

## SECTION 23 8129

### VARIABLE REFRIGERANT VOLUME (VRV) 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 23 0800 - Commissioning of HVAC.
- B. Section 23 2300 - Refrigerant Piping: Additional requirements for refrigerant piping system.
- C. Section 23 8130 - Basis of Design VRV Equipment.
- D. Section 26 2717 - Equipment Wiring: Power connections to equipment.

##### 1.03 PRICE AND PAYMENT PROCEDURES

- A. Alternates: Owner requests a bid Alternate for a system designed and manufactured by a manufacturer other than that listed as the Basis of Design.
  - 1. Alternate systems will be considered only under the terms described for Substitutions in the article MANUFACTURERS in PART 2 of this section.
  - 2. Construction Manager shall include with his bid the amount to be deducted from the bid amount if the alternate is accepted by the Owner.

##### 1.04 REFERENCE STANDARDS

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2008.
- B. ASHRAE Std 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Addenda.
- C. ITS (DIR) - Directory of Listed Products; current edition.
- D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

##### 1.05 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.

##### 1.06 SUBMITTALS

- A. See Section 01 3000 - 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 Std 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.

7. In addition to paper copies, submit shop drawings as CAD files in DXF format.
- 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.

### **1.07 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.

### **1.08 DELIVERY, STORAGE AND HANDLING**

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

## **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 Daikin AC; [www.daikinac.com](http://www.daikinac.com).
- B. Systems designed and manufactured by other manufacturers will be considered by Owner under the terms described for substitutions with the following exceptions:
  1. Substitution requests will be considered only if required submittal data is complete; see article SUBMITTALS above.
  2. Construction Manager (not equipment supplier) shall certify that the use of the substitute system and equipment will not require changes to other work or re-design by Architect.
  3. Do not assume substitution has been accepted until formal written notice has been issued by Architect.

### **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 not shown on the drawings.
  6. Required equipment unit capacities are shown on the drawings.
  7. Refrigerant piping sizes are not shown on the drawings.
  8. Connect equipment to condensate piping provided by others; condensate piping is shown on the drawings.
- B. Cooling Mode Interior Performance:
  1. Daytime Setpoint: 68 degrees F, plus or minus 2 degrees F.
  2. Setpoint Range: 57 degrees F to 77 degrees F.
  3. Night Setback: 78 degrees F.
  4. Interior Relative Humidity: 20 percent, maximum.
- C. Heating Mode Interior Performance:
  1. Daytime Setpoint: 68 degrees F, plus or minus 2 degrees F.

2. Setpoint Range: 59 degrees F to 80 degrees F.
  3. Night Setback: 60 degrees F.
  4. Interior Relative Humidity: 10 percent, minimum.
- D. Outside Air Design Conditions:
1. Summer Outside Air Design Temperature: 93 degrees F dry-bulb; 75 degrees F wet-bulb.
- E. Energy Design Wind Speed: 25 mph.
- F. 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.
- G. 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.
- H. Control Wiring Lengths:
1. Between Outdoor/Condenser Unit and Indoor/Evaporator Unit: 6,665 feet, minimum.
  2. Between Outdoor/Condenser Unit and Central Controller: 3,330 feet, minimum.
  3. Between Indoor/Evaporator Unit and Remote Controller: 1,665 feet.
- I. Controls: Provide the following control interfaces:
1. LonWorks gateways sufficient to connect all units to building automation system by others; include wiring to gateways.

### **2.03 EQUIPMENT**

- A. All Units: Factory assembled, wired, and piped and factory tested for function and safety.
1. Performance Certification: AHRI Certified; [www.ahrinet.org](http://www.ahrinet.org).
  2. Safety Certification: Tested to UL 1995 by UL or Intertek-ETL, listed in ITS (DIR), and bearing the certification label.
  3. Provide outdoor/condensing units capable of serving indoor unit capacity up to 200 percent of the capacity of the outdoor/condensing unit.
  4. Provide units capable of serving the zones indicated.
  5. Thermal Performance: Provide heating and cooling capacity as indicated, based on the following nominal operating conditions:
  6. 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. Power - Branch Selector Units: 208 to 230 Volts, single phase, 60 Hz.
  2. Power - Indoor Units: 208 to 230 Volts, single phase, 60 Hz.
  3. 208-230 Voltage Range: 187 to 253 volts.
- C. 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. Control direction of refrigerant flow using electronic expansion valves; use of solenoid valves for changeover and pressure equalization is not permitted due to refrigerant noise; use of multi-port branch selector boxes is not permitted unless spare ports are provided for redundancy.
  - 2. 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.
  - 3. When branch unit is simultaneously heating and cooling, energize subcooling heat exchanger.
  - 4. Casing: Galvanized steel sheet; with flame and heat resistant foamed polyethylene sound and thermal insulation.
  - 5. Refrigerant Connections: Braze type.
  - 6. Condensate Drainage: Provide unit that does not require condensate drainage.

## 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 - 3 FT by 3 FT: Four-way airflow cassette with central return air grille, for installation in a fixed ceiling.
  - 1. Face Size: 33 inches square, nominal.
  - 2. Cabinet Height: Maximum of 10 inches above face of ceiling.
  - 3. Exposed Housing: White, impact resistant, with washable decoration panel.
  - 4. 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.
  - 5. Return Air Filter: Manufacturer's standard.
  - 6. Minimum Capacity: As indicated on the drawings.
  - 7. Sound Pressure Range: Between 28 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.
  - 8. Fan: Direct-drive turbo type, with motor output range of 0.06 to 0.12 HP.
  - 9. Condensate Pump: Built-in, with lift of 21 inches, minimum.

10. Provide side-mounted supply air branch duct connection.
  11. Provide side-mounted fresh air intake duct connection.
  12. Product(s):
    - a. Daikin AC FXFQ Series.
- C. Recessed Ceiling Units - 2 FT by 2 FT: Four-way airflow cassette with central return air grille, sized for installation in standard 24 by 24 inch lay-in ceiling grid.
1. Cabinet Height: Maximum of 12 inches above face of ceiling.
  2. Exposed Housing: White, impact resistant, with washable decoration panel.
  3. Maintenance Access: All electrical components accessible through decoration panel.
  4. 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.
  5. Sound Pressure: Measured at low speed at 5 feet below unit.
  6. Fan: Direct-drive turbo type.
  7. Condensate Pump: Built-in, with lift of 21 inches, minimum.
  8. Provide side-mounted supply air branch duct connection.
  9. Provide side-mounted fresh air intake duct connection.
  10. Product(s):
    - a. Daikin FXZQ Series.
- D. Concealed-In-Ceiling Units: Ducted horizontal discharge and return; galvanized steel cabinet.
1. Return Air Filter: Manufacturer's standard.
  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.
  6. Product(s):
    - a. Daikin FXMQ\_P Series; three-speed direct-drive DC (ECM) type fan with automatic airflow adjustment; external static pressure selectable during commissioning.
    - b. Daikin FXDQ (Slim Duct) Series; side return; direct-drive Sirocco type fan.
    - c. Daikin FXMQ\_M Series; direct-drive Sirocco type fan.
    - d. Daikin FXMQ\_MF Series, Outside Air Processor: Capable of introducing up to 100 percent outside air controlled to fixed discharge air temperature; direct-drive Sirocco type fan.
- E. Ceiling Surface-Mounted Units: White, finished casing, with removable front grille; foamed polystyrene and polyethylene sound insulation, and mounting brackets; mildew-proof polystyrene 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. Fan: Two-speed, direct-drive cross-flow type.
  4. Products:
    - a. Daikin FXHQ Series.
- F. 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: Back, with piping concealed in wall.
  4. Fan: Direct-drive cross-flow type.
  5. Products:
    - a. Daikin FXAQ Series.
- G. Exposed Console Units: Top discharge grille, bottom return air; finished casing, sound-insulated with fiberglass urethane foam; auto-swing louver that closes automatically when unit stops.
1. Maintenance Access Required: Not more than 3/4 inch in rear, 4 inch on each side.
  2. Sound Pressure Range: Measured at high speed at 5 feet away and 5 feet above floor.
  3. Fan: Sirocco type.
  4. Products:
    - a. Daikin FXLQ Series.
- H. Concealed Console Units: Top discharge grille, bottom return air; unfinished casing, sound-insulated with fiberglass urethane foam; auto-swing louver that closes automatically when unit stops.
1. Maintenance Access Required: Not more than 3/4 inch in rear, 4 inch on each side.
  2. Sound Pressure Level: Measured at high speed measured at 5 feet away and 5 feet above floor.
  3. Fan: Sirocco type.
  4. Products:
- I. Air Handling Units: Factory-painted heavy gage steel casing insulated with sound absorbing foil faced insulation.
1. Secondary condensate drain pan; field installed.
  2. Fan: Direct-drive ECM type fan with automatic airflow adjustment.
  3. Provide air filter.
  4. External insulation; field installed.
  5. Products:
    - a. Daikin FXTQ Series.

## **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. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Provide manufacturer's field representative to inspect installation prior to startup.

### **3.04 SYSTEM STARTUP**

- A. Prepare and start equipment and system in accordance with manufacturer's instructions and recommendations.
- B. 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 COMMISSIONING**

- A. See Section 01 9113 - General Commissioning Requirements for commissioning requirements.
- B. Perform commissioning as specified in Section 23 0800.
- C. Perform the following Functional Tests:

**3.07 CLOSEOUT ACTIVITIES**

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Demonstrate proper operation of equipment to Owner's designated representative.
- D. Training: Train Owner'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.

**3.08 PROTECTION**

- A. Protect installed components from subsequent construction operations.
- B. Replace exposed components broken or otherwise damaged beyond repair.

**END OF SECTION 23 8129**

