence
  - a. The cooling is controlled to maintain the cooling coil setpoint. The dehumidification sequence will be locked out when the outside air is less than 10°F above the cold coil setpoint.
  - b. The controller will adjust the cold coil leaving air temperature set point between the minimum (50°F) and maximum (55°F) set points, to satisfy the room relative humidity set point (60% adjustable).
  - c. Reheat Sequence - While the unit is in dehumidification mode, the supply air shall be reheated using modulating hot gas reheat. The controller shall modulate the hot gas reheat valve to maintain the supply temperature set point.

8. Unoccupied Mode: When all associated zones are in the unoccupied, cool-down or warm-up modes of operation, the energy recovery unit shall be completely de-energized. The outside air damper shall be closed, the enthalpy wheel shall be disabled, and the return fan shall be disabled.
  9. Safeties:
    - a. The two position isolation valve shall fail open under loss of power or any other alarm shutdown scenario.
    - b. The DDC system shall shut down operation of the energy recovery unit and alarm whenever enthalpy wheel discharge air temperature drops below 35°F (adj.) (supply air temperature between the enthalpy wheel and refrigerant coil).
    - c. Condensate Overflow Switch: A condensate overflow switch shall be installed in the drain pan by the unit manufacturer. The condensate overflow switch shall lock out the compressors under an "alarm" condition. The DDC system shall monitor the condensate overflow alarm and indicate an alarm condition on the graphics page for each unit. The unit shall resume operation automatically once this device returns to normal.
    - d. Freezestat: A freezestat serpentine on the surface of the refrigerant coil shall disable the compressor upon sensing a freeze condition. The freezestat shall be adjustable and initially set for 38°F and shall automatically reset.
    - e. Isolation Valve Control: Each unit shall have a 2-way normally open ball control valve, as further defined herein, to shut down water flow to the unit whenever the compressor is off. The DDC system shall control the 2-position valves, via a separate Digital Output point, to open whenever the compressor runs and close whenever the compressor is off. An end switch shall verify actuator position. The DDC system shall not turn the compressor(s) on until the end switch proves the isolation valve open. An alarm shall be generated if the end switch fails to prove the valve position command.
    - f. Supply and Exhaust Air Alarm - Provide switch on each blower and display an alarm in case of blower failure.
- CC. Water Cooled Chiller, Cooling Tower, Condensing and Chilled Water Pumps.
1. Chilled Water system shall be controlled through built-in controls that shall be energized through the IFID controller, which shall also operate the condensing and chilled water pumps and through interlocks with the chiller and cooling tower.

2. Chiller capacity shall be controlled in response to return chilled water temperatures by loading or unloading of compressors by a factory approved method. Provide differential pressure switches in the chilled and condenser water piping to prevent chiller from operating unless there is a positive flow of water. Contractor shall provide necessary control and interlock wiring as recommended by the equipment manufacturer. The chiller shall send a pump request to the IFID which will enable the pumps to run in a lead/lag sequence.
  3. Condensing water temperature sensor on a fall in temperature shall de-energize cooling tower fan. On a continued fall in temperature, sensor shall position 3-way valve to gradually by-pass the cooling tower.
  4. This contractor shall interface with the chiller supplied network interface card. The points listed in the input/output summaries as well as those listed below shall be the minimum acceptable.
    - a. Chilled water pump request.
    - b. Chilled water setpoint.
    - c. Chiller enable/disable.
    - d. Chiller current draw.
    - e. Entering water temperature.
    - f. Leaving water temperature.
    - g. Compressor starts.
    - h. Compressor run time.
    - i. Alarm.
    - j. Present operating mode.
- DD. Water Cooled Chillers, Cooling Tower, Plate Type Heat Exchanger, Condenser and Chilled Water Pumps
1. General
    - a. The IFID controller shall index the chiller self contained controls, which shall operate the chillers, and through interlocks, shall control the stop/start of the condenser and chiller primary and secondary pumps and shall modulate the Heat Exchanger (HEX) two position diverting valves.

- b. Chiller capacity shall be controlled in response to return chilled water temperatures by unloading of compressors by a factory approved method. Provide differential pressure switches in the chilled and condenser water piping to prevent chiller from operating unless there is a positive flow of water. Contractor shall provide necessary control and interlock wiring as recommended by the equipment manufacturer.
- c. A sensor in the chilled water return piping shall control the chillers and HEX supply and condenser diverting valves.
- d. The HEX shall be enabled when chilled water is required and the when the outside air wet bulb is 52DEG F or less (adj).
- e. The chiller controls shall send a pump run request to the IFID controller which shall start the chiller and condenser pumps and prove operation. Should the lead pump fail an alarm will be initiated, the chiller run command will be removed. Once the standby pump manual selector switch has been indexed, the corresponding chiller shall be enabled, once the pump request has been issued the stand-by pump shall be commanded on within the factory defined time period and flow proven at this point this pump will become the lead pump for the associated chiller and cooling tower until the alarm condition is corrected, and the pump selector switch is manually placed in the normal position, should this pump fail alarms will be initiated and the chiller and cooling tower shall be disabled.
- f. This contractor shall interface with the chiller supplied network interface card. The points listed in the input/output summaries as well as those listed below shall be the minimum acceptable.
  - 1) Chilled water pump request.
  - 2) Chilled water setpoint.
  - 3) Chiller enable/disable.
  - 4) Chiller current draw.
  - 5) Entering water temperature.
  - 6) Leaving water temperature.
  - 7) Compressor starts.
  - 8) Compressor run time.

- 9) Alarm.
- 10) Present operating mode.

## 2. ECONOMIZER MODE

- a. When the outside air wet bulb is 52 DEG F or less (adj) the HEX diverting valves shall open to the HEX and close to the primary chiller. When the outside air wet bulb is 55DEG F (adj) or higher, the HEX diverting valves shall be closed to the HEX and open to the primary chiller. The primary chiller shall not operate simultaneously with the HEX.
- b. The primary chiller pump and condenser pump shall be energized. The tower by-pass valve shall modulate to maintain the chilled water leaving the HEX to 50 DEG F or less (adj). A low limit shall modulate the tower by-pass valve to prevent the chilled water from the HEX from being less than 45 DEG F.

## 3. SECONDARY CHILLER

- a. When the HEX economizer is not able to fully discharge 45 DEG F (adj), when the chilled water temperature rises to 50 DEG F the secondary chiller cooling tower by-pass valve shall close to the top of the tower; the secondary chiller and condenser pumps shall be energized.
- b. When flow is proven the secondary chiller self contained controls shall modulate the secondary chiller to provide 45 DEG F (adj) to the system.
- c. When the secondary chiller condenser water rises to 70 DEG F (adj) the cooling tower by-pass valve shall modulate open to the top of the tower.
- d. When the secondary chiller is operating and the cooling tower fan is de-energized, the secondary chiller condenser water temperature sensor shall prevent the condenser water temperature from falling below 55 DEG F by gradually bypassing the cooling tower. Fan and valve setpoints shall be different and independent. Valve shall be equipped with a hardwired positive positioning device to ensure proper sequencing so that the water does not bypass the cooling tower until the fan is stopped.
- e. The secondary chiller cooling tower controls shall cycle the fan to maintain the condenser water temperature at 55 DEG F (adj) or factory recommendation.

## 4. MECHANICAL COOLING

- a. When the combination of the HEX and the secondary chiller cannot maintain the desired chilled water temperature, the HEX diverting valves shall close, the primary chiller cooling tower by-pass valve shall close to the top of the tower and the primary chiller and condenser pumps shall be energized.
- b. When flow is proven the primary chiller self contained controls shall start the chiller to provide 45 DEG F (adj) to the system.
- c. When the primary chiller condenser water temperature rises to 70 DEG F (adj) the cooling tower by-pass shall open to the top of the tower.
- d. The primary chiller cooling tower controls shall cycle the fan to maintain condenser water temperature.
- e. When the primary chiller is operating and the cooling tower fan is de-energized, the primary chiller condenser water temperature sensor shall prevent the condenser water temperature from falling below 55 DEG F by gradually bypassing the cooling tower. Fan and valve setpoints shall be different and independent.
- f. When the temperature difference between the common supply and return temperature is greater than 12 DEG F (adj),the secondary chiller shall be energized .
- g. The primary chiller shall operate and the secondary chiller shall modulate to provide 45 DEG F (adj) to the system.
- h. When the temperature difference between the common supply and return temperatures is less than 7 DEG F (adj) the secondary chiller shall de-energize.

## EE. Makeup Air Unit with gas heat (auto shop areas)

1. Occupied Mode- The unit is energized and controlled by the ATC timed start/stop function. Unit shall operate only when the switch described below is set to " SUMMER" or "WINTER."
  - a. The gas temperature controls shall be electronically modulated between high fire and low fire. The unit shall be provided with pre-purged time delay and arranged for positive low fire start.
  - b. Discharge air temperature shall be controlled through a sensor mounted in the supply duct. An adjustable temperature selector with a range of 55F to 90F shall be mounted in the control panel in the makeup air unit.

- c. The factory provided control panel shall be mounted on the wall in the space served. The panel shall have a switch with "SUMMER-OFF- WINTER" positions. The switch shall be interlocked with the associated exhaust fan (to be interlocked under this section) so that when the switch is set to the "WINTER" position, the supply fan and exhaust fan will operate with the heating enabled. When set to "SUMMER" position, the supply fan and exhaust fan will operate with the heating disabled. The panel shall have indicating lights for "BLOWER ON", "BURNER ON" and "SAFETY LOCKOUT".
  - d. An adjustable outside air controller shall be provided to sense the outdoor air temperature and shut-off the burner if the outdoor temperature exceeds 65DEG F(adj).
2. Unoccupied Mode- The unit is de-energized.
- FF. Makeup Air Unit (self contained, plate heat exchanger and hot gas reheat for dehumidification)
1. The unit shall be controlled by a field mounted DDC controller, discharge air sensor, space temperature and humidity sensor furnished and installed by the controls contractor. Unit shall be started and stopped by a time schedule in the DDC controller. Any unit manufacturer device that is furnished with a factory DDC controller shall use EIA standard 709.1.
  2. When a zone is in the unoccupied mode, warm-up mode or cool-down mode of operation, the makeup air unit serving that zone shall remain de-energized. When any associated zone is in the occupied mode the makeup air unit shall be energized to operate and provide tempered ventilation air as required.
  3. Unit Start Command.
    - a. Factory mounted and wired outdoor air damper actuator is powered.
    - b. Heating, and cooling operation as follows.
  4. Unit Stop Command (Or De energized).
    - a. Supply fan is de-energized.
    - b. Outdoor air damper actuator is de-energized and dampers spring return closed.
  5. Cooling Sequence.



- a. The outside air damper shall be open and supply fan shall run.
  - b. A damper end switch shall be used to verify damper position and start the supply air fan once the damper has been proven open. A current switch shall verify run status of fan.
  - c. The cooling is controlled to maintain the 68°F (adj.) supply temperature setpoint. The mechanical cooling will be locked out when the outside air is less than 55°F, adjustable.
  - d. Packaged DX Cooling: Compressor shall modulate to maintain the supply air setpoint. This signal will come wired to the factory provided condensing section.
6. Dehumidification sequence.
- a. The cooling is controlled to maintain the cooling coil setpoint. The dehumidification sequence will be locked out when the outside air is less than 10°F above the cold coil setpoint.
  - b. The controller will adjust the cold coil leaving air temperature set point between the minimum (50°F) and maximum (55°F) set points, to satisfy the room relative humidity set point (60% adjustable).
  - c. Reheat Sequence - While the unit is in dehumidification mode, the supply air shall be reheated using modulating hot gas reheat. The controller shall modulate the hot gas reheat valve to maintain the supply temperature set point.
7. Heating Sequence
- a. The heating is controlled to maintain the supply temperature setpoint. The heating will be locked out when the outside air is above 70°F, adjustable.
  - b. Modulating Gas Furnace – DDC will operate the modulating gas furnace to maintain the 68°F supply temperature setpoint (adj).
8. Unoccupied Mode: When all associated zones are in the unoccupied, cool-down or warm-up modes of operation, the make up air unit shall be completely de-energized. The outside air damper shall be closed.
9. Safeties

- a. The DDC system shall shut down operation of the makeup air unit and alarm whenever the discharge air temperature drops below 35°F (adj.).
  - b. Condensate Overflow Switch: A condensate overflow switch shall be installed in the drain pan by the unit manufacturer. The condensate overflow switch shall lock out the compressors under an "alarm" condition. The DDC system shall monitor the condensate overflow alarm and indicate an alarm condition on the graphics page for each unit. The unit shall resume operation automatically once this device returns to normal.
  - c. Supply Air Alarm - Provide switch on each blower and display an alarm in case of blower failure.
- GG. Makeup Air Unit (hydronic heat pump, plate heat exchanger and hot gas reheat for dehumidification)
- 1. The unit shall be controlled by a field mounted DDC controller, discharge air sensor, space temperature and humidity sensor furnished and installed by the controls contractor. Unit shall be started and stopped by a time schedule in the DDC controller. Any unit manufacturer device that is furnished with a factory DDC controller shall use EIA standard 709.1.
  - 2. When a zone is in the unoccupied mode, warm-up mode or cool-down mode of operation, the makeup air unit serving that zone shall remain de-energized. When any associated zone is in the occupied mode the makeup air unit shall be energized to operate and provide tempered ventilation air as required.
  - 3. Unit Start Command
    - a. Factory mounted and wired outdoor air damper actuator is powered.
    - b. Heating and cooling operation as follows.
  - 4. Unit Stop Command (or de-energized)
    - a. Supply fan is de-energized.
    - b. Outdoor air damper actuator is de-energized and dampers spring return closed.
  - 5. Cooling and Heating Sequence
    - a. The outside air damper shall be open and supply fan shall run.

- b. A damper end switch shall be used to verify damper position and start the supply air fan once the damper has been proven open. A current switch shall verify run status of fan.
  - c. Compressors shall modulate to maintain supply air temperature setpoint of 68°F (adj). Supply air discharge shall have a 55°F low limit; the air leaving the DX coil shall have a 45°F low limit. The lead compressor operation shall be rotated to achieve even run time. The manufacturer's controller shall control the refrigeration circuits, refrigeration / water heat exchanger (head pressure control), refrigerant system safeties and override EMS operations to protect the equipment. When the ERU is running, the EMS condenser water valve shall open to the ERU when a compressor is commanded on. The ERU manufacturer-furnished head pressure control condenser water valves shall modulate / cycle with the compressors. The ERU fans shall continue to operate unless shut down by the low temperature limit. If the ERU is off, and the outdoor air temperature is below 40°F (adj.), the EMS and manufacturer's valves shall be open to allow flow through the refrigerant / water heat exchanger.
6. Dehumidification sequence
- a. The cooling is controlled to maintain the cooling coil setpoint. The dehumidification sequence will be locked out when the outside air is less than 10°F above the cold coil setpoint.
  - b. The controller will adjust the cold coil leaving air temperature set point between the minimum (50°F) and maximum (55°F) set points, to satisfy the room relative humidity set point (60% adjustable).
  - c. Reheat Sequence - While the unit is in dehumidification mode, the supply air shall be reheated using modulating hot gas reheat. The controller shall modulate the hot gas reheat valve to maintain the supply temperature set point.
7. Unoccupied Mode: When all associated zones are in the unoccupied, cool-down or warm-up modes of operation, the make up air unit shall be completely de-energized. The outside air damper shall be closed.
8. Safeties
- a. The two position isolation valve shall fail open under loss of power or any other alarm shutdown scenario.

- b. The DDC system shall shut down operation of the makeup air unit and alarm whenever the discharge air temperature drops below 35°F (adj.).
  - c. Condensate Overflow Switch: A condensate overflow switch shall be installed in the drain pan by the unit manufacturer. The condensate overflow switch shall lock out the compressors under an "alarm" condition. The DDC system shall monitor the condensate overflow alarm and indicate an alarm condition on the graphics page for each unit. The unit shall resume operation automatically once this device returns to normal.
  - d. Freezestat: A freezestat serpentine on the surface of the refrigerant coil shall disable the compressor upon sensing a freeze condition. The freezestat shall be adjustable and initially set for 38°F and shall automatically reset.
  - e. Isolation Valve Control: Each unit shall have a 2-way normally open ball control valve, as further defined herein, to shut down water flow to the unit whenever the compressor is off. The DDC system shall control the 2-position valves, via a separate Digital Output point, to open whenever the compressor runs and close whenever the compressor is off. An end switch shall verify actuator position. The DDC system shall not turn the compressor(s) on until the end switch proves the isolation valve open. An alarm shall be generated if the end switch fails to prove the valve position command.
  - f. Supply and Exhaust Air Alarm - Provide switch on each blower and display an alarm in case of blower failure.
- HH. Hot Water Finned Tube Radiation and Remote Water Coils.
- 1. The space sensor located where shown shall transmit space temperatures to the IFID that shall cause the hot water valve to modulate to maintain its programmed heating setting of 71°F. The heating valve shall be de-energized when the outdoor air temperature is above 62°F.
- II. Through the Wall Units
- 1. Units shall be operated through the time clock function and by the factory supplied on board controls. Unit controls shall include heating valve and system high, low, heat, off, and cool switches. Unit shall cycle to maintain setting heating 71°F - cooling 74°F - night 55°F. Unit shall have manual outside air damper.
- JJ. Cabinet Heaters and Unit Heaters

1. Cabinet and unit heaters shall be operated by remote wall mounted sensor located as shown on the drawings and strap-on aquastat sensing hot water availability. Unit fan shall cycle to maintain setting (65° F).
- KK. Electric Cabinet Heater
1. Unit heater shall be operated by a wall sensor to maintain setting of 65° F (Adj). Unit shall be locked out when the outside air temperature is above 62° F (Adj).
- LL. Electric Unit Heater
2. Unit heater shall be operated by a unit mounted sensor, unless shown otherwise, to maintain setting of 65° F. Unit shall be locked out when the outside air temperature is above 62° F (Adj).
- MM. Electric Wall Heater
3. Unit heater shall be operated by a wall sensor to maintain setting of 65° F. Unit shall be locked out when the outside air temperature is above 62° F (Adj).
- NN. Electric Duct Heater
1. Unit heater shall be operated by a wall sensor to maintain setting of 65° F. Unit shall be locked out when the outside air temperature is above 62° F (Adj).
- OO. Power Roof Ventilators
1. Kitchen Heat Removal Hood PRV - Shall be operated through time clock function constantly during occupied hours, interlocked with respective zone and shall be de-energized during unoccupied hours. All 3 phase fans shall be controlled by the ATC. All single phase fans shall be controlled manually by wall switch. Note: Firestat not required.
  2. PRV's/CEF's Nos. (Engineer to number PRV's/CEF's) - Shall be manually controlled at the wall switch in room.
  3. PRV's/ CEF's Nos. (Engineer to number PRV's/CEF's) - Shall be operated through the time clock function constantly during occupied hours interlocked with respective zones and shall be de-energized during unoccupied hours.
  4. Dry Food Storage Exhaust Fan PRV - Shall be cycled by. A wall mounted sensor thermostat. Unit shall cycle to maintain setting (75°F).
  5. Elevator Equipment Room, Electrical Room and Kiln Exhaust Fans - A wall mounted sensor shall cycle the fan and damper to maintain 75° F. In

addition, the KILN exhaust fan shall also be manually controlled at the wall switch in the room. The wall switch and the wall mounted sensor are to be wired in parallel. Note: Firestat not required for the kiln exhaust fan.

PP. Ceiling Exhaust Fans

1. Ceiling Exhaust Fans - Shall operate with local switch in affected area or through lighting circuit switch. See Plans.

QQ. Utility Vent Set - Shall be operated through time clock function energized during occupied hours and de-energized during unoccupied hours.

RR. Main Communication Room- The split system shall operate through microprocessor based wall mounted sensor provided by the manufacturer. A separate room sensor shall be provided for ATC monitoring purposes only.

SS. Domestic Hot Water and Tempered Water Circulating Pumps

1. Pumps shall be enabled through the time clock function starting one hour before occupied hours, and shall be de-energized during unoccupied hours.
2. The temperature sensor for the hot water circulating pump shall cause the BAS to start the pump at 125°F and stop the pump at 145°.
3. The temperature sensor for the tempered water circulating pump shall cause the BAS to start the pump at 95°F and stop the pump at 115°F.
4. The domestic hot water sensor shall monitor the domestic hot water temperature and display information on the graphics.

TT. HUMIDIFIER

1. Humidifier shall operate through a wall mounted humidity sensor to maintain a room relative humidity of 50%.

UU. ELECTRIC METER

1. The BAS shall monitor the electric meter for consumption on a continual basis. These values shall be made available to the system at all times
2. The BAS shall monitor and record the peak (high and low) demand readings from the electric meter. Peak readings shall be recorded on a daily, month to date, and year to date basis.
3. The BAS shall monitor and record electric meter readings so as to provide a power consumption history. Usage readings shall be recorded on a daily, month to date, and year to date basis.

### 3.05 SYSTEM COMMUNICATION DEVICES

- A. Provide a minimum of one LANID or equivalent function to support OW's.

- B. Provide gateways as required to support manufacturers configuration.

### 3.06 SYSTEM SOFTWARE AND PROGRAMMING

#### A. SYSTEM CONFIGURATION

- 1. Thoroughly configure ATC system software, network communications, remote operator workstations, portable operators terminals, printers, alarm printers.

#### B. SITE SPECIFIC APPLICATION PROGRAMMING

- 1. Provide all database creation and site-specific application control programming as required by these specifications for a fully functioning system. Contractor shall provide all initial site-specific application programming and thoroughly document programming. Meet the written sequences of operation. It is Contractor's responsibility to request clarification on sequence issues that require such clarification.
- 2. All site specific programming shall be fully documented and submitted for review and approval, both prior to downloading into the panel, at the completion of functional performance testing, and at the end of the warranty period.

#### C. PASSWORD SETUP

- 1. Set up the following password levels to include the specified capabilities:
  - a. Level 1: (Owner's BAS Administrator)
    - 1) Level 2 capabilities
    - 2) View, add, change and delete user names, passwords, password levels
  - b. Level 2: (Programmer)
    - 1) Level 3 capabilities
    - 2) Configure system software
    - 3) Modify control unit programs
    - 4) Modify graphic software
    - 5) Essentially unrestricted except for viewing or modifying user names, passwords, password levels

- c. Level 3: (HVAC Technician)
    - 1) Level 4 capabilities
    - 2) Override output points
    - 3) Change setpoints
    - 4) Change equipment schedules
    - 5) Exit BAS software to use third party programs
    - 6) Acknowledge alarms
  - d. Level 4: (Non-Technician)
    - 1) Temporarily override equipment schedules
    - 2) Display all graphic data and alarms
    - 3) Trend point data
2. Assist owner's operators with assigning user names, passwords and password levels.
- D. POINT PARAMETERS
1. Provide the following minimum programming for each analog input:
    - a. Name
    - b. Address
    - c. Scanning frequency
    - d. Engineering units
    - e. Offset calibration and scaling factor for engineering units
    - f. High and low alarm values and alarm differentials for return to normal condition
    - g. High and low value-reporting limits (reasonableness values) which shall prevent control logic from using shorted or open circuit values.





4. Provide the following minimum programming for each digital output:
  - a. Name
  - b. Address
  - c. Output updating frequency
  - d. Engineering units (on/off, open/closed, freeze/normal, etc.)
  - e. Direct or Reverse action selection
  - f. Minimum on time
  - g. Minimum off time
  - h. Status association with a DI and failure alarming (as applicable)
  - i. Reporting of each change of state, and memory storage of the time of the last change of state.
  - j. Totalization of on time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
  - k. Default value to be used when the normal controlling value is not reporting.

#### E. ALARMS

1. Alarm Priority Levels: Alarm messages specified below and the section "Sequence of Operation" shall be assigned to one of the following priority levels. Level 1 is the most critical. Level 5 is the least critical. Unless otherwise specified, alarm messages shall be assigned to priority level 5. If the BAS does not have the capability of displaying the entire specified message, it shall condense the message as necessary; if the entire meaning of the message cannot be included, the message shall reference a code number that refers to an alarm code list. The alarm code list shall be provided by the contractor with a third party database, spreadsheet, or word processor software package in a format that is searchable and easy to interface using the alarm code number. Return to normal conditions for all alarms shall be reported at the same priority level. For those alarm level, which include the POT as a reporting location, alarms shall be reported to the POT only during scheduled off-shift hours.
2. Alarm message reporting locations for each alarm priority level shall be as follows:

- a. Level 1: All Workstations and Energy Management Alarm Logger Printer
  - b. Level 2: Energy Management and Applicable HVAC Maintenance Shop Workstation, POT's, and Energy Management Alarm Logger Printers.
  - c. Level 3: Energy Management Engineer Workstation Screen and Applicable Zone Maintenance Shop Workstation Screen.
  - d. Level 4: Energy Management Engineer Workstation Screen.
  - e. Level 5: Maintenance Shop Workstation Alarm Logging Printer.
3. Override alarms: Any point that is overridden through the override feature of the graphic workstation software shall be reported as a Level 3 alarm.
  4. Analog Input Alarms: For each analog input, program an alarm message for reporting whenever the analog value is outside of the programmed alarm limits. Report a return to normal message after the analog value returns to the normal range, using a programmed alarm differential. The alarm limits shall be individually selected by the contractor based on the following criteria:
    - a. Space temperature, except as otherwise stated in sequence of operation with a built in delay of 15 minutes (adjustable): Level 2
      - 1) low alarm: 10°F below setpoint
      - 2) low return to normal: 8°F below setpoint
      - 3) high alarm: 10°F above setpoint
      - 4) high return to normal: 8°F above setpoint
    - b. Controlled media temperature other than space temperature (e.g. AHU discharge air temperature, boiler water supply, water temperature, condenser water supply, and chilled water supply) with a built in delay of 10 minutes (adjustable): Level 2
      - 1) low alarm: 8°F below setpoint
      - 2) low return to normal: 5°F below setpoint
      - 3) high alarm: 8°F above setpoint
      - 4) high return to normal: 5°F above setpoint.

- c. AHU mixed air temperature: Level 2
    - 1) low alarm: 45°F
    - 2) low return to normal: 47°F
    - 3) high alarm: 90°F
    - 4) high return to normal: 85°F
  - d. VAV Duct Pressure: Level 2
    - 1) low alarm: 1.0"w.g. below setpoint
    - 2) low return to normal: 0.5"w.g. below setpoint
    - 3) high alarm: 0.5"w.g. above setpoint
    - 4) high return to normal: 0.25"w.g. above setpoint
  - e. Space humidity: Level 2
    - 1) high alarm: 80%
    - 2) high return to normal: 70%
5. HOA Switch Tampering Alarms: The sequences of operation are based on the presumption that motor starter HOA switches are in the auto position. If a motorized equipment unit starts without a prior start command from the BAS, (as sensed by status sensing device), then BAS shall perform the remaining sequence as specified. BAS shall also enunciate the following Level 3 alarm message if status indicates a unit is operational when the run command is not present.
- a. *DEVICE XXXX FAILURE*: Status is indicated on even though it has been commanded to stop. Check the HOA switch, control relay, status-sensing device, contactors, etc. involved in starting the unit. Acknowledge this alarm when the problem has been corrected.
6. Maintenance Alarms: Enunciate Level 5 alarms when runtime accumulation exceeds a value specified by the operator
- a. *DEVICE XXXX REQUIRES MAINTENANCE*. Runtime has exceeded specified value since last reset.

7. To eliminate nuisance and invalid alarms, alarms shall not be reported if the software algorithm or point is inactive.
8. See requirements for additional equipment-specific alarms specified under "Sequence of Operation".
9. During the construction and warranty period the following alarms and their parameters are the only alarms which are to be considered Level 1. These alarms will not require acknowledgement and display return to normal when the alarm condition has cleared.
  - a. Boiler alarm
  - b. Chiller alarm
  - c. Hot water pump alarm- pump shall alarm when command=on and status is off, or command= off and status is on.
  - d. Chilled water pump alarm- pump shall alarm when command=on and status is off, or command= off and status is on.
  - e. Condenser water pump alarm- pump shall alarm when command=on and status is off, or command= off and status is on.
  - f. Supply fan failure alarm- fan shall alarm when command= on and status is off, or command=off and status is on.
  - g. Freeze stat alarm- implement only on those projects which have this capability.
  - h. Walk-in freezer alarm- alarm if temperature is greater than 15 Deg F for 30 or more minutes (adj).
  - i. Walk-in refrigerator alarm- alarm if temperature is greater than 40 Deg F for 30 or more minutes (adj).
  - j. Communications room high temperature alarm- alarm if room temperature is greater than 90 Deg F.
  - k. Cooling tower basin alarm- alarm if basin temperature is below 32 Deg F (adj).
  - l. Hot water reset alarm- alarm if the hot water temperature falls 30 Deg F or more below setpoint when the outdoor air temperature is 50 Deg F or less (adj).

## F. TRENDING

The following constitutes those items, which, at a minimum, shall be included in a history submittal:

1. Outdoor Air:
  - a. Drybulb temperature
  - b. Wetbulb temperature
  - c. Calculated Enthalpy
  - d. Relative Humidity
2. Phase, Voltage, Frequency: Histories should indicate time and duration of any occurrence of power interruption and normal power resumption.
3. Overrides: Run status:
4. Boilers:
  - a. Enabled command
  - b. Status (normal and alarm)
  - c. Common boiler header supply temperature
  - d. Common boiler return water temperature
  - e. Lead/Lag selection
5. Heating Water System:
  - a. System supply water temperature
  - b. System return water temperature
  - c. Calculated reset temperature
  - d. Reset valve position
6. Heating Water Pumps:
  - a. Schedule run status
  - b. Actual run status

- c. Log alarmed outages
  - d. Provide history for main and stand-by pumps
7. Chillers:
- a. Scheduled run status
  - b. Actual run status
  - c. Amperage
  - d. Log alarmed outages
  - e. Chilled water supply temperature (from each chiller)
  - f. Chilled water return temperature (common)
  - g. Lead/lag selection
8. Chillers' Pumps:
- a. Scheduled run status
  - b. Actual run status
  - c. Log alarmed outages
9. Condenser Water Pump:
- a. Scheduled run status
  - b. Actual run status
  - c. Log alarmed outages
10. System Chilled Water Pump:
- a. Scheduled run status
  - b. Actual run status
  - c. Log alarmed outages
11. Cooling Tower:
- a. Scheduled run status and fan speed sequencing

- b. Actual run status
  - c. Amperage
  - d. Log alarmed outages
  - e. Condenser water supply temperature
  - f. Condenser water return temperature
  - g. Calculated condenser water reset temperature
  - h. Reset valve position
12. Air Handling Equipment: (includes all equipment which supplies conditioned air)
- a. Supply fan command
  - b. Supply fan status
  - c. Supply air temperature
  - d. Return air temperature
  - e. Mixed air temperature
  - f. Outdoor, return, and relief air dampers positions
  - g. Valves positions
  - h. Duct static pressure (VAV units)
  - i. VAV control signal (VAV units)
13. Water Heating /Cooling Coils:
- a. Space or discharge (controlling) temperature
  - b. Valve position
14. Exhaust Fans:
- a. Scheduled run/enabled status
  - b. Actual run status or enabled status



- c. Histories shall show fans operation as interlocked with other equipment/systems when controlled as such.
15. Variable Air Volume Terminals:
- a. Space air temperature
  - b. Air damper position
  - c. Heating coil valve position
  - d. Fan command
  - e. Fan status
  - f. Space setpoint adjust
16. Incremental Units (Units Ventilators, Fan Coil Units, Heaters, VRF, Valance, etc):
- a. Fan command
  - b. Fan status
  - c. Dampers position
  - d. Valves positions
  - e. Space temperature
  - f. Space setpoint adjust
17. Provide trending of all inputs and outputs in a 24 hour period such that the occupied/ unoccupied schedule can be accurately observed. The school shall be programmed to the specified schedule prior to trending. Refer to section 3.04, A, 8.

#### G. EQUIPMENT SCHEDULES

1. Program the following master schedules with the stated equipment assignments according to the Control Zone Diagram on the mechanical drawings: Each zone shall have separate schedules as follows:
- a. Weekdays: occupied time: unoccupied time:
  - b. Weekends: occupied time: unoccupied time:
  - c. Holidays: occupied time: unoccupied time:

- d. Snow Days: occupied time: unoccupied time:
  - e. Override: occupied time: unoccupied time:
  - f. Administrative Days (no students or faculty): occupied time: unoccupied time:
- H. GRAPHIC SCREENS
- 1. Floor Plan Screens:
    - a. Provide County Graphic Site Screen showing the location of each county school and support facility building. Provide links to and from each building plan. Adjacent to each school provide a separate alarm flag (or similar icon) for any level one alarm and power failure alarm (loss of phase or power). The condition flag or icon shall be green for normal and red for alarm.
    - b. Provide a graphic floor plan screen for each floor of the building.
    - c. Indicate location of all equipment that is not located on the equipment room screens.
    - d. Indicate locations of temperature sensors associated with each temperature control zone on control floor plan screens.
    - e. Display space temperature setpoint adjustment to each sensor symbol.
    - f. Use distinct colors to demarcate the air handling equipment and perimeter radiation zones.
    - g. Indicate room numbers as provided by the owner (final room signage number).
    - h. Provide a drawing link from each space temperature sensor symbol and equipment symbol shown on the graphic floor screen.
    - i. Provide graphic floor plan screen for each mechanical equipment room and a plan screen of the roof.
    - j. Indicate the location of each item of mechanical equipment.
    - k. Provide a graphic floor plan override screen of the entire building. Use a distinct line to demarcate each temperature control zone and identify each zone. The zone background color shall be a solid color, when a control zone is overridden this zone will be indicated as red on the graphic floor plan override screen.



and calculate wet bulb temperature. A password protected button on this graphic screen labeled "Override" will, when enabled, place the chiller plant in manual operation regardless of the outside temperature.

- g. The cooling graphic screen shall display the supervisory message for start/ stop of the lead or lag chillers.
- h. Link screens for chilled and condenser water systems if they cannot fit on one cooling plant graphic screen.
- i. Provide a heating graphic screen showing all points associated with the boilers and heating pumps. Indicate outside air dry bulb temperature and relative humidity. A password protected button on this graphic screen labeled "Override" will, when enabled, place the heating plant in manual operation regardless of the outside temperature.
- j. Link screens for heating and cooling system graphics to utility history reports showing current and monthly use, demands, peak values ect.
- k. Provide a graphic link (button) from the equipment graphic screen to the written sequence of operation.

#### I. BAR CHART/LINE CHART SCREENS:

On each graphic Chart Screen, provide drawing links to the graphic air handling systems (includes all equipment which supplies conditioned air) schematic screens. The chart graphic shall include a vertical bar showing 0-100% output that is designated by a dynamic color fill that changes based on the analog output of the variable.

- 1. Provide a graphic air handling system status screen showing the current start or stop command and the status of all supply and return (or exhaust as applicable) fans.
- 2. Provide a graphic VAV fan screen showing the supply and return fan status of each VAV fan. Show the supply duct static pressure and setpoint of each VAV air handling system expressed in inches w.g., supply fan output signals expressed in percentage of maximum flow. Analog values shall be indicated in bar chart format. If multiple screens are necessary, provide links between screens.
- 3. Provide a graphic air handling equipment damper screen showing for each air handling system the economizer damper output signal in a bar chart format with signals expressed as percentage of fully open outside air damper return temperature return enthalpy and mixed air temperature.

4. Provide a chilled water valve screen showing the analog output signal of all chilled water valves in a bar chart format, with signals expressed as percentage of fully open (percentage of full cooling).
5. Indicate the discharge air temperature and setpoint of each air handling system and cooling system chilled water supply and return temperature. Provide drawing links between the graphic cooling plant screen and this graphic.
6. Provide a graphic heating valve screen showing the analog output signal of all air handling system heating water valves in a bar chart format with the signals expressed as percentage of fully open valve (percentage of fully open) indicate the temperature of the controlled medium (i.e. air handling system discharge air temperature) and the associated setpoint, heating plant hot water supply and hot water return temperature and outside air temperature and humidity. Provide drawing links between the graphic heating plant screen and this graphic screen.

#### J. TREND GRAPHS

1. Prepare controller and workstation software to display graphical format trends. Trend graphs shall demonstrate compliance with contract documents.
2. Lines shall be labeled and shall be distinguishable from each other by using either different line types, or different line colors.
3. Indicate engineering units of the y-axis values; e.g. degrees F., inches w.g., Btu/lb, percent wide open, etc.
4. The y-axis scale shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.
5. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended.
6. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended during the same trend period.
7. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.
8. All physical points and calculated variables shall be available for trending.
9. In the graphical format, the trend shall plot at least four different values for a given time period superimposed on the same graph.

10. The four values shall be distinguishable by using unique colors.
11. In the printed form the four lines shall be distinguishable by different line symbology. Displayed trend graphs shall indicate the engineering units for each trended value.
12. The trended value range shall be user selectable.

K. DYNAMIC SYMBOLS

1. Provide a selection of standard symbols which change in appearance based on the value of an associated point.
2. Analog symbol: provide a symbol that represents the value of an analog point as the length of line or linear bar.
3. Digital symbol: provide symbols such as switches, pilot lights, rotating fan wheels ect. to represent the value of a digital input or output point as appropriate. Animation for any operating machinery shall only represent digital inputs, and not outputs, in order to provide an accurate equipment status.
4. Point status color: graphic presentation shall indicate different colors for different point status. (For instance, green=normal, red= alarm, gray or??? for no response).
5. Use dynamic zone background colors (thermograph) to indicate thermal comfort based on temperature offset from setpoint on the zone graphic display screens.

The colors are as follows:

Red - 5 DEG F or more below setpoint  
Dark Blue - 4 DEG F below setpoint  
Light Blue - 2 DEG F below setpoint  
Green - Satisfied  
Yellow - 2 DEG F above setpoint  
Orange - 4 DEG f above setpoint  
Red - 5 DEG F or more above setpoint

- L. ALARMS: In general, alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (e.g., chiller alarm shall be shown on graphic cooling system schematic screen). For all

graphic screens, display analog values that are in an alarm condition in a red color. Indicate digital values that are in alarm condition in a red color.

- M. **ALARM MANAGER:** A master alarm management screen shall be provided on each workstation. The alarm management screen shall include the building location, the name of the piece of equipment in alarm, the nature of the alarm or alarm message. The alarm descriptor shall be fully descriptive and shall include the time of the alarm, the current status of the alarm (unacknowledged, acknowledged, return to normal) with appropriate reporting times. Once the alarm is acknowledged and has returned to normal the alarm shall be archived and the alarm shall be shaded on the screen. The operator, with the proper password, shall have the ability to delete those alarms that have been acknowledged and have returned to normal. The system shall be able to custom search for alarm types and locations. The system shall have the ability to print alarms to the workstation alarm printer and report alarms remotely to unlimited alphanumeric pagers and printers.

### 3.07 HVAC SYSTEMS – GENERAL DIAGNOSTICS AND MONITORING

#### A. AIR HANDLING EQUIPMENT DIAGNOSTICS – GENERAL

1. **Diagnostic Strategies:** In addition to the standard alarm limits specified for all sensed variables the BAS monitor and diagnose anomalies in the operation of the air handling units. The following “diagnostic strategies” shall be included by reference with each air handling system with any specific clarifications required:
  - a. **Run Time Limit:** BAS shall accumulate the runtime of the status of associated rotating equipment and enunciate a level 4 and 5 alarm to indicate that the unit is in need of service. Contractor shall set this interval as directed by the Owner.
  - b. **Heating Valve Leak:** While heating valve is closed, if the temperature increase across the heating coil exceeds 2°F continuously for 30 minutes; or if the discharge temperature is more than 5°F above setpoint for more than 30 minutes continuously, annunciate the following alarm at level 3 priority:
    - 1) **ENERGY WASTE:** An unexpected temperature rise is occurring across the heating coil. Please check for leaking valve or faulty controls.
  - c. **Cooling Valve Leak:** While cooling valve is closed, if the temperature drop across the cooling coil exceeds 2°F continuously for 30 minutes; or if the discharge temperature is more than 5°F below setpoint for more than 30 minutes continuously, annunciate the following alarm at level 3 priority:

- 1) ENERGY WASTE: An unexpected temperature drop is occurring across the cooling coil. Please check for leaking valve or faulty controls.
- d. Cooling Capacity Shortage: BAS shall monitor the output to the valve. If the output exceeds 99% open for 1 hour continuously, annunciate the following alarm at level 3 priority:
- 1) Lack of Capacity: The cooling valve of XXX has been commanded to the full open position for an extended time period. Ensure that the setpoint for the control loop is at a reasonable value and that flow to the coil has not been obstructed as in a plugged strainer, throttled balancing valve, debris in the control valve, etc.
- e. Economizer Anomaly: If mixed air temperature is less than 45°F or greater than 85°F; or if the outside air temperature is between 55°F and 65°F and the mixed air temperature is more than 2°F different from the outside air temperature for more than 30 minutes continuously, enunciate the following alarm at level 3 priority:
- 1) ENERGY WASTE: An unexpected mixed air temperature indicates a possible problem with the economizer damper controls. Please check for faulty dampers or controls.
- f. Fighting Valves: BAS shall monitor the valve positions of the preheat and cooling coils and shall enunciate the following level 3 alarm if the valve positions are both over 10% open.
- 1) Fighting Valves: The preheat and the cooling valves are opening simultaneously on XXX. Coordinate the control loops.

## B. AIR HANDLING EQUIPMENT MONITORING AND MANAGEMENT

1. General: The BAS shall monitor various aspects of the air handling systems and calculate parameters as specified below to facilitate operations and management.
2. System Condition Alarming: BAS shall monitor the following parameters and enunciate an alarm under any of the following conditions in addition to other monitor and alarm functions specified above:
  - a. Annunciate a Level 3 alarm when any active (air flowing) discharge temperature goes above or below its setpoint plus  $\pm 8^{\circ}\text{F}$  (adj.) for 15 min. continuously as follows:



- 1) AHU xx sensor is indicating that the discharge temperature is outside of acceptable limits.
  - b. Annunciate a Level 3 alarm when any active (air flowing) heating duct or heating coil leaving temperature falls below its setpoint minus 8°F (adj.) for 15 min. continuously as follows:
    - 1) AHU xx sensor is indicating that the heating air temperature is below acceptable limits.
  - c. Annunciate a Level 3 alarm when any active (air flowing) cooling duct or cooling coil leaving temperature exceeds setpoint plus 8°F (adj.) for 5 min. continuously as follows:
    - 1) AHU xx sensor is indicating that the cooling air temperature is above acceptable limits.
  - d. During the occupied period, enunciate a Level 3 alarm when any space temperature exceeds its active cooling setpoint plus 10°F (adj.) for 15 min. or falls below its active heating setpoint minus 10°F (adj.) for 15 min. continuously.
    - 1) Zone (Rm.#) appears to be outside of acceptable limits.
3. Trending: The BAS shall continuously monitor, calculate and display the following parameters at the intervals indicated. These values shall be stored initially in the buffer of the controlling control unit, and then be uploaded periodically and stored on a specified hard disc. All values shall be easily adjustable from the workstation screen. Contractor shall format this data to support one of the following data formats:
  - a. Quote (text strings) and Comma delimited
  - b. Microsoft EXCEL
  - c. Microsoft ACCESS
4. Parameters to be trended:
  - a. All temperature sensors at 30 minute intervals
  - b. All relative humidity sensors at 30 minute intervals
  - c. All pressure sensors at 30 minute intervals
  - d. All run requests and statuses on a change in value

- e. All analog loop outputs on 1 hour intervals
- f. Calculated enthalpies in 1 hour intervals
- g. Summed cooling and heating requests on 1 hour intervals

#### C. CENTRAL PLANT MONITORING AND MANAGEMENT

1. General: The BAS shall monitor various aspects of the heating and cooling systems and calculate parameters as specified below to facilitate plant operations and management.
2. System Condition Alarming: BAS shall monitor the following parameters and annunciate an alarm under any of the following conditions in addition to other monitor and alarm functions specified above
  - a. Annunciate a Level 2 alarm when any active (water flowing) CHW supply temperature exceeds its setpoint plus 8°F (adj.) for 15 min. continuously as follows:
    - 1) CHW sensor is indicating that the chilled water temperature is above acceptable limits.
  - b. Annunciate a Level 2 alarm when any active (water flowing) HW supply temperature exceeds its minus 20°F (adj.) for 15 min. continuously as follows:
    - 1) HW sensor is indicating that the hot water temperature is below acceptable limits.
  - c. Annunciate a Level 2 alarm when any active (water flowing) tower water supply temperature exceeds 100°F (adj.) for 2 min. continuously as follows:
    - 1) TW sensor is indicating that the tower water temperature is above acceptable limits.
  - d. Annunciate a Level 2 alarm when any active (water flowing) tower water supply temperature falls below 55°F (adj.) for 2 min. continuously as follows:
    - 1) TW sensor is indicating that the tower water temperature is below acceptable limits.

#### 3.08 SYSTEM ACCEPTANCE

General: The following list outlines the general sequence of events for system acceptance:

1. ATC/BAS Start-up, Testing, Adjusting, Calibration
2. Trending
3. Correction of deficiencies from Items 1 and 2
4. ATC Final Inspection following the HVAC equipment demonstration.
5. Correction of deficiencies from Item 4
6. ATC Demonstration
7. Graphics Inspection
8. Substantial Completion
9. ATC/BAS Operator Training
10. "Off Season" Inspection as Required

Projects with phased construction shall have items 1-3 completed from the sequence of events, prior to acceptance of Final Inspection for Phase. The remaining items shall be completed prior to completion of the Final Phase of the project.

**A. ATC/BAS START-UP TESTING, ADJUSTING, CALIBRATION**

1. Work and/or systems installed under this Division shall be fully functioning prior to final inspection. Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below, but not limited to the items listed:
  - a. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance.
  - b. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
  - c. Verify integrity/safety of all electrical connections.
2. Coordinate with TAB subcontractor to fine tune control settings that are determined from balancing procedures. Record the following control settings as obtained from TAB contractor, and note any TAB deficiencies in the ATC/BAS Start-Up Report:
  - a. Optimum duct static pressure setpoints for VAV air handling units.
  - b. Minimum outside air damper settings for air handling units

- c. Optimum differential pressure setpoints for variable speed pumping systems
  - d. Calibration parameters for flow control devices such as VAV boxes and flow measuring stations.
3. Test, calibrate, and set all digital and analog sensing, and actuating devices. Calibrate each instrumentation device by making a comparison between the ATC display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the ATC/BAS Start Up Report.
4. Check and set zero and span adjustments for all transducers and transmitters.
5. For dampers and valves:
  - a. Check for adequate installation including free travel throughout range and adequate seal
  - b. Where loops are sequenced, check for proper control without overlap
6. For actuators:
  - a. Check to insure that device seals tightly when the appropriate signal is applied to the operator.
  - b. Check for appropriate fail position, and that the stroke and range is as required
  - c. For sequenced electronic actuators, calibrate per manufacturer's instructions to required ranges
7. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device in the ATC/BAS Start-Up Report.
8. For outputs to reset other manufacturers devices (VSDs) and feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.

9. Verify proper sequences by using the approved checklists to record results and submit with ATC/BAS Start-Up Report. Verify proper sequence and operation of all specified functions.
10. Verify all safety devices trip at appropriate conditions. Adjust setpoints accordingly.
11. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the ATC/BAS Start Up Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond to) in the control loop, tolerances shall be maintained (exceptions noted):
  - a. Duct air temperature:  $\pm 1^{\circ}\text{F}$ .
  - b. Space Temperature:  $\pm 2^{\circ}\text{F}$
  - c. Chilled Water:  $\pm 1^{\circ}\text{F}$
  - d. Hot water temperature:  $\pm 3^{\circ}\text{F}$ .
  - e. Duct pressure:  $\pm 0.25''$  w.g.
  - f. Water pressure:  $\pm 1$  psid
  - g. Duct or space Humidity:  $\pm 5\%$
  - h. Air flow control:  $\pm 5\%$  of setpoint velocity
  - i. Space Pressurization (on active control systems):  $\pm 0.05''$  wg with no door or window movements
12. For interface and DDC control panels:
  - a. Ensure devices are properly installed with adequate clearance for maintenance and clearly labeled in accordance with the record drawings
  - b. Ensure termination's are safe, secure and labeled in accordance with the record drawings
  - c. Check power supplies for proper voltage ranges and loading.
  - d. Ensure wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.

- e. Check for adequate signal strength on communication networks.
  - f. Check for stand-alone performance of controllers by disconnecting the controller from the LAN. Verify the event is enunciated at OIs. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection
  - g. Ensure all outputs and devices fail to their proper positions/states.
  - h. Ensure buffered and/ or volatile information is held through power outage
  - i. With all system and communications operating normally, sample and record update/enunciation times for critical alarms fed from the panel to the OI.
  - j. Check for adequate grounding of all DDC panels and devices
13. For Operator Interfaces:
- a. Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
  - b. Output all specified BAS reports for review and approval.
  - c. Verify the alarm printing and logging is functional and per requirements
  - d. Verify trend archiving to disk and provide a sample to the CA for review
  - e. Verify paging/dial out alarm enunciation is functional
  - f. Verify functionality of remote OIs and that a robust connection can be established consistently.
  - g. Verify that required third party software applications required with the bid are installed and functional.
14. Submit Start-Up Test Report. Report shall be submitted and approved prior to Final ATC Inspection.

**B. ATC/BAS INSPECTION**

1. Demonstrate the operation of the ATC/BAS hardware, software, and all related components and systems to the satisfaction of the Owner and/or the CA. Schedule the inspection with the Owner 2 weeks in advance.

Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report is approved.

2. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the job site.
3. Demonstration shall include all major pieces of equipment, central plants and a small representative samples of terminal equipment randomly selected by the Owner.
4. The system shall be demonstrated following the same procedures used in the Start-Up Test Report. Demonstration shall include, but not necessarily be limited to, the following:
  - a. Demonstrate that required software is installed on BAS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
  - b. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
  - c. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.
  - d. Demonstrate correct calibration of input/output devices. A maximum of 10 percent of I/O points shall be selected at random by the Owner and/or Owner's Representative for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by Owner for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
  - e. Demonstrate that all DDC and other software programs exist at the respective distributed digital controllers. The Direct Digital Control (DDC) programming and point database shall be as submitted and approved.
  - f. Demonstrate that all DDC programs accomplish the specified sequences of operation.
  - g. Demonstrate that the panels automatically recover from power failures, as specified.

- h. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
  - i. Identify access to equipment selected by Owner. Demonstrate that access is sufficient to perform required maintenance.
  - j. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.
5. ATC/BAS Demonstration shall be completed and approved prior to Substantial Completion.

#### C. TRENDING

1. The Contractor shall have their software completely loaded and functional at least one week prior to the ATC final inspection and a complete set of histories shall have been submitted to the Engineer for his review. The intent of this is to determine whether installed software is functioning as intended. As there may be more points requiring trending than a single history program's capability, more than one run of histories may be necessary to provide all required data.
2. Prior to submitting a history, the Contractor shall perform a self-review to identify and correct problems. Histories shall be presented at hourly intervals for an occupied 24-hour period, unless directed otherwise. During the final inspection and during the warranty period, if any malfunction occurs in the system operation, systems being monitored shall be operated with an occupancy schedule; i.e. indications that a system was scheduled off for the 24 hours of the history and remained off are of no value.
3. During the inspection all system setpoints (both calculated and manual inputs) shall be provided with the histories. If malfunctions occur during subsequent histories review, the system in question shall have all pertinent setpoints logged in the history.
4. Inspections shall not occur without the system/s operating in either the mechanical heating or cooling mode; if scheduled delivery of the project falls during a period in which the system/s are not operating, the inspection will be delayed until such time as the system/s have been operating under control for one week.

#### D. TREND LOGS



1. Trend logs are databases of ASCII characters (usually numbers) representing a historical record of the systems operation. Contractor shall establish and store these trend logs.
  2. CA/Owner's representative shall analyze trend logs of the system operating parameters to evaluate normal system functionality. Contractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the CA/Owner's representative.
  3. Sample times indicated as COV ( $\pm$ ) or change of value mean that the changed parameter only needs to be recorded after the value changes by the amount listed. When output to the trending file, the latest recorded value shall be listed with any given time increment record. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the interval common to the unit.
  4. Contractor shall provide the CA/Owner's representative with required passwords, phone numbers, etc. to allow the CA/Owner's representative access to the trend log data and allow downloading to a remote location. Contractor shall also provide step-by-step written instructions for accessing the data.
- E. WARRANTY PERIOD ATC/BAS OPPOSITE SEASON TRENDING AND TESTING:
1. Trending: throughout the warranty period, trend logs shall be maintained. Contractor shall forward archived trend logs to the CA/OWNER for review upon CA/OWNER's request. CA/OWNER shall review these and notify contractor of any warranty work required.
  2. Opposite Season Testing: Within 6 months of completion of the Acceptance Phase, CA/OWNER shall schedule and conduct Opposite Season functional performance testing. Contractor shall participate in this testing and remedy any deficiencies identified.
- F. SOFTWARE OPTIMIZATION ASSISTANCE
1. The contractor shall provide the services of a control technician as specified above at the project site to be at the disposal of the CA/OWNER. The purpose of this requirement is to make changes, enhancements and additions to control unit and/or workstation software that have been identified by the CA/OWNER during the construction and commissioning of the project and that are beyond the specified Contract requirements. The cost for this service shall be included with the bid. Requests for assistance shall be for contiguous or non-contiguous 8 hour days, unless otherwise mutually agreed upon by contractor, Commissioning Agent, and Owner. The Owner's representative shall notify contractor 2 days in advance of each day of requested assistance.

2. The control technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the controls technician provided cannot perform every software task requested by the Commissioning Agent/Owner in a timely fashion, contractor shall provide additional qualified personnel at the project site as requested by the Commissioning Agent/Owner, to meet the total specified requirement on-site.

G. ATC/BAS OPERATOR TRAINING:

1. Provide services of controls contractor's qualified technical personnel for three 6-hour days to instruct Owner's personnel in operation and maintenance of BAS. CA/OWNER shall witness selected sessions. Instruction shall be in classroom setting at an Owner selected site for appropriate portions of the training. Training may be in non-contiguous days at the request of the Commissioning Agent or Owner. The Owner's representative shall notify contractor 1 week in advance of each day of requested training.
2. Demonstrate to the Owners building operation personnel and custodial crews, the proper use of the building Override Panel.
3. Provide up to 4 complete sets of the approved Operations and Maintenance Manual to be used for training in addition to the requirements in Section 1.10.D OPERATIONS AND MAINTENANCE MANUALS.
4. The contractor's designated training personnel shall meet with the Commissioning Agent and owner's representative for the purpose of discussing and fine-tuning the training agenda prior to the first training session.  
Training agenda shall generally be as follows:

a. Day 1

- 1) Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of CU portable and built-in operator interface device display capabilities.
- 2) Brief overview of the various parts of the O&M manual, including hardware and software programming and operating publications, catalog data, controls installation drawings, and DDC programming documentation.
- 3) Demonstration of workstation login/logout procedures, password setup, and exception reporting.

- 4) Demonstration of workstation menu penetration and broad overview of the various workstation features.
- b. Day 2
- 1) Introduction to CU programming.
  - 2) Review of sequence of operation, CU programming, standalone modes, fail modes and graphic workstation screen for each HVAC subsystem.
- c. Day 3
- 1) Review of alarm feature
  - 2) Review of diagnostics features
  - 3) Review of I/O hardware testing, calibration, and replacement.
  - 4) Review of trend feature.
  - 5) Review of workstation reports.
  - 6) Review of setpoint optimization and fine-tuning concepts.
  - 7) Review of all remaining miscellaneous workstation features.
  - 8) Question and answer period.

END OF SECTION

## SECTION 15905

### VARIABLE FREQUENCY DRIVE

#### PART 1 - GENERAL

##### 1.01 GENERAL

- A. The Bidding and Contract Requirements and Division I - General Requirements for the Construction of this project shall apply to this division and all sections herein.

##### 1.02 SCOPE

- A. This specification defines the minimum requirements for a Variable Frequency Drive (VFD) for pump speed control.

##### 1.03 QUALITY ASSURANCE

- A. The VFD shall have a U/L listing and shall comply with UL508.

##### 1.04 SUBMITTALS

- A. Provide shop drawings on this equipment as described in Section 15010 - 1.04.

#### PART 2 - PRODUCTS

##### 2.01 VARIABLE FREQUENCY DRIVE

The variable frequency drive shall be of the size, capacity, and voltage shown on the drawings. The variable frequency drive shall be manufactured by MAGNETEK. Variable frequency drives fully equal to the specified drive and manufactured by DANFOSS, SAFTRONICS, ABB and TOSHIBA are acceptable.

##### 2.02 GENERAL REQUIREMENTS

- A. The VFD shall convert incoming fixed frequency three phase AC power into a variable frequency and voltage for controlling the speed of three phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and/or fan control.
- B. The VFD shall use 32-bit microprocessor based digital control technology and ASIC's (Application Specific Integrated Circuits) to regulate motor operation.
- C. An advanced sine wave approximation and voltage vector control shall be used to allow operation at rated motor shaft output at nominal speed with no de-rating.

- D. Means shall be provided for local Hand operation and for the local or remote selection of Hand or Auto operation.
- E. There shall be a back lighted three line LCD alphanumeric display capable of displaying fault conditions, and suitable selectors to allow the display of operating conditions, set up of parameters and VFD configuration.
- F. Equipment supplied must conform to recognized international standards and be manufactured to ISO 9001.
- G. The manufacturer shall demonstrate a continuous period of manufacture and development for at least 10 years.
- H. The manufacturer shall have integral add-on systems available for the addition of an AC line disconnect, bypass switchgear, and other devices as specified.
- I. Manufacturer will provide contactors and controls as necessary for a complete system.
- J. The Division 15900 contractor is responsible for selecting and providing the differential pressure transducer. The drive manufacturer shall coordinate with the division 15900 contractor to ensure the drive will accept the control signal as specified in 15900 2.02.

### 2.03 PACKAGE REQUIREMENTS

- A. VFD enclosure shall be NEMA 1 for indoor applications and NEMA 3R for outdoor applications unless otherwise noted.
- B. The enclosure shall be sized to allow the drive to operate at full rated current continuously with no additional cooling in ambient temperatures from -10° C to +40° C (+14° F to +104° F).
- C. The VFD shall be rated to operate at a humidity of 95% RH to IEC 68-2.3 standard.
- D. The VFD shall comply with the following vibration standards:
  - IEC 68-2-6, Vibration (sinusoidal) 1970
  - IEC 68-2-34, Random vibration wide band general requirement
  - IEC 68-2-35, Random vibration wide band reproducibility high
  - IEC 68-2-36, Random vibration wide band reproducibility med
- E. The VFD shall comply with the following EMC (Electromagnetic compatibility) standards:
  - Emission - EN55011/CISPR 11 (w/RFI filter option)
  - Immunity - IEC 801-2 Electrostatic discharge
  - Immunity - IEC 801-3 Radiated electromagnetic field

- F. Power line noise shall be limited to a voltage distortion factor and line notch depth as defined by IEEE Standard 519-1992. Harmonic distortion shall not exceed 5% for general systems or 10% for dedicated power feed systems as measured at a point of common coupling (as defined at the point of utility metering). VFD manufacturer shall be responsible for acquiring all information necessary to determine harmonic content of the system and to certify compliance.

#### 2.04 INPUT POWER

- A. VFD's rated nominal 460 volts AC shall meet all specifications when operating from 440 to 500 Volts +/-10%, three phase, 47 to 63 Hz power.
- B. VFD's rated nominal 230 volts AC shall meet all specifications when operating from 200 to 230 Volts +/-10%, three phase, 47 to 63 Hz power.
- C. An input isolation transformer shall not be required.
- D. The VFD shall be capable of being powered from an AC distribution system having a symmetrical short circuit current rating of 100,000 amps RMS when the manufacturer's recommended fuses are used.
- E. The VFD shall incorporate filters in the EDC link section sized so as to limit the AC line current 5th harmonic to approximately 35%. External AC line reactors are not permitted.
- F. Displacement power factor shall be 90% or greater from no load to full load.
- G. Full load efficiency shall be greater than 96% at 100% load and greater than 92% at 20% load.
- H. The VFD input shall comply with the following AC line disturbance standards:
  - VDE 0160, Section 5.3.1.1.3, Under voltage
  - VDE 0160, Section 5.3.1.1.3, Over voltage
  - VDE 0160, Section 5.3.1.1.3, Phase loss
- I. The VFD shall be insensitive to input phase rotation. Changing input phase rotation during shut down must have no effect on the VFD operation and shall not require reconnection of incoming power or motor wiring.
- J. Inrush current shall be limited to a value that will not cause nuisance blowing of the incoming power line fuses when drive manufacturer recommended fuses are used.
- K. The VFD's AC line input shall comply to the following EMC (Electromagnetic compatibility) standards:

Emission - EN55011, class A group 1 or class B group 1 as applicable (with optional RFI filter)  
Emission - VDE 0875, part 3, curve N or G as applicable (with optional RFI filter)  
Immunity - IEC 801-4 Burst  
Immunity - IEC 801-5 Surge  
Immunity - ANS/NEMA ICS 2-230 showering arc test  
Immunity - VDE -0160 Section 7.3.1.1 AC line transient.  $V_{peak}=2.3 \times AC$  line, 1.3 ms half value time.

## 2.05 OUTPUT POWER

- A. The output shall be variable frequency variable voltage capable of operating NEMA A, B, C, or D 230 volts AC or 460 volts AC (as applicable) 60 Hz three phase induction motors and shall be capable of being field reprogrammed to operate other standard three phase induction motors (IEC34/VDE030).
- B. The VFD shall have the capacity to deliver full motor output voltage 10% greater than the supply voltage continuously.
- C. The VFD will be supplied with output coils as standard to limit output voltage rate of rise to typical 500 volts per microsecond (1-60 hp) and 2000 volts per microsecond (75 hp+). The addition of external coils is not permitted.
- D. The output switches shall operate at a nominal frequency of 4.5 kHz and will be field changeable from 2 to 14 kHz (1-60 hp units). The VFD shall be capable of varying switching frequency with the output frequency to maintain a high efficiency.
- E. The VFD shall be self-protected while running or at rest against:
  - Switching motors on the drive output.
  - Output line-to-line short circuits.
  - Output line to ground short circuits.
- F. The VFD shall be capable of driving a motor up to 1,000 feet away without the addition of output reactors.
- G. The VFD shall be capable of operating without a motor connected for servicing.
- H. The VFD shall be capable of starting in a constant torque mode to provide high starting torque with automatic switching to a variable torque mode.
- I. The VFD shall be capable of operating a motor sized one standard size larger than the drive rating. The drive is not required to operate this larger motor beyond the drive rating.
- J. The VFD design shall include a motor preheat circuit to prevent condensation forming in the motor during shutdown periods.

- K. The VFD shall have electronic thermal overload protection to prevent damage to the variable frequency drive.
- L. Electronic Thermal Overload protection shall be available with or without motor temperature feedback. This protection shall include the effects of the speed of the motor and the length of time of operation at a given speed and current in the calculation of the motor protection. The overload protection will be U/L recognized as a Class 20 overload device.

## 2.06 PERFORMANCE

- A. Advanced PWM control shall be used to generate sine wave current output. Predictive control techniques shall be used to calculate pulse widths and spaces. Alternatively, systems utilizing a full wave diode bridge input with a PWM sine-coded output wave form will be considered. Such systems shall incorporate an input diode bridge that provides complete immunity against voltage dips, line noise, and harmonics. Additionally, output transistors shall be of the IGBT type (Insulated Gate Bipolar Transistor) to facilitate noiseless motor operation.
- B. VFD's shall not "cog" at frequencies above 1.5 Hz. There shall be no sudden frequency shifts and associated acoustical noise shifts as the output frequency is varied between 1.5 and 60 Hz. Minimum switching frequency shall be as follows:
  - 12 kHz for drives rated from 1 to 75 hp at 460 volts AC and from 1 to 40 hp at 230 volts AC.
- C. The VFD shall be capable of automatic energy optimization. The volts per hertz ratio shall be automatically optimized to match the loads requirements.
- D. The speed regulation of the VFD shall be +/- .5% of rated speed, with a 10 - 90% load variation from 6 - 60 Hz.
- E. There shall be programmable start and slip compensation so that the variable frequency drives can optimize motor performance.
- F. The VFD shall have built in DC injection braking programmable from 0 - 15 seconds with programmable DC injection voltage.
- G. The drive output shall have a selectable frequency range from 0 -120 Hz and 0 - 500 Hz.
- H. The VFD will have adjustable ramp times from 0.1 to 3, 600 seconds.
- I. The VFD shall be capable of a flying start function. It shall be able to start into a rotating load (forward or reverse) without tripping.
- J. The VFD shall have four programmable critical bypass frequencies to skip over resonant frequency ranges during acceleration/deceleration. The width of the bypass frequencies shall be adjustable.



- K. The VFD shall be programmable for extended power loss ride through capability utilizing the stored energy of the rotating load.
- L. There shall be provided as standard a closed loop PID controller which can be programmed to be supplied by a standard analog signal (0 - 5 V, 0 -10 V, 0 - 20 mA, 4 - 20 mA) or a maximum pulse signal of 100 Hz, 1 kHz, 10 kHz. The PID controller shall have a programmable low pass filter, programmable feed-forward function, and programmable and configuration functions of the drive. Where noted or required for pneumatic speed control, system shall be controlled by a 3-15 psi signal.

## 2.07 DISPLAYS AND PROGRAMMING

- A. Data shall be displayed on a backlighted three-line LCD alphanumeric keypad mounted on the front of the VFD. The keypad shall be able to perform all programming and configuration functions of the drive.
- B. The keypad shall display the VFD's status and programming in plain text. The language shall be English.
- C. The programming keypad shall be remotely mountable to a distance of up to 3 meters.
- D. The keypad shall include a red "FAULT" lamp and a green "POWER ON" lamp.
- E. The keypad shall provide a HOA (Hand-Off-Auto) function and Hand mode speed up/down push buttons. Auto/Hand change over must be performed with a single keystroke.
- F. The VFD shall be programmable to display any one of the following items during operation:
  - Reference signal (%)
  - Frequency of the output (Hz)
  - Feedback (programmable unit)
  - Motor current (Amps)
  - Motor torque (%)
  - Power (kW)
  - Power (HP)
  - Energy (kWh)
  - Output Voltage (Volts)
  - DC Bus Voltage (Volts)
  - Motor temperature (% until trip)
  - Drive temperature (% until trip)
- G. The keypad display shall continuously display the VFD operating status and fault conditions in plain text.

- H. There shall be provided a lock switch inside the VFD to prevent unwanted programming. The lock must not prevent operation of the Hand/Off/Auto modes.
- I. The VFD shall include an RS485 serial communication port. The port shall permit monitoring, programming, and control of the VFD. The VFD manufacturer shall provide a DOS based VFD programming program upon request.

## 2.08 PROGRAMMED CONTROL INPUTS/OUTPUTS

- A. Potential free terminals shall be provided for contact closure control inputs. A nominal +24 v DC supply shall be provided to operate these inputs or an external voltage between + 10 and + 37 v DC may be applied to operate the control.
- B. The control inputs shall be operable with any mechanical or solid state switching device rated for a closed circuit current of 25 ma DC, and having an open circuit leakage of 100 uA or less at 24 VDC.
- C. Control inputs shall be isolated from the AC line and power components sufficiently to withstand a test voltage of 2500 volts RMS for one minute. The control inputs shall be tested to the following standard:

VDE 0106/0160 (PELV), Galvanic isolation

- D. The VFD control inputs shall comply with the following EMC (Electromagnetic compatibility) standards:

Immunity - IEC 801-4 Burst  
Immunity - IEC 801-5 Surge  
Immunity - SEN 361503 Line-conducted interference

- E. Logic terminals shall be programmable. A minimum of eight shall be programmable for the following functions:

Hand mode/Auto mode  
Auto mode enable  
Start (Two wire non-latching control)  
Reverse  
Start (Three wire latching control)  
Start reverse (Three wire non-latching control)  
Stop (Ramping)  
Stop (Alternate deceleration rate)  
Stop (Coast to stop)  
Stop (DC brake to stop)  
Jog  
Reset  
Preset speed select (20 preset speeds)  
Parameter set select (4 parameter sets)  
Speed increment/decrement  
Pulse train follower/feedback input]

## Motor thermistor input

- F. Terminals shall be provided for analog control of motor speed. Two terminals shall be programmable for the following functions:

Voltage input; 0-10 VDC, 2-10 VDC, 0-5 VDC, and 1-5 VDC signal (or inverted)

Current input; 0-20 mA and 4-20 mA signal, 226 ohm (or inverted)

- G. A 4-20 mA signal loss detection function shall switch the VFD to the last speed, full speed, jog speed, or zero speed following a signal loss.

- H. The VFD shall have two relay outputs (1 form A, 1 form C, UL rated 240 volts AC 2 amps) programmable to provide the following indications:

Ready  
Alarm (Fault)  
Warning  
Current limit  
Motor overload  
Running on reference  
Running  
Out of frequency range  
Out of current range

- I. The VFD shall have two analog outputs (rated 0-20 mA or 4-20 mA, 470 ohm max.) programmable to provide the following analog or digital signals:

Frequency  
Current  
Torque  
Reference  
Ready  
Alarm/Fault  
Warning  
Current limit  
Motor overload  
Running on reference  
Running  
Out of frequency range  
Out of current range

- J. Where noted VFD shall be capable of interfacing with Profibus RS485 serial communications networks.

- K. Where noted VFD shall be capable of interfacing with Modicon Modbus Plus RS485 serial communication networks.

## 2.09 ADJUSTMENTS

- A. The VFD shall default to a quick setup mode. The quick setup mode will limit the possible adjustments to the following:

- Minimum frequency 0-120/500 Hz
- Maximum frequency 0-120/500 Hz
- Acceleration rate (0.1-3,600 seconds)
- Deceleration rate (0.1-3,600 seconds)
- Motor voltage
- Motor frequency
- Language
- Reset to factory settings

- B. The VFD shall have an extended setup mode. The extended mode will provide the following additional programmable adjustments:

- Start frequency
- Four acceleration and deceleration ramps (0.1-3,600 seconds)
- Four bypass frequencies and adjustable bandwidth
- Preset speeds (Twenty speeds)
- Accel/decel ramp profile
- Current limit
- Start compensation
- Start voltage
- Slip compensation
- Magnetization current
- V/Hz ratio
- Carrier switching frequency
- Auto restart times (0-10 restarts)
- PID parameters
- D Differential time
- FF Feed forward
- LP Low pass filter
- Feedback scale factor
- Warning current High/Low
- Warning frequency High/Low
- Motor parameters: Horsepower, Voltage, Frequency
- Custom display: Engineering unit, Scale factor
- DC brake time
- DC brake voltage
- DC brake cut in frequency
- Power loss ride through mode
- Flying start mode

## 2.10 DIAGNOSTICS

- A. The VFD shall have on board diagnostics, which will display faults and status messages. A log recording fault codes, time and value will be stored for past 8 faults. VFD operational data for the last fault shall be stored every 120 ms or immediately upon a trip condition for later analysis.

## 2.11 SERVICE AND WARRANTY

- A. The VFD shall have a manufacturer's warranty period of one year.
- B. The VFD manufacturer shall maintain a network of factory trained, stocking authorized service centers.

## 2.12 ACCESSORIES

- A. The VFD manufacturer shall provide an integrated UL/UL listed NEMA 1 Adaptable Packaged Unit (APU) housing the following devices:

- AC line disconnect, lockable, door interlocked
- AC line fuses
- VFD bypass circuit (3 contactor w/AC line isolating contactor)
- Thermal overload relay, class 20 Control transformers, fused contactors.

- B. The Adaptable Packaged Unit (APU) shall be capable of housing the following devices:

- Start push button
- Stop push button
- Reset push button
- VFD-Line selector switch
- Speed meter
- Current meter
- Fault lamp
- Bypass mode lamp
- 3-15 PSI input
- Auto bypass circuit

The VFD shall have provisions to accommodate other control devices as specified.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. The variable frequency drives shall be installed and serviced in accordance with the manufacturer's recommendations and as shown on the drawings.

END OF SECTION  
15905-10

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## SECTION 15990

### TESTING, ADJUSTING AND BALANCING

#### PART 1 - GENERAL

##### 1.01 GENERAL

The Bidding and Contract requirements, Division 1 - General Requirements, Section 15010 - General Provisions and Section 15050 -Basic Materials and Methods, shall apply to this section.

##### 1.02 SCOPE

- A. The testing, adjusting and balancing of the air distribution systems, hot water heating systems chilled water cooling systems and condenser water systems, are specified under Section 01660 of Division 1.
- B. The installers shall give notice when the systems are ready for testing, adjusting and balancing, and give assistance in adjusting and correcting deficiencies.

#### PART 2 - PRODUCTS

##### 2.01 SHEAVES AND BELTS

- A. The installer shall be responsible for providing and installing new fan or motor sheaves and belts when required to obtain the designed airflow.

##### 2.02 AIR FILTERS

- A. The installer shall be responsible for providing and installing new, clean, air filters. Filters shall be installed before final inspection and before giving notice for the testing, adjusting and balancing.

#### PART 3 - EXECUTION

##### 3.01 GIVING NOTICE TO PROCEED

- A. It shall be the responsibility of the installers to properly install, inspect and assure proper operation of each individual component of the system before giving notice to proceed with the testing, adjusting and balancing. The testing, adjusting and balancing shall not be performed until all mechanical equipment is properly installed and is 100 percent operational, all temperature controls are installed and calibrated and all systems are cleaned and clean filters installed.
- B. The mechanical contractor shall set all outside air dampers to the approximate

minimum position during equipment installation and prior to start-up of equipment.

- C. The Balancing Contractor shall be responsible for properly plugging test holes which were made for testing purposes. Plugs shall be made of rubber and shall be sized to fit testing holes.
- D. The balancing contractor shall set relief vent counter balanced backdraft dampers per the manufactures installation instructions to maintain .05 " (positive) building static pressure.

### 3.02 CORRECTION OF DEFICIENCIES AND ASSISTANCE

The installers shall assist in the testing, adjusting and balancing the systems, shall adjust the system and make corrections of any deficiencies found such as: motor starters and horsepower; improper sheave and belt sizes; missing, improperly installed or malfunctioning volume control dampers, air extractors, air terminals, air monitors, variable or constant volume boxes, power wiring, controls and any other items that prevent the completion of the testing, adjusting and balancing of the systems.

### 3.03 ADDITIONAL MATERIAL

Any additional items or material required to be installed in the ductwork system to implement the testing, adjusting and balancing shall be furnished under Section 01660 along with the location. The installers shall install these items or materials.

### 3.04 COMMISSIONING RESPONSIBILITIES

This contractor shall be responsible for participation and coordination with the commissioning process as specified in section 01660.

END OF SECTION