SECTION 089000 - LOUVERS AND VENTS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Provide louvers complying with performance requirements indicated as demonstrated by testing according to AMCA 500-L.

B. Submittals: Product Data and Shop Drawings.

PART 2 - PRODUCTS

2.1 LOUVERS

A. Horizontal Extruded-Aluminum, Stationary, Drainable Blade Louver:

1. Manufacturers:
   a. Greenheck
   b. Ruskin

2. Louver Depth: 6 inches
3. Aluminum Thickness: 0.081 inches
4. Free Area: Not less than 0.71 sqft louver.
5. Air Performance: Not more than 0.04 static pressure drop at 500 fpm.

2.2 LOUVER SCREENS

A. Provide screen at interior face of each exterior louver. Fabricate screen frames from same kind and form of metal as indicated for louver to which screens are attached.

1. Screening: Aluminum with ½” square square mesh.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install louvers level, plumb, and at indicated alignment with adjacent work.

B. Provide perimeter reveals of uniform width for sealants and joint fillers, as indicated.

C. Use concealed anchorages where possible.

D. Protect metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

END OF SECTION 089000

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals:

1. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hangers and Supports for Piping Equipment:

1. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

a. Design supports for multiple pipes capable of supporting combined weight of supported systems, and system contents.
b. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
c. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.2 SLEEVES AND SLEEVE SEALS

A. Galvanized-Steel Pipe Sleeves: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

2.3 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

2.4 ESCUTCHEONS AND FLOOR PLATES

A. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.5 HANGERS AND SUPPORTS FOR HVAC

A. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

B. Fastener Systems:

1. Verify suitability of fasteners in this article for use in lightweight concrete or concrete slabs less than 4 inches thick.
2. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
3. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated Steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

C. Miscellaneous Materials:

1. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.

   a. Properties: Nonstaining, noncorrosive, and nongaseous.
   b. Design Mix: 5000-psi , 28-day compressive strength.

PART 3 - EXECUTION

3.1 GENERAL PIPING INSTALLATIONS

A. Install piping free of sags and bends.

B. Install fittings for changes in direction and branch connections.

C. Sleeves:

1. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
2. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

   a. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
3. Exterior Wall, Pipe Penetrations: Mechanical sleeve seals installed in steel or cast-iron pipes for wall sleeves.
4. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials

D. Sleeve-Seal-System Installation:

1. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
2. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

E. Escutcheons & Floor Plates:

1. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
2. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
3. Install floor plates for piping penetrations of equipment-room floors.
4. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

F. Install unions at final connection to each piece of equipment.

G. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in water piping.

3.2 HANGERS AND SUPPORTS

A. Comply with MSS SP-69 and MSS SP-89. Install building attachments within concrete or to structural steel.

B. Install hangers and supports to allow controlled thermal and seismic movement of piping systems.

C. Install powder-actuated fasteners and mechanical-expansion anchors in concrete after concrete is cured. Do not use in lightweight concrete or in slabs less than 4 inches thick.

D. Load Distribution: Install hangers and supports so piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

E. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in

3.3 GENERAL EQUIPMENT INSTALLATIONS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

E. Mix and install grout for pump and other equipment base plates, and anchors. Place grout, completely filling equipment bases.

END OF SECTION 230500

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals:

1. Certified TAB reports.
2. Documentation of work performed per ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
3. Documentation of work performed per ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

B. TAB Firm Qualifications: AABC or NEBB certified.

C. TAB Report Forms: Standard TAB contractor's forms approved by Architect.

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

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine the approved submittals for HVAC systems and equipment.

C. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

D. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

E. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

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

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

1. Dampers, valves, and other controlled devices are operated by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of dampers and valves for free and full operation and for tightness of fully closed and fully open positions.
4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
5. Thermostats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at indicated values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to indicated values.

H. Report deficiencies discovered before and during performance of test and balance procedures.

3.2 GENERAL PROCEDURES FOR TESTING AND BALANCING

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

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish.

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

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

3.3 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

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

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

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

E. Check for airflow blockages.

F. Check condensate drains for proper connections and functioning.

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

H. Check for proper sealing of air duct system.

3.4 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data; number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
4. Set system controls so automatic valves are wide open to heat exchangers.
5. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.

3.5 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10%
2. Air Outlets and Inlets: Plus or minus 10%
3. Heating-Water Flow Rate: Plus or minus 10%
4. Cooling-Water Flow Rate: Plus or minus 10%.

END OF SECTION 230593

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals:

1. Product Data: For each type of product indicated.
2. For adhesives and sealants, documentation including printed statement of VOC content.

B. Quality Assurance: Labeled with maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to ASTM E 84.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics:

1. Indoor Insulation and related materials: To be factory labeled designating maximum flame-spread index of 25 or less, and smoke-developed index of 50 or less according to ASTM E 84.
2. Outdoor Insulation and related materials: To be factory labeled designating maximum flame-spread index of 75 or less, and smoke-developed index of 150 or less according to ASTM E 84.

2.2 INSULATION MATERIALS

A. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

B. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

C. Mineral-Fiber, Preformed Pipe Insulation: Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ.

D. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Mineral-Fiber Blanket Insulation: Comply with ASTM C 553, Type II and ASTM C 1290, Type I.

F. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

H. Factory-Applied Jackets: When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

I. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

PART 3 - EXECUTION

3.1 INSULATION INSTALLATION

A. Comply with requirements of the Midwest Insulation Contractors Association's "National Commercial & Industrial Insulation Standards" for insulation installation on pipes and equipment.

B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

C. Insulation Installation at Fire-Rated Wall, Partition, and Floor Penetrations: Install insulation continuously through penetrations. Seal penetrations. Comply with requirements in Section 078413 "Penetration Firestopping."

D. Plenums and Ducts Requiring Insulation:
1. Concealed and exposed supply and outdoor air.
2. Concealed and exposed return air & exhaust air.

E. Flexible Elastomeric Insulation Installation:

1. Seal longitudinal seams and end joints with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
2. Insulation Installation on Pipe Fittings and Elbows: Install mitered sections of pipe insulation. Secure insulation materials and seal seams with adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

F. Mineral-Fiber Insulation Installation:

1. Insulation Installation on Straight Pipes and Tubes: Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
2. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
3. Blanket and Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier.

3.2 HVAC PIPING INSULATION SCHEDULE

A. Concealed duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches, 0.75-lb/cu. ft.

B. Chilled Water: Insulation shall be the following:

1. Flexible Elastomeric: 3/4 inch

C. Heating-Hot-Water Supply and Return: Insulation shall be the following:

1. Mineral-Fiber, Preformed Pipe, Type I: 1.5 inch thick.

D. Refrigerant Liquid, Suction and Hot-Gas Piping: Insulation shall be the following:

1. Flexible Elastomeric: 3/4” thick.

E. Condensate Piping
1. Flexible Elastomeric: 3/4” thick.

END OF SECTION 230700

SECTION 23 21 13 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals:

1. Product Data: For each type of product indicated.
2. For solvent cements and adhesive primers, documentation including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Hot-Water Heating Piping: 150 psi at 200 deg F
2. Chilled-Water Piping: 150 psi at 200 deg F
3. Condensate-Drain Piping: 120 psi at 140 deg F.

2.2 PIPES, TUBES, AND FITTINGS

A. Hard Copper Tubing: Type L with ASME B16.22 wrought-copper solder fittings and ASTM B 32, 95-5 tin antimony solder.

B. PVC Pipe: ASTM D 1785, Schedule 40, plain ends with ASTM F 438, socket-type solvent welding fittings.

1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Steel Pipe: ASTM A 53, Schedule 40, plain ends with malleable-iron threaded fittings, Class 150.

D. Unions: ASME B16.39, malleable-iron, Class 150, hexagonal stock, with ball-and-socket joints, metal-to-metal bronze seating surfaces; female threaded ends.

E. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, ends.

2.3 HYDRONIC SPECIALTIES

A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure, 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.

B. Y-Pattern Strainers: Threaded connections for NPS 2 and smaller, bolted cover, perforated Type 304 stainless-steel basket, and bottom drain connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with requirements in Section 230500 "Common Work Results for HVAC" for basic piping installation requirements.

B. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Comply with requirements in Section 230500 "Common Work Results for HVAC" for wall penetration systems.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping free of sags and bends and install fittings for changes in direction and branch connections.

E. Use the fewest number of joints belowground and within floor slabs.

F. Install piping at a uniform slope of 0.2 percent upward in the direction of flow.

G. Make reductions in pipe sizes using eccentric reducer fitting installed with level side up.

H. Install branch connections to mains using tee fittings in main with takeoff out the bottom of the main, except for up-feed risers, which shall have swing joint and takeoff out the top of the main line.

I. Install unions in pipes adjacent to each valve, at final connections with each piece of equipment, and elsewhere as indicated.

J. Install flexible connectors at inlet and discharge connections to pumps (except in-line pumps) and other vibration-producing equipment.

K. Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before soldering or brazing.

3.2 VALVE INSTALLATIONS

A. Shutoff Duty: Use gate or ball valves.

B. Install shutoff-duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, and elsewhere as indicated.

C. Install manual air vents at high points in the system, at heat-transfer coils, and elsewhere as required for system air venting.

D. Install valves with stem up. Allow clearance above stem for check mechanism removal.

3.3 TESTING, ADJUSTING, AND BALANCING

A. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens.

B. Hydrostatically test completed piping at a pressure one and one-half times operating pressure. Isolate equipment before testing piping. Repair leaks and retest piping until there are no leaks.

C. Balance water flow as required by Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.4 PIPING SCHEDULE

A. Hot and Chilled Water, NPS 2 and Smaller:

1. Aboveground: Drawn-temper copper tubing with soldered joints, or steel pipe with threaded joints.

B. Condensate Drain Lines: Drawn-temper copper tubing with soldered joints or PVC pipe with solvent-welded joints.

END OF SECTION 232113

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals:

1. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop based on manufacturer's test data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIRMENTS

A. Line Test Pressure for Refrigerant R-410A:
1. Suction Lines for Heat-Pump Applications: 150 psi
2. Hot-Gas and Liquid Lines: 150 psi
3. Test as per unit Manufacturer’s recommendation.

B. Comply with ASME B31.5, "Refrigerant Piping," and with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

2.2 TUBES AND FITTINGS

A. Copper Tube: Type ACR.

B. Wrought-Copper Fittings and Unions: ASME B16.22.

C. Brazing Filler Metals: AWS A5.8.

2.3 VALVES AND SPECIALTIES

A. Refrigerant: R-410A.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with requirements in Section 230500 "Common Work Results for HVAC" for basic piping installation requirements.

B. Install wall penetration system at each pipe penetration through foundation wall. Make installation watertight. Comply with requirements in Section 230500 "Common Work Results for HVAC" for wall penetration systems.

C. Install refrigerant piping and charge with refrigerant according to ASHRAE 15.

D. Insulate suction lines to comply with Section 230700 "HVAC Insulation."

E. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

F. Install thermostatic expansion valves as close as possible to distributors on evaporator coils.

G. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

C. END OF SECTION 232300

SECTION 233100 - HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals:

1. Product Data: For each type of product indicated.
2. Documentation indicating that duct systems and accessories comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning." and Section 6.4.4 - "HVAC System Construction and Insulation."
4. Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
5. For adhesives and sealants, documentation including printed statement of VOC content.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" .

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

E. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

G. Comply with NFPA 96 for ducts connected to commercial kitchen hoods.

H. Comply with UL 181 for ducts and closures.

2.2 DUCTS

A. Galvanized-Steel Sheet: ASTM A 653/A 653M, with G60 hot-dip galvanized coating.

1. Galvanized Coating Designation: G**60**
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

B. Joint and Seam Tape, and Sealant: Comply with UL 181A.

C. Rectangular Metal Duct Fabrication: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 ACCESSORIES

A. Volume Dampers and Control Dampers: Single-blade and multiple opposed-blade dampers, standard leakage rating, and suitable for horizontal or vertical applications; factory fabricated and complete with required hardware and accessories.

B. Fire Dampers: Rated and labeled according to UL 555 by an NRTL; factory fabricated and complete with required hardware and accessories.

C. Flexible Connectors: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

D. Flexible Ducts: Factory-fabricated, insulated, round duct, with an outer jacket enclosing 1-inch-thick, glass-fiber insulation around a continuous inner liner complying with UL 181, Class 1. Maximum length shall be 8 feet.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Outdoor, Supply-Air Ducts: Seal Class A.
2. Outdoor, Exhaust Ducts: Seal Class C.
3. Outdoor, Return-Air Ducts: Seal Class C.
4. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
6. Unconditioned Space, Exhaust Ducts: Seal Class C.
7. Unconditioned Space, Return-Air Ducts: Seal Class B.

C. Conceal ducts from view in finished and occupied spaces.

D. Avoid passing through electrical equipment spaces and enclosures.

E. Support ducts to comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Hangers and Supports."

F. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

G. Install volume and control dampers in lined duct with methods to avoid damage to liner and to avoid erosion of duct liner.

H. Install fire dampers according to UL listing.

I. Install fusible links in fire dampers.

J. Clean duct system(s) before testing, adjusting, and balancing.

3.2 TESTING, ADJUSTING, AND BALANCING

A. Balance airflow within distribution systems, including submains, branches, and terminals to indicated quantities.

END OF SECTION 233100

SECTION 27213 – HEAT RECOVERY AIR-TO-AIR HEAT RECOVERY EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

a. Energy recovery ventilators.

1.2 REFERENCE STANDARDS

a. ANSI/AHRI 1060 – Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment.
b. ANSI/AMCA 300 – Reverberant Room Method for Sound Testing of Fans.
c. ASHRAE 84 – Method of Testing Air-to-Air Heat Exchangers.
d. ASTM A 792/A 792M – Standard Specification for Steel Sheet, 55 % Aluminum-Zinc Alloy- Coated by the Hot-Dip Process.
e. CSA C22.2, No. 77 – Motors with Inherent Overheating Protection.
f. CSA C22.2, No. 100 – Motors and Generators.
g. CSA C22.2, No. 113 – Fans and Ventilators.
h. CSA C22.2, No. 236 – Heating and Cooling Equipment.
i. ISO 9001:2008 – Quality Management Systems – Requirements.
j. NFPA 70 – National Electrical Code (NEC).
k. UL 723 – Standard for Test for Surface Burning Characteristics of Building Materials.
l. UL 900 – Standard for Air Filter Units.
m. UL 1004-1 – Standard for Rotating Electrical Machines - General Requirements.
n. UL 1004-2 – Standard for Impedance Protected Motors.
o. UL 1004-3 – Standard for Thermally Protected Motors.
p. UL 1004-7 – Standard for Electronically Protected Motors.
q. UL 1812 – Standard for Ducted Heat Recovery Ventilators.
r. UL 2111 – Standard for Overheating Protection for Motors.

1.3 SUBMITTALS

a. Product Data: Submit manufacturer's product data, including preparation and installation instructions.

b. Shop Drawings: Submit manufacturer's shop drawings, including plans, elevations, sections, and details.
    a. Wiring Diagrams: Indicate wiring for each item of

equipment and interconnections between items of equipment.

b. Include manufacturer's names, model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.

c. Manufacturer's Certification: Submit manufacturer's certification that energy recovery ventilators comply with specified requirements and are suitable for intended application.

d. Operation and Maintenance Data:
   a. Submit manufacturer's operation and maintenance manual; including the following:
      i. Operation, maintenance, adjustment, and cleaning instructions.
      ii. Troubleshooting guide.
      iii. Parts list.
      iv. Electrical wiring diagrams.
   b. Provide detailed information required for Owner to properly operate and maintain equipment.

e. Warranty Documentation: Submit manufacturer's standard warranty.

1.4 QUALITY ASSURANCE

a. Manufacturer's Qualifications:
   Manufacturer regularly engaged, for past 5 years, in manufacture of air handling units of similar type to that specified.
   ISO 9001 certified company.

1.5 DELIVERY, STORAGE, AND HANDLING

a. Delivery Requirements: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

b. Storage and Handling Requirements:
   i. Store and handle materials in accordance with manufacturer's instructions.
   ii. Keep materials in manufacturer's original, unopened containers and packaging until installation.
   iii. Store materials in clean, dry area indoors.
   iv. Protect materials during storage, handling, and installation to

prevent damage.

1.6 WARRANTY

a. Warranty Period: 3 years.

PART 2 PRODUCTS

2.1 MANUFACTURERS

a. SYSTEMAIR, INC, SEMCO, RENEWAIRE, AIRXCHANGE

2.2 ENERGY RECOVERY VENTILATORS

a. Energy Recovery Ventilators: “Topvex TR Series”.

i. 1. Model: Topvex TR800EL-208-3.

ii. 2. Indoor, compact, commercial, air handling units.

iii. 3. Airflow Control: Constant air volume.

b. General:

i. Each Unit or Group of Units: Capable of operating in any mode independently or dependently of other systems.

ii. Capable of changing modes with no interruption to system operation.

iii. Listed under CSA C22.2, No. 113/UL 1812.

iv. Wiring: NFPA 70.

v. Performance: As scheduled on the Drawings.

vi. Equip with control systems.

vii. Perform all functions necessary for operation.

viii. Ventilation to Building: Not to cease in any mode based solely on operational temperature of minus 13 to 104 degrees F.

ix. Surrounding Sound Power Rating: Not higher than 67 dB(A).

x. Sound Data: Measured in accordance with AMCA 300.

xi. Capable of operating at normal condition with specific fan power (SFP) lower than 0.9 W/cfm (2.35 kW/m3/s).

xii. Capable of operating in winter and summer conditions without imbalance or loss of ventilation capacity greater than specified in design.

c. Unit Cabinet:

i. Cabinet Exterior: 20-gauge sheet steel, ASTM A 792/A 792M, 55 percent aluminum-zinc alloy coating with corrosion protection rated Class III.

ii. Double-Wall Cabinet Interior:
a. 20-gauge sheet galvanized steel, G90.
b. Seams: Sealed, requiring no caulking in field.

iii. Insulation within Double Wall:
a. 2.0-inch (50.8-mm) fiberglass.
b. Flame Spread Index, UL 723: Not over 25.
c. Smoke Developed Index, UL 723: Not over 50.

iv. Provisions for field installed pre-heater system.

d. Fans:

i. Direct-drive, backward-inclined, motorized impellers.
ii. Fan Motors:
a. Maintenance-free, permanently lubricated, sealed ball bearings.
b. Thermal overload protected (TOP).
c. UL listed to UL 1004-1, 1004-2, 1004-3, 1004-7 and/or UL 2111; CSA C22.2, No. 77 and No.100.
d. IP Protection: Class 44 or 54.
e. Electronically commutated “EC” to maximize efficiency at different speeds.
f. Mounted for quiet operation.

iii. Separate fans for exhaust and supply blowers.

e. Energy Recovery Wheel:

i. Rotor Matrix: Corrosion-resistant aluminum alloy, composed of alternating corrugated and flat, continuously wound layers of uniform width that guarantee laminar air flow and low static pressure loss.
ii. Counter-flow construction type.
iii. Free cooling capacity.
iv. Performance: Certified and listed by AHRI.
v. Rotor Wheel: 8-inch-thick wheel reinforced with spokes, welded at hub and perimeter to prevent uneven run-out during normal operations.
vi. Corrugated Surfaces: Coated with thin, non-migrating, adsorbent, Zeolite particles.
vii. Effectiveness of Wheel: Documented in accordance with ASHRAE 84 and AHRI 1060.
viii. Flame Spread Index, Energy Recovery Wheel, UL 723: Not over 25.
ix. Smoke Developed Index, Energy Recovery Wheel, UL 723: Not over 50.

f. Air Filters:

i. Fresh air protected by MER13 pockets filter constructed to meet UL 900.
ii. Exhaust air protected by MER9 pockets filter constructed to meet UL 900.
iii. Individual Pockets: Assembled into galvanized steel header providing rigid support to filter.
iv. Filter Element: Fully synthetic fiber, not shedding or affected by humidity.
v. Adjustable Monitoring System: Activates alarm through main controller when pressure drop increase through supply or exhaust filters.

g. Temperature Sensors: Four stainless steel temperature sensors for monitoring supply and exhaust air in and air out, maximizing units efficiency and detecting need for frost prevention.

h. Electric Re-Heater:
   i. Provides temperature control of supply air.
   ii. Available only for 3 phase systems as to minimize ampacity and conductor size.
   iii. Temperature Control Functions:
      a. Supply air.

   iv. Solid 5/16-inch (8.5-mm) tubular air heating elements sheathed with stainless steel, AISI Type 304.
   v. Electric Heater Regulators: Control output by time proportional control (intermittent ON/OFF control).
   vi. Temperature Limiting Switches: 2.
      a. Automatic Reset: 1.
      b. Manual Reset: 1.
   vii. 7. Initiate alarm and shut down of unit when temperature limit switches are activated.

i. Electrical:
   i. Electrical Power: 208-230 VAC, 3 phase, 60 Hz with neutral line.
   ii. Internal Electrical Components: Factory wired for single-point power connection.
   iii. Electrical Box Components: Accessible without stopping unit or opening doors.
   iv. Electrical Box:
      a. Isolated from airflow paths.
      b. Protect integral wires and connections.
   v. Controlled by integral microprocessor controller.

l. Serviceability:

   i. Access Panel: Hinged and/or screwed access panel on bottom of unit.
   ii. Energy Recovery Wheels, Filters, and Motors: Serviceable from front of unit.
   iii. Fan Assemblies: Mounted on removable base.
   iv. Energy Recovery Wheels and Filters: Mounted on slide-out rails.

2.3 ENERGY RECOVERY VENTILATOR CONTROLS

a. General:

i. All energy recovery units will be equipped with a factory installed and configured “Corrigo” controller with remote display by Regin.

ii. The controller shall be pre-programmed for ventilation applications; no further programming will be required.

iii. All controller settings, I/O points, configurations, functions, set-points, time schedules, and control modes shall be modifiable via remote display, PC software or network.

iv. Access rights: there shall be four different program access levels: Admin, Service, Operator and Normal. Each level with have a password and grant the following level of access:

a. Admin level: full read/write access to all settings and parameters in all menus.
b. Service level: access to all menus except the submenus under Configuration: In- and Outputs & System.
c. Operator level: gives access to all menus except “Configuration”.
d. Normal level: only permits changes in "Running mode" and read-only access to a limited number of menus.

v. The controller must be capable of supporting remote controllers, schedule timers, system controllers, centralized controllers, integrated web-based interface, graphical user workstation, and system integration to Building Management Systems via BACnet and TCP/IP.

vi. Controller Communications: Via common non-polar communications bus.

vii. Control Wiring: Installed in system daisy-chain configuration from unit to BAS controller and to other units, if applicable.

viii. Network Wiring: CAT-5e with RJ-45 connection or two wire RS-485.

b. Sensors:

i. The following sensors shall also be installed and pre-configured with the controller by the manufacturer: temperature sensors (supply, return, exhaust, outdoor & entering), wheel rotation sensor, dirty filters sensor, defrost sensor, and electric heating high temperature limit sensor.
ii. In constant air volume applications, independent pressure sensors shall monitor both supply and exhaust fans for constant airflow.

c. Temperature Control Modes:

i. Supply air control: the supply air temperature will be controlled using the supply air temperature and the user setpoint values as control inputs.

d. Airflow Control [Select one of the following only]:

i. The controller shall be capable of constant air volume control and independently controlling both the supply and exhaust air fans to maintain the supply and exhaust air volume setpoints.

e. Alarms:

i. Alarms are indicated by the red alarm LED on the remote display or on the network.

ii. All alarms can be monitored, acknowledged and blocked.

iii. Three different classes of alarms: A, B & C. Each level will relate to the severity of the alarm, with class A being the most serious and class C being the least. Class A & B alarms have the potential to shut down the unit. Class C alarms will not cease operation of the unit.

iv. On applicable alarms, alarm delays, setpoints and class level may be settable.

f. Integration with Building Management Systems:

i. Corrigo connected to BACnet system:

ii. Schedule Timer:
a. Corrigo: Year-base clock function. Weekly schedule with holiday periods for full year can be set.

b. Clock:
1) Automatic summertime/wintertime change-over, individual schedules for each weekday, and separate holiday setting.
2) Up to 24 individual holiday periods configurable.
3) Holiday Period: Anything from 1 day up to 365 days.
4) Holiday Schedules: Take precedence over other schedules.
5) Each Day: Up to 2 individual running periods.

2.4 ASSEMBLY

a. Factory assemble and wire energy recovery ventilators.

2.5 ACCESSORIES

a. Electric Pre-Heat: Model EPH.
b. Shut-Off Damper: Model EFD and Model AF24 motor.
c. Converter: Model E-BacNET-V.

2.6 SOURCE QUALITY CONTROL

a. Run test at factory.

PART 3 EXECUTION

3.1 EXAMINATION

a. Examine areas and supporting structure to receive energy recovery ventilators.

b. Notify Engineer of conditions that would adversely affect installation or subsequent use.

c. Do not begin installation until unacceptable conditions are corrected.

3.2 PREPARATION

a. Prepare surfaces where energy recovery ventilators are to be mounted.

b. Ensure surfaces are flat, level, plumb, and can support weight of energy recovery ventilators.

3.3 INSTALLATION

a. Install energy recovery ventilators in accordance with manufacturer's instructions at locations indicated on the Drawings.

b. Install energy recovery ventilators in accordance with NFPA 70.

c. Install energy recovery ventilators level, plumb, and secure.

d. Do not expose electronic components to temperatures below 32 degrees F (0 degrees C) or above 122 degrees F (50 degrees C).

3.4 ADJUSTING

a. Adjust energy recovery ventilators for proper operation in accordance with manufacturer's instructions.

3.5 DEMONSTRATION

a. Demonstration:
   i. Demonstrate that energy recovery ventilators function properly in every respect.
   ii. Perform demonstration at final system inspection by factory-trained and certified representative of manufacturer.
b. Instruction and Training:
   i. Provide instruction and training of Owner's personnel as required for operation and maintenance of energy recovery ventilators.
   ii. Provide hands-on demonstrations of operation of system components and complete system, including user-level program changes and functions.
   iii. Provide instruction and training by factory-trained and certified representative of manufacturer.

3.6 PROTECTION

a. Protect installed energy recovery ventilators from damage during construction.

END OF SECTION

SECTION 23 81 29 – VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.01 SYSTEM DESCRIPTION

The variable capacity, heat pump air conditioning system shall be Trane Advantage VRF systems and shall be the HP (cool/heat) split system heat pump.

The Heat Pump system shall consist of an outdoor unit, multiple indoor units , and BACNET MS/TP interface. The outdoor unit shall be a vertical discharge, 208/230/3 volt, three phase unit. Each indoor unit or group of indoor units shall be independently controlled.

1.02 QUALITY ASSURANCE

A. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.
B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).
C. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
D. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.

1.03 DELIVERY, STORAGE AND HANDLING

A. Unit shall be stored and handled according to the manufacturer's recommendation.

1.04 TRAINING

A. Provide (8) hours of on-site training with a factory trained technician to review operation and maintenance of the systems.

1.05 MANUFACTURERS

A. Trane
B. Samsung
C. Mitsubishi

PART 2 – WARRANTY

2.01 The units shall be covered by the manufacturer's limited warranty for a period of (24) months from date of Start Up.

a. In addition the compressor shall have a manufacturer's limited warranty for a period of 5 years from date of installation.

b. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer.

c. This warranty shall include labor.

PART 3 – PRODUCTS

3.01 VRF HP OUTDOOR UNIT

A. GENERAL

1. The outdoor unit shall have a powder coated finish. The outdoor unit shall be completely factory assembled, piped and wired.
2. Each unit shall be run tested at the factory.
3. The sum of connected capacity of all indoor units shall range from 50% to 130% of outdoor rated capacity.
4. Outdoor unit shall have a sound rating no higher than 62/83(Pressure/Power) dB(A).
5. Both refrigerant lines from the outdoor unit to indoor units shall be insulated.
6. The outdoor unit shall have an accumulator.
7. The outdoor unit shall have a high pressure safety switch, fuse, over-current protection and crank case heater.
8. The outdoor unit shall have the ability to operate with a maximum height difference 131ft (outdoor unit below).
9. The greatest length is not to exceed 220ft between the outdoor unit and the indoor units with the need for line size changes.
10. The outdoor unit shall be capable of operating in heating down to -4°F ambient temperatures without additional low ambient controls.
11. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.

B. UNIT CABINET

1. The casing(s) shall be fabricated of galvanized steel, bonderized and finished with a powder-coated baked enamel.

C. FAN

1. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
2. All fan motors shall be mounted for quiet operation.
3. All fans shall be provided with a raised guard to prevent contact with moving parts.
4. The outdoor unit shall have vertical discharge airflow.

D. REFRIGERANT

1. R410A refrigerant shall be required for outdoor unit.

E. COIL

1. The outdoor coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.
2. The coil shall be protected with an integral metal guard.

F. COMPRESSOR

1. The outdoor unit compressor(s) shall have digital scroll or inverter driven technology to modulate capacity. The capacity shall be completely variable down to 12.5% of rated capacity.
2. The outdoor unit compressor(s) shall have a vapor injection technology which can enlarge the mass flow rate of refrigerant, as a result a performance improvement at an extremely low temperature condition.
3. The compressor(s) shall be equipped with an internal thermal overload protection.
4. The compressor(s) shall be mounted to avoid the transmission of vibration.

G. ELECTRICAL:

1. The outdoor unit electrical power shall be 208/230 volts, 3 phase, 60 hertz.
2. Voltage Tolerance is ±10%, maximum allowable voltage between phases is 2%.
3. The outdoor unit shall be controlled by integral microprocessors.
4. The control circuit between the indoor units and the outdoor unit shall be 12VDC completed using stranded, annealed copper conductor, two-core cable to provide total integration of the system.

3.02 WALL-MOUNTED INDOOR UNIT

A. General:

The unit shall be a wall-mounted indoor unit section with a slim silhouette and must be installed with an optional modulating linear expansion valve.

B. Indoor Unit

The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, control circuit board and fan motor. An optional electronic modulating linear expansion valve is available for accessories. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function.

C. Unit Cabinet:

1. The casing shall have a white finish.
2. Multi directional drain and refrigerant piping offering four (4) directions for refrigerant piping and four (4) directions for draining shall be standard.
3. There shall be a separate back plate which secures the unit firmly to the wall.

D. Fan:

1. The indoor fan shall be an assembly with Cross-flow fan direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
3. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
4. A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution.

E. Filter:

1. Return air shall be filtered by means of an easily removable, washable filter.

F. Coil:

1. The indoor coil shall be of nonferrous construction with Slit fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The fins of coil are coated hydrophilic paints.
7. Both refrigerant lines to the indoor units shall be insulated.

G. Electrical:

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage tolerance is ±10%.

H. Controls:

1. This unit shall use controls provided by manufacturer to perform functions necessary to operate the system. Please refer to Part 4 of this specification for details on controllers and other control options.

I. Condensate Pump:
1. Provide mini condensate pump housed within a duct. Unit shall be MiniFLOWATCH®2 pump rated at 1.3 GPH @ 20ft of head.

3.03 4-WAY MINI CEILING CASSETTE WITH GRILLE INDOOR UNIT

A. General:
The unit shall be a four-way cassette style indoor unit that recesses into the ceiling with a ceiling grille and shall have a modulating linear expansion device.

B. Indoor Unit.
The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function.

C. Unit Cabinet:
1. The cabinet shall be space-saving ceiling-recessed cassette.
2. The cabinet panel shall have provisions for a field installed filtered outside air in-take.

D. Fan:
1. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
3. The indoor fan shall consist of three (3) speeds, Low, Mid, and High.
4. The auto air swing vanes shall be capable of automatically swinging up and down for uniform air distribution.

E. Filter:
1. Return air shall be filtered by means of a long-life washable permanent filter.

F. Coil:
1. The indoor coil shall be of nonferrous construction with slit fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.

6. The Fins of coil are coated hydrophilic paints.
7. The condensate lift mechanism shall be able to raise drain water 29.5 inches water column above the condensate pan.
8. Both refrigerant lines to the indoor units shall be insulated.

G. Electrical:
1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage tolerance is ±10%.

H. Controls:
1. This unit shall use controls provided by manufacturer to perform functions necessary to operate the system. Please refer to Part 4 of this guide specification for details on controllers and other control options.

3.04 SLIM 1-WAY CEILING CASSETTE WITH GRILLE INDOOR UNIT

A. General:
The unit shall be a one-way cassette style indoor unit that recesses into the ceiling with a ceiling grille and shall have a modulating linear expansion device.

B. Indoor Unit.
The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function.

C. Unit Cabinet:
1. The cabinet shall be space-saving ceiling recessed.
2. The cabinet panel shall have provisions for a field installed filtered outside air in-take.
3. The one-way grille shall be fixed to bottom of cabinet allowing for one-way air-flow.

D. Fan:
1. The indoor fan shall be an assembly with cross-flow fan direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
3. The indoor fan shall consist of three (3) speeds, Low, Mid, and High.

E. Filter:
1. Return air shall be filtered by means of a long-life washable permanent filter.

F. Coil:
1. The indoor coil shall be of nonferrous construction with slit fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The condensate lift mechanism shall be able to raise drain water 29.5 inches water column above the condensate pan.
7. The Fins of coil are coated hydrophilic paints.
8. Both refrigerant lines to the indoor units shall be insulated.

G. Electrical:
1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage tolerance is ±10%.

H. Controls:
1. This unit shall use controls provided by manufacturer to perform functions necessary to operate the system. Please refer to Part 4 of this guide specification for details on controllers and other control options.

Part 4 – Controls

4.01 Overview

A. General:

The VRF System shall be capable of supporting remote controllers, system controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet® MS/TP or IP.

4.02 Electrical Characteristics

A. General:

The VRF System Network Controls shall operate at 12VDC. Controller power and communications shall be via a common non-polar communications bus.

B. Wiring:

Control wiring shall be installed in a system daisy chain configuration from the indoor unit to wired remote controller to indoor units, and to outdoor unit. Control wiring to wired remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.

Control wiring for system controllers, and centralized controllers shall be installed in a daisy chain configuration from interface module to interface module, to system controllers, to the power supply.

The VRF Web User Interface shall be capable of being networked with the VRF System Controller for web-based control.

C. Wiring type:
Wiring shall be 2-conductor (16 AWG or 22 AWG), untwisted unshielded pair, and standard wire, as defined by the Samsung wiring guideline

Network wiring shall be CAT-5e with RJ-45 connection.

4.03 VRF System Network Controls
The VRF System Network Controls consists of individual controllers, system controllers, and integrated management system. The VRF System Network Controls shall support operation monitoring, scheduling, error monitor, power distribution, personal browsers, online maintenance support, and integration with Building Management Systems (BMS) using a BACnet® interface.

4.04 Individual Control System
A. Multi-Function Controller VRF SC
1. Connection
The Multi-Function Controller VRF SC shall be capable of controlling up to 16 indoor units (defined as 1 group).
2. Dimensions
The Multi-Function Controller shall be approximately 4.72” x 4.88” in size and white in color with a light-white LCD display.
3. Function
The Multi-Function Controller shall control the following grouped operations: On/Off, Operation Mode (auto, cool, heat, dry, and fan), temperature set point, fan speed setting, and airflow direction setting.
The Multi-Function Controller shall support a weekly operating schedule up to 42 schedules and support an Auto Off timer. The Multi-Function Controller shall support temperature display selection of Fahrenheit or Celsius.
The Multi-Function Controller shall be able to limit the set temperature range and sensed at either the Multi-Function Controller or the Indoor Unit dependent on the Multi-Function Controller mode setting. The Multi-Function Controller shall display a three-digit error code in the event of system abnormality/error.
The Multi-Function Controller shall only be used in the same group with a same wired remote controller up to two remote controllers per group.

The Multi-Function Controller shall require no addressing. The Multi-Function Controller shall connect using two-wire (2-wire power line communication), untwisted, non-polar control wire to the connection terminal on the indoor unit. The Multi-Function Controller shall require cross-over wiring for grouping across indoor units.

TVCTRLTWRWE10T (**Multi-Function Controller**)			
Item	**Description**	**Operation**	**Display**
ON/OFF	Run and stop operation for a single group Include operating the ERV	Each Group	Each Group
Operation Mode	Switches between Auto/Cool/Dry/ /Fan/Heat Switches to Heat-ex, Auto or By-pass.	Each Group	Each Group
Tempera-ture Setting	Sets the temperature for a single group. Range of temperature setting Auto/Cool/Dry: 16°F-86°F(18°C-30°C) Heat: 61°F-86°F(16°C-30°C)	Each Group	Each Group
Fan Speed Setting	Models with 4 air flow speed settings: High /Mid/Low/Auto Models(ERV) with 3 air flow speed settings: Turbo/High/Low	Each Group	Each Group
Air Flow Di-rection Set-ting	Air flow 2-step direction (Swing/Stop) Direct setting at a specific angle. Individual blade control Air flow operation varies depending on the model.	Each Group	Each Group
Weekly Scheduler	ON/OFF/Temperature setting can be done at most 6 schedules may be set for each day. Real-time clock function: current time, day display function	Each Group	Each Group
Button lock	Button permission level setting (On/Off / Temperature setting / Mode button / Fan speed) Temperature limit setting ※ After power reset, the setting value is re-stored	Each Group	Each Group
Specified Function	Automatic stop setting - Setting time range : 0~12 (Hr) Energy saving operation mode - EHP+ERV or ERV operation only de-pending on outdoor temperature	Each Group	Each Group
Service Mode	Setting/Viewing the indoor unit option code Setting/Viewing the indoor unit MAIN, RMC	Each Group	Each Group

TVCTRLTWRWE10T (**Multi-Function Controller**)			
Item	**Description**	**Operation**	**Display**
	address Viewing the indoor unit cycle data Setting/Viewing temperature sensor Viewing the RPM compensation Viewing the EEV step when the indoor unit is off during the heating mode Viewing the filter time (1000hours, 2000hours) Viewing indoor unit temperature sensor compensation under Heating (+3.6 or +9°F) Viewing the H/W option setting Setting/Viewing the ERV operation mode Setting/Viewing the ERV Plus installation option Viewing the wired remote controller software version		
Error	When an error is currently occurring on an air conditioner or ERV unit, the afflicted unit and the error code are displayed	Each Group	Each Group
Permit / Prohibit Local Operation	Setting/releasing of simplified locking for remote control buttons can be performed	Each Group	N/A
the Quiet Mode	Select the Quiet mode to run the indoor unit to the set mode to lower the fan noise level.	Each Group	N/A
Room Temperature	Actual room temperature display for 5 seconds	Each Group	Each Group

4.05 Building Management System

A. BACnet® Gateway

1. Connection

   The BACnet ® Gateway shall be capable of controlling up to 256 indoor units/EEVs support.

2. Dimensions

   The BACnet ® Gateway shall be approximately 9.44inches x 10.03inches x 2.55inches in size and steel in shape with LCD display.

3. Function

   The BACnet ® Gateway shall support up to 256 indoor units/EEVs support with a variety of network variables on a per indoor unit basis.

BACnet® Gateway		
Input Variables (Control)	**Output Variables(Monitor)**	
On/Off control	On/Off state	In/out contact state
Operation mode	Operation mode	Emergency Stop
Temperature setting	Set/Room temperature	Error code
Fan speed/direction	Fan speed/direction	
ERV operation mode	ERV operation mode	
ERV fan speed	ERV fan speed	
Filter alarm reset	Filter alarm	
User control restriction	User control restriction	
Operation mode lock	Power distribution	
Set temperature limit	Operation mode lock	
Emergency stop	Set temperature limit	
Output contact control		

23 82 23 UNIT VENTILATORS

PART 1-GENERAL

1.1 Deliver and install a complete unit ventilator certified for ventilation at AHRI-840, or tested by an independent testing and balancing lab witnessed by owner's representative.

1.2Safety-All standard units are UL-listed in the United States and Canada and comply with NFPA 90A requirements.

1.3The unit ventilator is certified or rated in accordance to the following listings for performance proof and safety: ETL, AHRI-840, AHRI-350, BACnet®

PART 2-PRODUCTS

2.1 EQUIPMENT CONSTRUCTION

a. The exterior cabinet shall be constructed of heavy-gauge metal for strength and durability. All exposed edges shall be rounded to safeguard against injury. All interior sheet metal shall be of galvanized steel to restrain against deterioration.
b. The front plane of the unit shall consist of a three panel design. The control compartment shall be accessible without removing the entire front panel.
c. The discharge air grille shall contain rounded edged steel bars, and shall be placed at a 15° slope to provide proper airflow deflection.
d. Access for inspection and cleaning of the unit drain pan, coils, and fan section shall be provided. The unit shall be installed for proper access. Procedures for proper maintenance of the unit shall be included in the Installation & Operation manual.
e. Cabinet insulation shall be closed cell to maximize thermal performance. It shall be suitable for use in air streams up to 4500 feet per minute (fpm). Insulation will meet the Underwriters Laboratories Fire Hazard Classification and long term thermal resistance (LTTR) classification per CAN/ULC S770 standard.
f. Piping and control end pockets shall be a minimum of 12 inches wide to facilitate piping, auxiliary drain pan, and service access.
g. Final finish of the cabinet shall be cleaned, phosphatized and painted with an electrostatic powder spray system, with a minimum thickness of 1.5 mil to avoid visible runs and resist abrasion. The Contractor shall provide the

Owner with the manufacturer's standard color samples to choose from. Contractor shall be required to match color selection with adjacent fin tube radiator enclosures.

h. Unit shall be provided with a "False Back" with horizontal baffle which can be utilized as an air plenum to locate the wall box anywhere along the height of the baffle.
i. Provide the unit with a 2" sub-base the entire depth and width of the unit in order to match the height of the existing unit.

2.2 UNIT FANS

a. The unit fan board assembly shall ship from the factory and wired to the commission schedule for engineered cfm expectancy. A motor speed switch shall be located in the unit for motor speed adjustment.
b. The fan board shall be a single, rigid construction, made from corrosion resistive material. It shall be a trouble-free slide design to provide cleaning and serviceability ease to maintenance personnel.
c. The fans shall contain a double width/double inlet, forward curved centrifugal design to sustain appropriate air throw into the space. The wheels shall be galvanized metal to resist corrosion. The dynamically balanced fan and motor shall be of direct drive style.
d. The fan and coil arrangement shall be of a blow-thru configuration to supply unvarying coil face velocity avoiding cold spots on the coil.

2.3 MOTORS

a. All motors shall be brushless DC (BLDC)/electronically commutated motors (ECM) factory programmed and run-tested in assembled units. The motor controller shall be mounted in a touch-safe control box with a built-in integrated user interface and LED tachometer. If adjustments are needed, motor parameters shall be adjustable through momentary contact switches, accessible without factory service personnel, on the motor control board. Motors shall soft-ramp between speeds to lessen the acoustics due to sudden speed changes. Motors shall be operated at three speeds or with a field-supplied variable speed controller. The motor shall choose the highest speed if there are simultaneous/conflicting speed requests. All motors shall have integral

thermal overload protection with a maximum ambient operating temperature of 104°F and shall be permanently lubricated.

b. Motors shall capable of starting at 50 percent of rated voltage and operating at 90 percent of rated voltage on all speed settings. Motors shall operate up to 10 percent over voltage.

2.4 DRAIN PAN

a. The unit drain pan shall consist of a corrosion resistant, environmentally friendly, dual sloped design to facilitate condensate removal quickly.
b. The pan shall be removable for cleaning.
c. Hook-up to the drain pan for condensate removal is made on the cooling coil union side.
d. The drain side connection shall be easily field-inverted by removing and rotating the pan 180°.

2.5 HYDRONIC COILS

a. All hydronic coils shall be plate-fin type, mechanically bonded to tubes.
b. The coils shall be hydrostatically tested to 350 psig and burst tested to 450 psig.
c. The coils shall be rated in accordance with AHRI-840.
d. A threaded drain plug shall be provided at the header's lowest point, and a manual air vent provided at its highest point.
e. The heating coil shall be placed in the preheat location.

2.6 OUTSIDE AIR/RETURN AIR DAMPER

a. Each unit ventilator shall be equipped with a linkage free, air-tight damper design. This linkage free design results in a fixed air seal of the damper assembly.

2.7 CONTROLS

a. Unit-mounted Fan Speed Switch (FSS). The unit-mounted FSS will employ a low-voltage fan switch. The low-voltage fan speed option will provide an interface to factory wiring, including variable speed/high-medium-low (HML) control.
b. The control box shall contain a line voltage to 24-volt transformer, EC motor controller, and an optional disconnect switch.
c. Units shall be provided with a BACNET MS/TP compatible controller. Controller shall be factory mounted, wired and programmed.

a. Zone Temperature Sensors shall be wall mounted and compatible with the unit controller Sensor shall have an Occupancy override to allow operation of the unit for 1 hour during unoccupied periods. Sensor shall have an 10 kΩ thermistor with an accuracy of +/- 1%.
d. Zone CO_2 Sensors shall be wall mounted and compatible with the unit controller. Sensor shall have a range of 0-2000 ppm +/- 30 ppm.
e. Outside air damper actuators shall be spring return closed for fail safe operation.
f. Units shall be provided with a Freezestat and discharge air temperature sensor.
g. The unit shall have an outside air sensor in order to enable the economizer when cooling is required and the outside air is suitable for free cooling.
h. Units shall be provided with an integral time clock for occupied/unoccupied control. *If the unit is not capable of providing this function, the unit manufacturer/control contractor shall provide a supervisory controller with web-based interface to access the unit schedules.*

2.8 FILTER

a. Units shall be equipped with 1-in. MERV 8 filter that have a rating based on ASHRAE Standard 52.2. The average dust spot efficiency shall be no less than 35 to 40 percent when tested in accordance with ASHRAE Standard 52.1 atmospheric dust spot method.

2.9 MANUFACTURERS:

a. Trane
b. McQuay
c. Carrier
d. Johnson Controls
e. Airedale
f. Magic Aire

PART 3- EXECUTION

3.1 INSTALLATION

a. Install units to comply with NFPA 90A.
b. Install units level and plumb and anchor firmly to the building structure.
c. Connect to supply and return piping with shutoff valve and union at each connection.

d. Connect units to wiring systems and to ground.
e. Provide air tight gasketed seal between the unit ventilator and exterior wall.

3.2 SEQUENCE OF OPERATION

1. Occupied or Tenant Override Operating Mode:
   The supply fan shall run continuously during the occupied or tenant override modes.
2. Morning Warm-up:
   If the space temperature is below the Occupied Heating Set-point, the unit shall operate in the "Occupied Heating Mode" as described below. The outdoor air damper shall remain closed if a Warm-up Temperature Check has been enabled and the space temperature is below the occupied heating alarm set-point (65°F). After the space temperature rises above this limit, the damper operation shall be determined by the selected ASHRAE cycle. Cycle II operation shall cause the damper to modulate open and maintain the ventilation set-point, while Cycle III operation shall provide a damper position which shall maintain the mixed air temperature at the desired ASHRAE Cycle III damper set-point temperature.

3. Morning Start-Cooling:
   If the space temperature is above the Occupied Cooling Set-point, the unit shall operate in the "Occupied Cooling Mode" as described below. If Cycle II operation is selected and outdoor air is suitable for cooling, the damper shall be modulated to maintain the space temperature at the midpoint between the heating and cooling set-points in order to minimize the need for "mechanical" cooling or heating.

4. Occupied Heating Mode:
   If the space temperature falls below the heating set-point and the changeover input has enabled heating, the hot water control valve shall modulate as required to maintain the heating set-point. During heating, the fan shall operate at the lowest speed necessary to meet the space load conditions, and to minimize fan noise. If the load increases, the fan speed shall increase. When the load decreases and the space temperature rises, the fan speed shall be reduced. If the space temperature rises further, above the heating set-point, the hot water valve shall be driven closed.

5. Occupied Cooling Mode:
   If the space temperature rises above the cooling set-point, the chilled water valve shall modulate as required to maintain the cooling set-point.

During cooling, the fan shall operate at the lowest speed necessary to meet the space load conditions, and to minimize fan noise. If the space load increases, the fan speed shall increase to meet the load as required. When the load decreases and the space temperature falls, the fan speed shall be reduced. If the space temperature falls further, below the cooling set-point, the chilled water valve shall be driven closed.

6. Outdoor Air Damper Operation:
   a. Demand Controlled Ventilation:
   As the air quality of the space deteriorates and the value of the IAQ sensor exceeds the IAQ setpoint, the outdoor air damper minimum position shall be increased (damper opened) to increase ventilation. The outdoor air damper shall be modulated as necessary to maintain the desired IAQ setpoint. The maximum calculated IAQ damper position shall be automatically limited to prevent the mixed air temperature from falling below 50°F. If desired, an adjustable maximum IAQ limit (default 85%) shall also be used. During DCV operation, if the changeover input has enabled heating, the hot water valve shall modulate open as required in order to maintain the supply air temperature at 65°F, if heating or cooling is not required. Also, if the space temperature exceeds a high limit or falls below a low limit, then the outdoor air damper shall maintain the normal minimum ventilation setpoint (ASHRAE II) or the desired mixed air temperature (ASHRAE III) until the space temperature returns to normal.

   b. Unoccupied Operating Mode:
   The outdoor air damper shall be closed and the fan shall be off except as specified below:
      1. Unoccupied Fan Cycling:
   The fan shall start once an hour and shall operate for 1 minute to circulate the air in the space and provide better space temperature sensing. The actual start time for each unit shall be determined by its address.

7. Unoccupied Heating Mode:
   The fan shall be energized when the space temperature falls 1°F below the unoccupied heating set-point, and if the changeover input has enabled heating. The hot water valve shall be driven open by its valve actuator motor. The fan shall operate at low speed unless the low speed is unable to raise the space temperature to the unoccupied heating set-point. When the space temperature rises above the unoccupied heating set-point, the water valve shall close.

8. Unoccupied Cooling Mode:
   The fan shall be energized when the space temperature rises 1°F above the unoccupied cooling set-point, and if the changeover input has enabled cooling. The chilled water valve shall be driven open by its valve actuator motor. The fan shall operate at low speed unless that speed is unable to lower the space temperature to the unoccupied cooling set-point. When the space temperature falls below the unoccupied cooling set-point, the water valve shall be driven closed. The fan shall be de-energized after 5 minutes.

9. Unoccupied Free Cooling:
   If Unoccupied Free Cooling is enabled, the fan shall be energized when the space temperature is above the occupied cooling se-tpoint and if the outdoor air is suitable for cooling [(OAT is at least 8°F below SPT) and (OAT < Economizer Lockout Temperature (63°F, default)]. The outdoor air damper shall open. When the space temperature falls below the occupied cooling set-point or if the outdoor air becomes unsuitable for cooling, the fan shall be de-energized and the outdoor air damper shall close.

10. Freeze Protection Safeties (All Modes)
    To help protect against coil freezing when the fan is off, the control shall monitor the supply air temperature sensor and modulate the water valve to maintain the desired fan off value (55°F). If at any time the coil freeze detection (low limit thermostat) senses a temperature below its setpoint (38°F), its contacts shall close and the following actions will occur:

    A. The outdoor air damper shall close
    B. The fan shall stop
    C. The water valve shall fully open

    When the thermostat temperature rises and the contacts open, the unit shall return to normal operation.

3.3 TRAINING

1. The unit supplier shall provide (4) hours of training to the Owner upon completion and commissioning of the unit ventilator control system.
2. Training shall include reviewing maintenance procedures and sequence of operation of the units.

3.4 WARRANTY

2. The unit ventilator shall have a parts and labor warranty for a time period of (1) year from start up. The warranty shall cover all mechanical, electrical and control components.

END OF SECTION 23 82 23

SECTION 23 83 16 - RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 SECTION REQUIREMENTS

A. Submittals:
   1. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ENCLOSURE

A. Enclosures shall be wall mounted cold rolled steel, 16 ga.
B. Enclosures shall be 11-7/16” in height and 3-9/16” in depth.
C. Enclosures shall be electrostatically applied baked enamel. Color shall be matched to the unit ventilator manufacturer’s standard color. Provide color samples to the Owner for review.

2.2 BACKPLATE

A. Backplate shall be full height.
B. Backplates shall be standard20 ga. galvannealed.

2.3 ELEMENTS

A. Elements shall be mechanically expanded, copper tube with aluminum fin.

2.4 BRACKETS

A. Brackets shall be ball bearing with slide cradle.

2.5 ACCESSORIES

A. Provide all accessories including access doors, end caps, S-hooks, etc to provide a complete operating system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Secure piping all piping and backplates per the manufacturer’s recommendations.
B. Pressure test all piping prior to filling the system.
C. Provide access doors at all shut off and balancing valve locations.

END OF SECTION 238316