SECTION 23 81 29

VARIABLE REFRIGERANT VOLUME (VRV, VRF) HVAC SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Variable refrigerant volume HVAC system includes:
   1. Outdoor/Condensing unit(s).
   2. Indoor/Evaporator units.
   3. Branch selector units.
   4. Refrigerant piping.
   5. Control panels.
   6. Control wiring.

1.02 RELATED REQUIREMENTS

A. Section 01 23 00 - Alternates: List of alternates relevant to this section.

B. Section 01 79 00 - Demonstration and Training.

C. Section 01 91 13 - General Commissioning Requirements.

D. Section 01 91 14 - Commissioning Authority Responsibilities.

E. Section 22 10 05 - Plumbing Piping: Condensate drain piping.

F. Section 22 30 00 - Plumbing Equipment: Cooling condensate removal pumps.

G. Section 23 08 00 - Commissioning of HVAC.

H. Section 23 23 00 - Refrigerant Piping and Specialties: Additional requirements for refrigerant piping system.

I. Section 26 27 17 - Equipment Wiring: Power connections to equipment.
   1. Provide separate power connections for each unit of equipment.

J. Section 23 09 23 and 23 09 93: Building automation system providing centralized control of this system.

1.03 REFERENCE STANDARDS

A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; Air-Conditioning, Heating, and Refrigeration Institute.

B. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals.

C. ASHRAE Std 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings; American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc (ANSI/ASHRAE/IESNA Std 90.1).

D. NFPA 70 - National Electrical Code; National Fire Protection Association.

E. UL 1995 - Heating and Cooling Equipment.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Pre-Bid Submittals: For proposed substitute systems/products, as defined in PART 2, and alternate systems/products, as defined above, proposer shall submit all data described in this article, under the terms given for substitutions stated in PART 2.

C. Design Data:
   1. Provide design calculations showing that system will achieve performance specified.
   2. Provide design data required by ASHRAE 90.1.

D. Product Data: Submit manufacturer's standard data sheets showing the following for each item of equipment, marked to correlate to equipment item markings shown in the contract documents:
   1. Outdoor/Central Units:
      a. Refrigerant Type and Size of Charge.
      b. Cooling Capacity: Btu/h.
      c. Heating Capacity: Btu/h.
      d. Cooling Input Power: Btu/h.
      e. Heating Input Power: Btu/h.
      f. Operating Temperature Range, Cooling and Heating.
      g. Air Flow: Cubic feet per minute.
      h. Fan Curves.
      i. External Static Pressure (ESP): Inches WG.
      j. Sound Pressure Level: dB(A).
      k. Electrical Data:
         1) Maximum Circuit Amps (MCA).
         2) Maximum Fuse Amps (MFA).
         3) Maximum Starting Current (MSC).
         4) Full Load Amps (FLA).
         5) Total Over Current Amps (TOCA).
         6) Fan Motor: HP.
      l. Weight and Dimensions.
      m. Maximum number of indoor units that can be served.
      n. Maximum refrigerant piping run from outdoor/condenser unit to indoor/evaporator unit.
      o. Maximum height difference between outdoor/condenser unit to indoor/evaporator unit, both above and below.
      p. Control Options.
   2. Indoor/Evaporator Units:
      a. Cooling Capacity: Btu/h.
      b. Heating Capacity: Btu/h.
      c. Cooling Input Power: Btu/h.
      d. Heating Input Power: Btu/h.
      e. Air Flow: Cubic feet per minute.
      f. Fan Curves.
      g. External Static Pressure (ESP): Inches WG.
      h. Sound Pressure level: dB(A).
      i. Electrical Data:
         1) Maximum Circuit Amps (MCA).
         2) Maximum Fuse Amps (MFA).
         3) Maximum Starting Current (MSC).
         4) Full Load Amps (FLA).
         5) Total Over Current Amps (TOCA).

6) Fan Motor: HP.
j. Maximum Lift of Built-in Condensate Pump.
k. Weight and Dimensions.
l. Control Options.
3. Control Panels: Complete description of options, control points, zones/groups.

E. Specimen Warranty: Copy of manufacturer's warranties.

F. Shop Drawings: Installation drawings custom-made for this project; include as-designed HVAC layouts, locations of equipment items, refrigerant piping sizes and locations, condensate piping sizes and locations, remote sensing devices, control components, electrical connections, control wiring connections. Include:
1. Detailed piping diagrams, with branch balancing devices.
2. Condensate piping routing, size, and pump connections.
3. Detailed power wiring diagrams.
4. Detailed control wiring diagrams.
5. Locations of required access through fixed construction.
6. Drawings required by manufacturer.

G. Operating and Maintenance Data:
1. Manufacturer's complete standard instructions for each unit of equipment and control panel.
2. Custom-prepared system operation, troubleshooting, and maintenance instructions and recommendations.
3. Identification of replaceable parts and local source of supply.

H. Project Record Documents: Record the following:
1. As-installed routing of refrigerant piping and condensate piping.
2. Locations of access panels.
3. Locations of control panels.

I. Warranty: Executed warranty, made out in Owner's name.

1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications:
1. Company that has been manufacturing variable refrigerant volume heat pump equipment for at least 5 years.
2. Company that provides system design software to installers.

B. Installer Qualifications: Trained and approved by manufacturer of equipment.

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, and handle equipment and refrigerant piping according to manufacturer's recommendations.

1.08 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. Compressors: Provide manufacturer's warranty for six (6) years from date of installation. During the stated period, should any part fail due to defects in material and workmanship, it shall be repaired or replaced by the manufacturer. All warranty service work shall be preformed by a Daikin factory trained service professional.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Basis of Design: The system design shown in the contract documents is based on equipment and system designed by Mitsubishi Electric: www.mitsubishipro.com.

B. Additional acceptable manufacturers:
   1. Daikin AC: www.daikinac.com
   2. LG Industries: www.lg-vrf.com
   3. Samsung: www.www.samsungaccentre.com
   4. Trane Corporation: www.trane.com

C. For systems proposed by other manufacturers, all required modifications to the design and installation shall be the responsibility of the contractor and supplier for both costs and coordination with all other contractors and designers. These changes include, but are not limited to:
   1. Changes in refrigerant piping sizes, lenghts, and locations.
   2. Changes in branch selector quantities, locations, and accessibility.
   3. Changes in electrical requirements, including all power wiring, terminations, breakers, disconnects, and control wiring.
   4. Changes in heat-pump unit locations and quantities.
   5. Changes in structural supports, vibration isolation, and hangers.
   6. Changes to the drawings to reflect the new system parameters.

2.02 HVAC SYSTEM DESIGN

A. System Operation: Heating and cooling, simultaneously.
   1. Zoning: Provide capability for temperature control for each individual indoor/evaporator unit independently of all other units.
   2. Zoning: Provide heating/cooling selection for each individual indoor/evaporator unit independently of all other units.
   3. Provide a complete functional system that achieves the specified performance based on the specified design conditions and that is designed and constructed according to the equipment manufacturer's requirements.
   4. Conditioned spaces are shown on the drawings.
   5. Branch selector unit locations are shown on the drawings for reference only. Final design locations shall be corrdinated in the field to ensure optimized line lengths and maintanence access.
   6. Required equipment unit capacities are shown on the drawings.
   7. Refrigerant piping sizes shown on the drawings are for general reference only. Final line sizing shall be the responsibility of the successful contractor and manufacturer.
   8. Connect equipment to condensate piping; condensate piping is shown on the drawings.

B. Cooling Mode Interior Design Performance:
   1. Daytime Setpoint: 74 degrees F, plus or minus 2 degrees F.
   2. Setpoint Range: 57 degrees F to 80 degrees F.
   3. Night Setback: 78 degrees F.
   4. Interior Relative Humidity: 50 percent, maximum.

C. Heating Mode Interior Design Performance:
   1. Daytime Setpoint: 70 degrees F, plus or minus 2 degrees F.
   2. Setpoint Range: 59 degrees F to 76 degrees F.
   3. Night Setback: 60 degrees F.
   4. Interior Relative Humidity: 20 percent, minimum.

D. Outside Air Design Conditions:

1. Summer Outside Air Design Temperature: 0.4 percent cooling design condition listed in ASHRAE Fundamentals Handbook.

E. Operating Temperature Ranges:
1. Simultaneous Heating and Cooling Operating Range: minus 4 degrees F to 60 degrees F dry bulb.
2. Cooling Mode Operating Range: minus 4 degrees F to 110 degrees F dry bulb.
3. Heating Mode Operating Range: 0 degrees F to 77 degrees F dry bulb; minus 4 degrees F to 60 degrees F wet bulb; without low ambient controls or auxiliary heat source.

F. Refrigerant Piping Lengths: Provide equipment capable of serving system with following piping lengths without any oil traps:
1. Minimum Piping Length from Outdoor/Central Unit(s) to Furthest Terminal Unit: 540 feet, actual; 620 feet, equivalent.
2. Total Combined Liquid Line Length: 3280 feet, minimum.
3. Minimum Piping Length Between Indoor Units: 49 feet.

G. Controls: Provide the following control interfaces:
1. For Each Indoor/Evaporator Unit: One wall-mounted wired "local" controller, with temperature sensor; locate where directed, in each space.
2. One central remote control panel for entire system; locate where indicated.
3. BACNet gateways sufficient to connect all units to building automation system by others; include wiring to gateways.
4. Building automation system by HVAC system manufacturer; provide one user stations located where indicated.

H. Local Controllers: Wall-mounted, wired, containing temperature sensor, setpoint adjustment (with central control override, maximum temperature adjustment +1/-1 degree, adjustable), and temperature display.

2.03 EQUIPMENT

A. All Units: Factory assembled, wired, and piped and factory tested for function and safety.
1. Refrigerant: R-410A.
2. Performance Certification: AHRI Certified; www.ahrinet.org.
3. Safety Certification: Tested to UL 1995 by UL or Intertek-ETL and bearing the certification label.
4. Provide outdoor/condensing units capable of serving indoor unit capacity up to 200 percent of the capacity of the outdoor/condensing unit.
5. Provide units capable of serving the zones indicated.
6. Thermal Performance: Provide heating and cooling capacity as indicated, based on the following nominal operating conditions:
7. Energy Efficiency: Report EER and COP based on tests conducted at “full load” in accordance with AHRI 210/240 or alternate test method approved by U.S. Department of Energy.

B. Electrical Characteristics:
1. See drawings.

C. System Controls:
1. Include self diagnostic, auto-check functions to detect malfunctions and display the type and location.

D. Unit Controls: As required to perform input functions necessary to operate system; provided by manufacturer of units.

E. Wiring:
   1. Control Wiring: 18 AWG, 2-conductor, non-shielded, non-polarized, stranded cable.
   2. Control Wiring Configuration: Daisy chain.
   3. All control wiring for the VRF system in it's entirety is the responsbility of the installig contractor.

F. Refrigerant Piping:
   1. Insulate each refrigerant line individually between the condensing and indoor units.

2.04 OUTDOOR/CONDENSING UNITS

A. Outdoor/Condensing Units: Air-cooled DX refrigeration units, designed specifically for use with indoor/evaporator units; factory assembled and wired with all necessary electronic and refrigerant controls; modular design for ganging multiple units.
   1. Refrigeration Circuit: Scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator.
   2. Refrigerant: Factory charged.
   3. Variable Volume Control: Modulate compressor capacity automatically to maintain constant suction and condensing pressures while varying refrigerant volume to suit heating/cooling loads.
   4. Capable of being installed with wiring and piping to the left, right, rear or bottom.
   5. Capable of heating operation at low end of operating range as specified, without additional low ambient controls or auxiliary heat source; during heating operation, reverse cycle (cooling mode) oil return or defrost is not permitted, due to potential reduction in space temperature.
   6. Sound Pressure Level: As specified, measured at 3 feet from front of unit; provide night setback sound control as a standard feature; three selectable sound level steps of 55 dB, 50 dB, and 45 dB, maximum.
   7. Power Failure Mode: Automatically restart operation after power failure without loss of programmed settings.
   8. Safety Devices: High pressure sensor and switch, low pressure sensor/switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
   9. Provide refrigerant sub-cooling to ensure the liquid refrigerant does not flash when supplying to us indoor units.
   10. Oil Recovery Cycle: Automatic, occurring 2 hours after start of operation and then every 8 hours of operation; maintain continuous heating during oil return operation.
   11. Controls: Provide contacts for electrical demand shedding.

B. Unit Cabinet: Weatherproof and corrosion resistant; rust-proofed mild steel panels coated with baked enamel finish.
   1. Designed to allow side-by-side installation with minimum spacing.

C. Fans: One or more direct-drive propeller type, vertical discharge, with multiple speed operation via DC (digitally commutating) inverter.
   1. Provide minimum of 2 fans for each condensing unit.
   2. External Static Pressure: Factory set at 0.12 in WG, minimum.
   3. Indoor Mounted Air-Cooled Units: External static pressure field set at 0.32 in WG, minimum; provide for mounting of field-installed ducts.
   4. Fan Airflow: As indicated for specific equipment.

5. Fan Motors: Factory installed; permanently lubricated bearings; inherent protection; fan guard; output as indicated for specific equipment.

D. Condenser Coils: Copper tubes expanded into aluminum fins to form mechanical bond; waffle louver fin and rifled bore tube design to ensure high efficiency performance.

E. Compressors: Scroll type, hermetically sealed, variable speed inverter-driven and fixed speed in combination to suit total capacity; minimum of one variable speed, inverter driven compressor per condenser unit; minimum of two compressors per condenser unit; capable of controlling capacity within range of 6 percent to 100 percent of total capacity.
   1. Multiple Condenser Modules: Balance total operation hours of compressors by means of duty cycling function, providing for sequential starting of each module at each start/stop cycle, completion of oil return, and completion of defrost, or every 8 hours.
   2. Failure Mode: In the event of compressor failure, operate remaining compressor(s) at proportionally reduced capacity; provide microprocessor and associated controls specifically designed to address this condition.
   3. Provide each compressor with crankcase heater, high pressure safety switch, and internal thermal overload protector.
   4. Provide oil separators and intelligent oil management system.
   5. Provide spring mounted vibration isolators.

2.05 BRANCH SELECTOR UNITS

A. Branch Selector Units: Concealed boxes designed specifically for this type of system to control heating/cooling mode selection of downstream units; consisting of electronic expansion valves, subcooling heat exchanger, refrigerant control piping and electronics to facilitate communications between unit and main processor and between branch unit and indoor/evaporator units.
   1. Provide one electronic expansion valve for each downstream unit served, except multiple indoor/evaporator units may be connected, provided balancing joints are used in downstream piping and total capacity is within capacity range of the branch selector.
   2. When branch unit is simultaneously heating and cooling, energize subcooling heat exchanger.
   3. Casing: Galvanized steel sheet; with flame and heat resistant foamed polyethylene sound and thermal insulation.
   4. Refrigerant Connections: Braze type.
   5. Condensate Drainage: Provide condensate drain tap where required.

2.06 INDOOR/EVAPORATOR UNITS

A. All Indoor/Evaporator Units: Factory assembled and tested DX fan-coil units, with electronic proportional expansion valve, control circuit board, factory wiring and piping, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
   1. Refrigerant: Refrigerant circuits factory-charged with dehydrated air, for field charging.
   2. Temperature Control Mechanism: Return air thermistor and computerized Proportional-Integral-Derivative (PID) control of superheat.
   3. Coils: Direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond; waffle louver fin and high heat exchange, rifled bore tube design; factory tested.
      a. Provide thermistor on liquid and gas lines.
   4. Fans: Direct-drive, with statically and dynamically balanced impellers; high and low speeds unless otherwise indicated; motor thermally protected.
   5. Return Air Filter: Washable long-life net filter with mildew proof resin, unless otherwise indicated.
   6. Condensate Drainage: Built-in condensate drain pan with PVC drain connection.

7. Cabinet Insulation: Sound absorbing foamed polystyrene and polyethylene insulation.

B. Recessed Ceiling Units: Four-way airflow cassette with central return air grille, for installation in a fixed ceiling.
1. Cabinet Height: Maximum of 10 inches above face of ceiling.
2. Exposed Housing: White, impact resistant, with washable decoration panel.
3. Supply Airflow Adjustment:
a. Via motorized louvers which can be horizontally and vertically adjusted from 0 to 90 degrees.
b. Field-modifiable to 3-way and 2-way airflow.
c. Three auto-swing positions, including standard, draft prevention and ceiling stain prevention.
4. Return Air Filter: High efficiency, MERV 8.
5. Minimum Capacity: As indicated on the drawings.
6. Sound Pressure Range: Between 28 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.
7. Fan: Direct-drive turbo type, with motor output range of 0.06 to 0.12 HP.
8. Condensate Pump: Built-in, with lift of 21 inches, minimum.
9. Provide side-mounted fresh air intake duct connection.

C. Concealed-In-Ceiling Units: Ducted horizontal discharge and return; galvanized steel cabinet.
1. Return Air Filter: MERV 11.
2. Sound Pressure: Measured at low speed at 5 feet below unit.
3. Provide external static pressure switch adjustable for high efficiency filter operation
4. Condensate Pump: Built-in, with lift of 9 inches, minimum.
5. Switch box accessible from side or bottom.

D. Wall Surface-Mounted Units: Finished white casing, with removable front grille; foamed polystyrene and polyethylene sound insulation; wall mounting plate; polystyrene condensate drain pan.
1. Airflow Control: Auto-swing louver that closes automatically when unit stops; five (5) steps of discharge angle, set using remote controller; upon restart, discharge angle defaulting to same angle as previous operation.
2. Sound Pressure Range: Measured at low speed at 3.3 feet below and away from unit.
3. Condensate Drain Connection: Side (end), not concealed in wall.
4. Fan: Direct-drive cross-flow type.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that required electrical services have been installed and are in the proper locations prior to starting installation.

B. Verify that condensate piping has been installed and is in the proper location prior to starting installation.

C. Notify Architect if conditions for installation are unsatisfactory.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install refrigerant piping in accordance with equipment manufacturer's instructions.

C. Perform wiring in accordance with NFPA 70, National Electric Code (NEC).

D. Coordinate with installers of systems and equipment connecting to this system.

3.03 FIELD QUALITY CONTROL

A. Provide manufacturer's field representative to inspect installation prior to startup.

3.04 SYSTEM STARTUP

A. Provide manufacturer's field representative to perform system startup.

B. Prepare and start equipment and system in accordance with manufacturer's instructions and recommendations.

C. Adjust equipment for proper operation within manufacturer's published tolerances.

3.05 CLEANING

A. Clean exposed components of dirt, finger marks, and other disfigurements.

3.06 CLOSEOUT ACTIVITIES

A. Demonstrate proper operation of equipment to Red Clay Consolidated School District's designated representative.

B. Demonstration: Demonstrate operation of system to Red Clay Consolidated School District's personnel.
   1. Use operation and maintenance data as reference during demonstration.
   2. Briefly describe function, operation, and maintenance of each component.

C. Training: Train Red Clay Consolidated School District's personnel on operation and maintenance of system.
   1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
   2. Provide minimum of two hours of training.
   3. Instructor: Manufacturer's training personnel.
   4. Location: At project site.

3.07 PROTECTION

A. Protect installed components from subsequent construction operations.

B. Replace exposed components broken or otherwise damaged beyond repair.

3.08 MAINTENANCE

A. See Section 01 70 00 - Execution Requirements, for additional requirements relating to maintenance service.

END OF SECTION