VRF Guide Specification

NOTE: Significant revisions or additions to the previous standards are highlighted in italics.

Article I. PRODUCT DESCRIPTION
Variable Refrigerant Flow (VRF) HVAC system shall be a variable capacity, direct expansion (DX) field selectable Heat Pump or Heat Recovery engineered system unified within a single cabinet. The outdoor unit shall consist of one or more frames connected through a common 2-pipe Heat Pump or 3-pipe Heat Recovery refrigerant piping network and control communication wiring. Each system shall have single or multiple, inverter compressor(s). Each system shall be connected to multiple indoor units (ducted, non-ducted or mixed combinations) through a common refrigerant piping network and integrated system controls and communication network. Each indoor unit shall be controlled individually or as a group. Additionally, heat recovery systems shall be capable of simultaneous heating and cooling of individual zone(s).

2.01 Basis of Design Mfg. - Daikin or LG. Acceptable standards shall be supplied based upon the performance characteristics and features of the model number(s) specified, model families specified and as otherwise specified herein. Alternate suppliers shall request permission to bid, in writing, from the engineer at least 10 days prior to the bid date. This request by the contractor to bid an alternate supplier to the basis of design, listed or not listed, shall not relieve the contractor of supplying all materials, options, controls, sequences, efficiencies and intents of the original specifications written or implied by model number or model family or as otherwise specified. The written request and engineers’ written response to such request shall be included in all submittal documents for approval. This is a performance-based specification, not intended to disqualify either manufacturer on a technical basis.

2.02 ALT Equipment Bid Instruction: The contractor shall provide basis of design bid as specified and with specified products. If the contractor should wish to propose any alternate products to the basis of designed products they shall provide a separate and complete Bid detailing the proposed alternate products and the associated adjustment of price to support the change from basis of design products. The contractor bids the alternate product with full knowledge that the proposed product may not be acceptable or approved. In no event shall the contractor be entitled to additional compensation to supply such specified products, options, sequences or intents. Any and all additional cost, to any party, because of any product submitted on or supplied other than that of the original specified products shall be the responsibility of the contractor without recourse. It is agreed that any and all disputes regarding any differences between the specified products, options, sequences or intents and that proposed as an alternate shall be arbitrated by the engineer of record. It shall be further agreed by all parties that all decisions of arbitration shall be final and binding. Any product proposed as an alternate shall have been offered, as a VRF product, in the United States for a minimum of (5) years.

ALTERNATE Equipment Mfg. (approval to bid if meeting the specifications): LG or Daikin

2.03 System Performance Documentation: The VRF manufacturer shall provide published outdoor unit performance data in table format which states the products heating and cooling capacity.
expressed in British thermal units per hour (BtuH) and power consumption expressed in kilowatts (kW) at a minimum of 8 possible combinations of allowed conditions between 50% and 130% connection ratio. Possible combinations of allowed condition variables include Combination Ratios expressed as a percentage value, Outdoor Ambient Temperature expressed in degrees Fahrenheit (°F), and indoor unit Entering Air wet and dry bulb temperature expressed in degrees Fahrenheit (°F). Any product whose system design and engineering manuals or guides where published data tables are expressed in units other than these specified will not be accepted.

2.04 Any product whose published documentation requires the design engineer to apply a correction factor derived from a published curve or tabular data for combination ratio, outdoor ambient temperature, and/or entering air temperature against rated conditions to obtain performance at any possible combination of allowed conditions will not be accepted.

2.05 Submittals: A complete submittal package shall be complied and 10 copies shall be forwarded to the general contractor who shall supply the architect with the submittals for dissemination to all parties. The submittal shall be a collection of documents that represent the technical aspects of each product or collection of products to be used on the project. All performance submissions shall be calculated at the design temperatures, nominal performance data shall not be allowed. The submission and approval of said submittals does not relieve the contractor of supplying all requirements set forth in the specification and drawings. Any substitutions offered by the contractor shall include, as a separate document, any and all differences between the submitted products and the specified products including but not limited to, all dimensions, electrical, control, weights, warranties, country of origin and a statement from the manufacturer that no child labor has been used in the manufacture or assembly of said products and a copy shall be supplied with the product outdoor unit submittal.

2.06 If submittals contain any proposed alternate equipment specifications, calculations, dimensions, electrical specifications, sound specifications or any other mandated submission which are not accepted, are noted or rejected for any reason the contractor shall be allowed to correct any deficiency and re-submit a second time. Should there be any issues found on second submission, the contractor will be directed to and agrees to submit on the original specified products, including any changes or revisions, and provide those specified products without any additional compensation.

2.07 Manufacturer’s representative shall attend preconstruction meeting. Rep shall also verify that the training certifications provided by the contractor are in order.

2.08 Upon job completion: Provide the owner with an commercially available tablet containing a copy of approved submittal, Mobile service and diagnostic software (VRF system service diagnostics) software, project mechanical and control drawings, all as-built piping drawings, O&M’s, troubleshooting guides, service manuals and engineering manuals in PDF format. Provide any specialized repair tools needed for system maintenance.

2.09 Heat Pump & Heat recovery Cooling and Heating VRF System
VRF (Unified Heat Pump & Heat recovery System)
Unified heating and cooling system shall be an air cooled system allowing user to configure in the field a heat pump or a heat recovery system consisting of one to three outdoor unit modules, conjoined to make a 6-42 ton single refrigerant circuit. Heat recovery systems, employing three pipes, shall be connected to Heat recovery (heat
recovery) unit(s) and indoor unit(s). Multi-port heat recovery units shall allow simultaneous heating and cooling of individual zone(s) at various capacities as required to satisfy their zone requirements. Heat pump systems shall require two pipes, simultaneous heating and cooling shall not be supported. The heat recovery system shall consist of three pipes, liquid, suction and hot gas pipes, two pipe heat recovery systems that cannot deliver, at zero degrees outdoor ambient, 182°F hot gas to the indoor coils for heat shall not be acceptable.

The heat recovery system shall be capable of operating with <208/230V> or <460V> 60Hz, 3 phase power.

Article II. STANDARDS / CERTIFICATIONS

3.01 VRF unified heating and cooling (variable refrigerant flow systems) shall have published performance ratings certified by AHRI (Air-Conditioning, Heating, and Refrigeration Institute) and listed in the AHRI Standard 1230 certified product directory.

3.02 All VRF system components shall be manufactured in production facilities maintaining the following ISO certifications:
   a) ISO 9001 Quality Management System
   b) ISO 14001 Environmental Management System


3.04 All-VRF system electrical power wiring shall be installed according to National Electrical Code (NEC) or applicable state and local building codes.

Article III. MANUFACTURERS WARRANTY AND ADDITIONAL OWNERS SERVICES:

3.05 VRF shall be provided with an industry leading, standard 10 year warranty for compressors and mechanical parts. A standard 1 year labor warranty is provided + an additional 4 years labor warranty is required for this project, for a total of 5 years. If an issues arises, the Owner of Equipment personnel will provide diagnostic services to determine issues using VRF mfg. training and tablet with diagnostic software.

3.06 This warranty covers the owner of the equipment in which the unit is installed (“owner”).

3.07 This warranty does not apply to:
   1. Units that are ordered over the Internet, by telephone, or by other electronic means unless the unit is installed by a mechanical contractor adhering to all applicable federal, state, and local codes, policies, and licensing requirements. Does not cover fuses or refrigerant loss.
   2. Units that are operated in an incomplete building envelope or to heat or cool the structure during construction.

3.08 This warranty covers defects in materials and workmanship that appear under normal use and maintenance.

3.09 Other Warranties: THIS WARRANTY IS PROVIDED IN LIEU OF ANY OTHER WARRANTIES,

3.010 Damage or repairs required as a consequence of faulty installation or application, including, without limitation, Damage as a result of floods, fires, winds, lightning, accidents, corrosive atmosphere, or other conditions beyond manufacturer’s control. Damage or the need for repairs arising from the use of components or accessories not compatible with this unit.

3.011 Normal maintenance as described in the installation and operating manual, such as cleaning of the coils, filter cleaning and/or replacement, and lubrication. Parts or accessories not supplied
or designated by the manufacturer. Damage or the need for repairs resulting from any improper use, maintenance, operation, or servicing.

3.012 Damage or failure of the unit to start due to interruption in electrical service or inadequate electrical service or due to poor power quality issues.

3.013 Any damage caused by frozen or broken water pipes in the event of equipment failure. Changes in the appearance of the unit that do not affect its performance. Replacement of fuses and replacement or resetting of circuit breakers.

3.014 Damage or the need for repairs resulting from the use of unapproved refrigerant types or used or recycled refrigerant or use of non-approved oil.

3.015 **Refrigerant Analysis services will be required for each system.** If the refrigerant shows signs of fractionation or impurities above the VRF mfgs. Recommended limits the units will not be started up until corrective action by the installing contractor is complete. The ability of the technician to determine refrigerant type and purity is severely hampered by the presence of air when attempting to utilize temperature-pressure relations. **The refrigerant analyzer services will be provided by the VRF mfg. rep. and used at start up to protect the owner and engineer against poor installations.**

3.016 Any additional system clean up driers or 3-valve isolations systems required to clean up the system will provided and installed by the installing contractor.

3.017 The Refrigerant Analyzer shall provide a fast, easy and accurate means to determine refrigerant purity in refrigerant storage cylinders or directly in air conditioning systems. The instrument utilizes non-dispersive infrared (NDIR) technology to determine the weight concentrations of multiple refrigerant types. Refrigerant purity is displayed on the LCD Screen and the user must determine acceptable levels of purity based on their recovery or use standards.

3.018 The instrument is supplied complete with a ¼” Flare Vapor Sampling Hose, a High Pressure Liquid Sample Trap Assembly, a 100-240 VAC power transformer, built in Lithium Iron Phosphate battery, thermal printer, and all required plumbing housed within a rugged, portable, storage case.

3.019 Testing occurs when sample gas is admitted into the instrument through the supplied sampling hose configurations and presented to the sensing device. The instrument provides the user with direct **percent by weight** concentrations.

3.020 The instrument interfaces with the user via a LCD graphic display, status indicator LED’s, and push button communication switches. Direct **percent by weight** concentrations of the sampled refrigerant are provided on the display as well as user directions and prompts. An on-board printer is provided to print an on-the-spot analysis report.

3.021 The Refrigerant Analyzer provides the refrigerant technician with excellent knowledge of refrigerant type and purity as well as protection against refrigerant contamination and potential flammability.

3.022 Features shall Include: Advanced ergonomic design, Fast test time, Built in printer for instant analysis report, Built in oxygen sensor to detect presence of Air, Vapor or Liquid Sampling ability, Internal, rechargeable Lithium Iron Phosphate battery for cordless operation in any location.

3.023 The actual refrigerant analysis for each system will be made part of the start-up documentation provide to the owner and serve as a baseline for refrigerant purity when checked again if the system is every opened.

3.024 **VRF Support Services** – during construction VRF Mfg. rep. will provide monthly walkthroughs of the project site during piping installation to ensure the system is being installed properly. In addition, each installing contractor MUST be certified to install the VRF system by the system manufacturer. Report(s) generated by the monthly walkthroughs to be provided to Owner.
Article IV. VRF (Unified Heat Pump & Heat Recovery SYSTEM)

4.01 All three-phase unified outdoor units shall be from the same product design. Mixing of different product designs, families, or product lines are not acceptable.

4.02 All three-phase VRF unified heat pump and heat recovery outdoor units shall be from the same product development generation. Mixing of outdoor units from different development generations is not acceptable.

4.03 The VRF systems shall be capable of providing continuous compressor operation over the required ambient operating range stated in section 4.03. VRF systems that provide possible, but don’t guarantee continuous compressor operation over the required ambient operating range stated in section 4.03, will not be accepted. Submittal that states performance data is reference data, data that is for reference only, or that is footnoted as such shall not be accepted.

4.04 Outdoor Unit shall be capable of continuous compressor operation between the following operating ambient air conditions, operation outside of these conditions are possible and may involve non-continuous operations.

Operating ambient air conditions

a) Heat Pump & Heat recovery System
   (i) Cooling: 14°F DB to 122°F DB <With optional low ambient kit from -9.9°F DB to 122°F DB>
   (ii) Heating: -13°F WB to 61°F WB
   (iii) Cooling based synchronous: 14°F DB to 81°F DB (Heat Recovery Operation Only)
   (iv) Heating-based synchronous: 14°F WB to 61°F WB (Heat Recovery Operation Only)

4.05 General features:
   a) The air-conditioning system shall use R410A refrigerant.
   b) The system shall be capable of an automatic refrigerant charge function for use in both the heat mode and cool mode to ensure the proper amount of refrigerant is installed into the system.

   c) Each system shall consist of one, two or three air source outdoor unit modules conjoined together in the field to result in the capacity specified elsewhere in these documents.
   d) Dual and triple frame configurations shall be field piped together using manufacturer’s designed and supplied Y-branch kits and field provided interconnecting pipe to form a common refrigerant circuit.
   e) System shall employ self-diagnostics function to identify any malfunctions and provide type and location of malfunctions via fault alarms.

   f) Cabinet weights and foot prints shall vary between 430 Lbs., 7.61 sq. ft. (1.27 sq. ft. per ton), for 6 ton cabinet to 662 Lbs., 10.14 sq. ft. (.51 sq. ft. per ton), for 20 ton cabinet for single cabinet configurations. Multi cabinet configurations shall be per specifications and as listed in table below. (Install setbacks and service areas not included).

   g) Refrigerant circuit configuration for unified heat pump and Heat recovery Heat System:
      (i) The refrigerant circuit shall be constructed using field provided ACR copper, dehydrated, refrigerant rated copper pipe, piped together with manufacturer supplied Heat recovery unit(s) and Y-branches, as may be required, connected to multiple
(ducted, non-ducted or mixed combination) indoor units to effectively and efficiently control the heat pump or Heat Recovery mode operations or simultaneous heating and cooling operation of the VRF system. Other pipe materials, if used, shall perform, at a minimum, as well as that specified above, shall not have any adverse reactions to any other components or materials also in use in the system and shall be installed per manufactures instructions.

a) All refrigerant pipe, y-branches, elbows and valves shall be individually insulated with no air gaps. Insulation R-value (thickness) shall not be less than the minimum called for by the local building code, local energy code or as a minimum per manufacture installation requirements. In no case shall the insulation be allowed to be compressed at any point in the system.

(ii) All joints shall be glued and sealed per insulation manufacturers instructions to make an air tight assembly.

h) Factory installed microprocessor controls in the outdoor unit(s), heat recovery unit(s), and indoor unit(s) shall perform functions to optimize the operation of the VRF system and communicate in a daisy chain configuration between outdoor unit and heat recovery unit(s) and indoor unit(s) via RS485 network. Controls shall also be available to control other building systems as required from the VRF control system. DIO/AIO capabilities shall be available as well as a central controller to perform operation changes, schedules and other duties as required by this specification. Addition of separate building control system shall not be required. Other control devices and sequences shall be as specified in other sections of this project specification.

i) Inverter PCB cooling: Cooling of the inverter PCB shall be conducted by way of high pressure, sub-cooled liquid refrigerant via heat exchanger attached to rear side of inverter PCB. The full capacity flow of refrigerant shall pass though the heat exchangers to maximize the cooling effect of the PCBs and to aid in the evaporation process and capacity of the outdoor coil during the heating mode. The recovered heat of the PCBs must be used to enhance the overall heating process, other uses or dissipation of heat to ambient shall not be permitted.

j) Compressor control: Fuzzy control logic shall establish and maintain target evaporating temperature (Te) to be constant on cooling mode and condensing temperature (Tc) constant on heating mode by Fuzzy control logic to ensure the stable system performance. Other compressor control capabilities shall be available via special function controls as noted elsewhere in this specification.

k) Flexible Capacity Control: (Demand limiting) The system shall allow for up to 5 steps of flexible capacity control using an I/O controller or up to 8 steps of flexible capacity control using a BMS control by others. This FCC shall be employed when electrical demand limiting, night time noise reduction or any other flexible capacity control requirement based on any other requirement using contact closures or 0-10vdc to engage.

l) Initial Test Run (ITR) (Heating) / Fault Detection Diagnosis (FDD) Code: This control mode shall monitor and display positive or negative results of system initial startup and commissioning. It shall monitor the following, but not be limited to, refrigerant quantity charge, auto-charge, stable operations, connection ratios, indoor unit status, error status, and number of indoor units connected. This control mode shall not replace the system error monitoring control system.

m) Integration: Each system shall be able to integrate via open protocol via BACnet IP, This gateway converts between BACnet IP or Modbus TCP protocol and manufacturer’s protocol allowing third party control and monitoring of the A/C system, or LonWorks
gateways. See controls specification for more detailed description of integration and points to be controlled and monitored.

n) **Advanced Smart load control:** Smart load control operation shall be available at any time during or after system Commissioning. Smart load control shall be initiated by outdoor air temperature and relativity humidity as sensed at the outdoor unit and shall automatically adjust the evaporator target (condenser target for heat) pressure / temperature that the system will operate to in order precisely load match the system to the building load as the outdoor ambient temperature and humidity increases or decreases, by varying the compression ratios of the system and increase the operating efficiencies and reducing energy consumption by adjusting the compressor lifts. The system shall poll all indoor units’ data in real time and apply its algorithm to determine the optimal evaporating temperature to satisfy varying loads. Systems that rely on the worst performing zone to reset the system conditions shall not be sufficient and shall not be allowed.

o) **Wi-Fi communication:** The outdoor unit shall be Wi-Fi enabled and capable. Wi-Fi shall allow service or maintenance personal access to the complete operating system, via mobile, without need of tools other than smart phone or tablet. Active live system review, collection of all system data for a field determined duration presented in a .csv file format or collection of all operating conditions, including all indoor units, valves, sensors, compressor speeds, refrigerant pressures, etc., by snapshot of conditions and placing that snapshot into a power point slide to be reviewed at another time. Systems that require computers, hard wire only connection or other devices to collect, review or record operating conditions shall not be allowed.

p) **Indoor unit connectivity:** The system shall be designed to accept connection up to 64 indoor units of various configuration and capacity, depending on the capacity of the system.

q) **Power and communication interruption:** The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable or allowed.

r) **Connection Ratios:** The maximum allowable system combination ratio shall be 130%. Systems designed with combination ratio above 130% are not acceptable. The total nominal capacity of all indoor units shall be no less than 50% and no more than 130% of outdoor unit’s nominal capacity.

s) **Smart heat mode:** Smart heating shall be initiated via a field setting at the outdoor unit. Smart heating shall extend the heating operation by calculating the dew point of the outdoor coil surface using the outdoor units’ temperature and Humidity sensors to maintain the coil surface temperature above the dew point minimizing the frost build-up and delaying a defrost operation while maintaining indoor space temperature. This feature shall be capable of eliminating several defrost actions per day based on outdoor air temperature and humidity conditions.

t) The outdoor unit refrigerant circuit shall employ for safety a threaded fusible plug.

u) The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor(s), controls, contacts, relay(s), fans, power and communications wiring as necessary to perform both Heat Pump and Heat recovery operations.

v) Each outdoor unit refrigeration circuit shall include, but not limited to, the following components:

(i) Refrigerant strainer(s)

(ii) Check valve(s)
(iii) Inverter driven, medium pressure vapor injection, high pressure shell compressors
(iv) Liquid refrigerant cooled inverter PCB
(v) Oil separator(s)
(vi) Accumulator - receiver(s)
(vii) 4-way reversing valve(s)
(viii) Vapor injection valve(s)
(ix) Variable path heat exchanger control valve(s)
(x) Oil balancing control
(xi) Oil Level sensor(s)
(xii) Electronic expansion valve(s)
(xiii) Sub-cooler(s)
(xiv) High and low side Schrader valve service ports with caps.
(xv) Service valves

4.06 Refrigerant Flow Control
a) System shall have a variable flow and path outdoor heat exchanger function to vary the refrigerant flow and volume and path. Control of the variable path circuits shall be based on system operating mode and operating conditions as targeted to manage the efficiency and minimize the circulating volume of the operating fluids of the system.
b) System shall have a medium pressure gas vapor injection function employed in the heating and cooling modes to increase system capacity when the outdoor ambient temperatures are low and lower compressor lift when temperatures are high. The compressor vapor injection flow amount shall be controlled by the vapor injection sub-cooling algorithm reset by discharge gas temperatures of the compressor.
c) System shall have an active refrigerant control and multi section accumulator-receiver that dynamically changes the volume of refrigerant circulating in the system based on operating mode and operating conditions to ensure maximum system performance and efficiency.
d) The compressor design shall be of the high pressure shell scroll type where the internal pressure below the suction valves of the compressor shall be at the same high pressure and high temperature. The motor shall be cooled by high pressure gas at temperatures above saturation conditions and prevents the mixing of refrigerant liquid with oil in the sump. Bearing surfaces are continually coated with oil. The compressor shall employ an Aero bearing constructed with high lubricity materials increasing operation time in case of low sump oil level. Compressor shall have a nominal operating range from 15Hz to 150 Hz.
e) The VRF outdoor unit shall include a factory provided and mounted sub-cooler assembly consisting of a double spiral tube-type sub-cooling heat exchanger and EEV providing refrigerant sub-cooling modulation control by fuzzy logic of EEV and by mode of operation to provide capacity and efficiency as required.
f) System shall have following frame configurations vs. capacity.
   i. 6 to 20 ton units shall be a single frame.
   ii. 22 to 36 ton units shall be dual frame.
   iii. 38 to 42 ton heat recovery units shall be triple frame.

*VRF Systems with Onboard Alternate Operating Mode Selection capability.
a. All VRF systems which provide field selectable Alternate Operating Modes, for example, High Heat or High Ambient Cooling, published data tables must be available to the public for all modes offered. Table format must comply with section 2.03.
g) Acceptable Alternate Operating Modes must ship with all models of the VRF product offering and must be factory embedded. Custom factory or field modifications to factory provided algorithms created to meet scheduled requirements are not acceptable.

h) Provide a copy of instructions required to set the Alternate Operation Mode with the initial submittal.

i) For systems that provide field selectable Alternate Operating Modes, **ALL** technical data provided in the submittal data sheets showing product rated condition performance data, must also provide separate data sheets that show product performance data at each field selectable Alternate Operating Modes available. Capacity, power input, and acoustic performance data for each mode offered shall be reported separately. Mixing of ODU, IDU, or VRF system performance capability operating in one mode with for example the power consumption, sound power rating, or electrical requirements of the same system operating in another mode is not acceptable.

4.07 Field Supplied Refrigerant Piping Design Parameters

a) The outdoor unit shall be capable of operating at an elevation difference of up to 360 feet above or below the lowest or highest indoor unit respectively without the requirement of field installed sub cooler or other forms of performance enhancing booster devices.

b) The outdoor unit shall be capable of operating with up to 3280 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.

c) The outdoor unit shall be capable of operating with up to 656 actual feet or 738 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.

d) The piping system shall be designed with pipe expansion and contraction possibilities in mind. Required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. In addition to these requirements, the piping system installation must conform to the VRF equipment manufacturer’s published guidelines.

e) The installation of pipe hangers, supports, insulation, and in general the methods chosen to attach the pipe system to the structure must allow for expansion and contraction of the piping system and shall not interfere with that movement.

f) Inverted refrigerant traps per VRF mfg. recommendations shall be provided between each ODU outdoor unit module if unit are space more than 6 ft. apart for enhanced oil management control.

4.08 Defrost Operations

a) The outdoor unit(s) shall be capable of **Intelligent defrost** operation to melt accumulated frost, snow and ice that may have accumulated on the outdoor unit heat exchanger. The defrost cycle length and sequence shall be based on outdoor ambient temperatures, outdoor unit heat exchanger temperature, and various differential pressure variables.

b) **Defrost Mode Selection:** The outdoor unit shall be provided with a minimum of three field selectable defrost operation modes; Normal, Fast, or Forced.

1. **Fast Defrost** operation intended for use in areas of the country with mild winter temperatures and light to moderate humidity levels. The strategy minimizes defrost cycle frequency allowing frozen precipitation to build longer in between cycles. Minimum time between defrost cycles shall be 20 minutes. Intelligent Defrost shall choose between split coil/frame and full system methods based on current weather conditions to minimize energy consumption and maximize heating cycle time.
2. Normal Defrost operation intended for use in areas of the country that experience adverse winter weather with periods of heavy winter precipitation and extremely low temperatures. This strategy shall maximize the system's heating performance and maintain operational efficiency. When the ambient temperature is either: a) above 32°F; b) below 32°F with the humidity level below 60% RH, Intelligent Defrost shall continue to heat irrelevant of ice build-up on the coil until the quality of the heated air (i.e. discharge air temperature) decreases. At temperatures below 4°F, a defrost cycle shall occur every two hours to optimize system heating efficiency.

3. Forced Defrost operation shall be available for the service provider to test defrost operations at any weather condition and to manually clear frozen water from the outdoor coil surfaces.

c) Defrost Method Selection: The outdoor unit shall be provided with two field selectable defrost operation methods: Split Coil/Frame and Full System. Split Coil/Frame option provides continuous heating of the occupied space during defrost operation.

1. Split Coil/Frame method shall be available when Normal Defrost mode is selected. Split Coil method shall be available on all Heat Pump and Heat recovery single-frame VRF systems. Split Frame defrost shall be available on all Heat Pump and Heat recovery multi-frame outdoor units.

2. Split Coil method shall remove ice from the bottom half of the outdoor unit coil first for a maximum time of six minutes, then the top half for a maximum of six minutes. Next the bottom coil shall be heated again for an additional three minutes to remove any frozen water that may have dripped onto the lower coil during the top coil defrost operation.

3. When Split Coil/Frame method is selected, a Full System defrost shall occur every 1-9 (field selectable) defrost cycles to assure 100% of the frozen precipitation has been removed to maintain efficient performance.

4. Full System method shall be available as a field selectable option. All outdoor units located in areas of the country where large volumes of frozen precipitation are common, the commissioning agent shall be able to select the Full System only defrost method.

d) Indoor Unit Fan Operation During Defrost

1. During partial defrost operation indoor units operating in cooling or dry mode shall continue normal operation.

2. During partial defrost operation, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the defrost cycle.

3. During full system defrost operation indoor unit fans will cycle off and remain off during the remainder of the defrost cycle.

4.09 Oil Management

a) The system shall utilize a high pressure oil return system to ensure a consistent film of oil on all moving compressor parts at all points of operation. Oil is returned to compressor through a separate high pressure oil injection pipe directly into the oil sump. Oil returned to the compressor via the suction port of the compressor shall not be allowed.

b) Each compressor shall be provided with a high efficiency independent centrifugal oil separator, designed to extract oil from the oil/refrigerant gas stream leaving the compressor.

c) The system shall have an oil level sensor in the compressor to provide direct oil level sensing data to the main controller.
d) The system shall only initiate an oil return cycle if the sensed oil level is below oil level target values as determined by the microprocessor.

e) A default oil return algorithm shall automatically initiate the oil return mode if the system detects a failure of the oil sump sensor. A fault code shall be reported by the system.

f) Timed oil return operations or systems that do not directly monitor compressor oil level shall not be permitted.

g) Inverted refrigerant traps per VRF mfg. recommendations shall be provided between each ODU outdoor unit module if unit are space more than 6 ft. apart for enhanced oil management control.

e) Indoor Unit Fan Operation During Oil Return Cycle

1. During oil return cycle indoor units operating in cooling or dry mode shall continue normal operation.

2. During oil return, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the oil return cycle.

3. During oil return cycle indoor unit fans will cycle off and remain off during oil return cycle while operating in all modes except 4.07.e.1 and 2.

**4.010 Cabinet**

a) Outdoor unit cabinet shall be made of 20 gauge galvanized steel with a weather and corrosion resistant enamel finish. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours.

b) The front panels of the outdoor units shall be removable type for access to internal components.

c) A smaller service access panel, not larger than 7” x 7” and secured by a maximum of (2) screws, shall be provided to access the following:

(i) Service tool connection

(ii) DIP switches

(iii) Auto addressing

(iv) Error codes

(v) Main microprocessor

(vi) Inverter PCB

d) The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.

**4.011 Fan Assembly**

a) 6 ton frames shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor with a vertical air discharge.

b) 8 to 20 ton frames shall be equipped with two direct drive variable speed propeller fan(s) with BLDC motor(s) with a vertical air discharge.

c) The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material and incorporate biomimetic technology to enhance fan performance and reduce fan generated noise.

d) The fan(s) motor shall be equipped with permanently lubricated bearings.

e) The fan motor shall be variable speed with an operating speed range of 0-1150 RPM cooling mode and 0-1150 RPM heating mode.

f) The fan shall have a guard to help prevent contact with moving parts.
g) The cabinet shall have option to redirect the discharge air direction from vertical to horizontal with the addition of optional factory provided air guides.

h) The fan controller shall have a DIP switch setting to raise external static pressure of the fan up to 0.32 in-wg to accommodate ducted installations.

i) The fan control shall have a function setting to remove excess snow automatically.

4.012 Outdoor Unit Coil

a) Shall be comprised of aluminum fins mechanically bonded to copper tubing and shall be four sided and 2 or 3 rows deep and 17 fins per inch.

b) The copper tubes shall have inner riffling to expand the total surface of the tube interior.

c) The aluminum fins shall have a factory applied Black Fin heat exchanger coating that is comprised of a highly corrosion resistant epoxy resin coating, 1.6-2.0 um thick, designed to perform in corrosive environments such as contaminated and humid conditions. The Black Fin heat exchanger protection shall include a Hydrophilic coating which minimizes moisture buildup on the fin heat exchanger. The “Black Fin” heat exchanger shall have been tested to the following conditions. 1) ASTM B-117 Salt spray test – 1500 hours with no corrosion, 2) Acid salt test – 900 hours .02% corrosion, 3) ASM corrosion test – 3,000 hours. The Black Fin coating shall be certified by underwriters Laboratories and per ISO 21207. The above conditions shall establish the minimum allowable performance which all alternates must comply. Shall have multiple circuits designed for path isolation and variable velocity control.

d) Shall be designed, built and provided by the VRF outdoor unit manufacturer.

e) The outdoor unit coil, all indoor units and pipe network shall be field tested to a minimum pressure of 550 psig. Manufacturers that do not specify and/or allow field testing at 550 psig shall not be allowed.

f) The outdoor unit coil for each cabinet shall have lanced aluminum fins with a maximum fin spacing of no more than 17 Fins per Inch (FPI). All the outdoor unit coils shall be a 2 or 3 rows consisting of staggered tubes for efficient air flow across the heat exchanger. The outdoor unit shall be factory tested to a minimum of 609 PSI and shall be so indicated on outdoor unit name plate.

g) The cabinet shall have a factory or field installed coil guard with cottonwood screen.

4.013 Compressor(s)

a) Each 6, 8, 10 ton frames shall be equipped with a single hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressor.

b) 12, 14, 16, 18 and 20 ton frames shall be equipped with dual hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressors.

c) Each inverter driven, HSS scroll compressor shall be capable of operating from 12 Hz up to 165 Hz with control in 0.5 Hz increments in any and all modes (cooling, heating or simultaneous modes).

d) The compressor(s) shall be equipped with a 60 Watt crankcase heater controlled by oil temperature.

e) The compressor shall employ a factory metered charge of Polyvinyl Ether (PVE) oil.

f) The compressor shall be designed for a separate port for oil to be directly returned to the compressor oil sump.

g) The compressor bearing(s) shall have Teflon™ coating and shall be an aero type design using High lubricity materials.

h) The compressor(s) shall be protected with:
   (i) High Pressure switch
   (ii) Over-current /under current protection
   (iii) Oil sump sensor
(iv) Phase failure
(v) Phase reversal
(vi) Compressor shall be capable of receiving injection of medium pressure gas at a point in the compression cycle where such injection shall allow a greater mass flow of refrigerant at lower outdoor ambient and achieving a higher heating capability. The VRF outdoor unit shall have published performance data for heating mode operation down to -13F on both heat pump and heat recovery systems.

(i) [OPTIONAL:] To be used if poor power quality is present or expected. The enhanced digital phase monitor=EDPM is a fully programmable, 3-phase line voltage monitor with a backlit LCD, 100 fault memory, and a real-time clock for accurate date and time stamp. It offers complete system protection by monitoring both the line (front) and load (back) side of the system, including the power, motor and contactor lines. The EDPM will be installed on EACH VRF outdoor module or on the power supply to each outdoor unit module and will not affect the manufacturer’s warranty and will be field installed by the certified installation contractor under the direction of the VRF mfg. authorized representative. Fully programmable with LED backlit diagnostic display

2) Monitors “front” and “back” sides of system
3) Protects against voltage unbalance, high/low voltage, phase loss, reversal, faulty power, incorrect sequencing and rapid short cycling
4) Universal voltage operation: 190-600 VAC
5) 100-fault memory and storage with Real-Time Clock for accurate fault timestamps
6) Backup supply reliably records brownout conditions for up to 4 hours
7) Built-in anti-short cycle protection
8) Higher noise immunity
9) 0-10 VDC output for remote monitoring capability
10) EDPM shall be ICM model 455 or equal.

a) Standard, non-inverter driven compressors shall not be permitted nor shall a compressor without vapor injection or direct sump oil return capabilities.

4.014 Inverter Compressor Controller(s)

b) The VRF outdoor unit shall be provided with a separate inverter compressor controller PCB for each compressor. Inverter compressor controllers that host more than one compressor shall not be accepted.

c) The inverter compressor controller shall be designed and programmed to utilize the entire range of operation of the connected compressor during cooling cycle operation and/or heating cycle operation.

4.015 Operational Sound Levels

a) Each single frame outdoor unit shall be rated with an operational sound level not to exceed as listed on below chart when tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available. Such documentation shall be presented in all submittals, manufactures who elect to rate their equipment at other than tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available and the highest field selectable conditions shall not be allowed. Rated sound pressure values shall not exceed the tabled values per system size as below: 6-42 from 58 to 67 dB(A).
b) A field setting shall be available to program the outdoor unit to reduce sound levels at
night, when desired, to a selectable level while still able to meet building load
requirement.

4.016 Sensors
a) Each outdoor unit module shall have
(i) Suction temperature sensor
(ii) Discharge temperature sensor
(iii) Oil level sensor
(iv) High Pressure sensor
(v) Low Pressure sensor
(vi) Outdoor temperature sensor
(vii) Outdoor humidity sensor
(viii) Outdoor unit heat exchanger temperature sensors

Article V. Heat recovery heat recovery Units (heat recovery SYSTEMS ONLY)

5.01 General
d) Heat recovery unit shall be designed and manufactured by the same manufacturer of
VRF indoor unit(s) and outdoor unit(s).
e) Heat recovery unit casing shall be constructed with galvanized steel.
f) Heat recovery unit shall require 208-230V/1-phase/60Hz power supply.
g) Heat recovery Unit shall be an intermediate refrigerant control device between the air
source outdoor unit and the indoor units to control the systems cooling and heating
operation.
h) Heat recovery unit shall be engineered to work with a three pipe VRF system comprising
of
(i) High Pressure Vapor Pipe
(ii) Low Pressure Vapor Pipe
(iii) Liquid Pipe
i) Heat recovery units’ main 3 pipe connections shall be capable of series or parallel pipe
configuration.
j) The quantity of heat recovery units that can be piped in series shall be limited to 16.
k) A single string of series piped heat recovery units shall be capable of serving any
combination of styles of VRF indoor units with a combined nominal capacity of up to
192MBh.
l) Heat recovery unit shall have 2, 3 or 4 ports, each port supporting one or more indoor
units with a maximum connected capacity of 54 MBH.
m) Each port shall be capable of operating in cooling or heating independently regardless of
the operating mode of any other port on the heat recovery unit or in the system.
n) Each port shall be capable of connecting from 1 to 8 indoor units.
o) Connection to Indoor units totaling greater than 54MBh nominal capacity shall be
twinned to two adjacent ports of the heat recovery unit using a reverse Y-branch
connector supplied by manufacture.
p) Heat recovery unit shall be internally piped, wired, assembled and run tested at the
factory.
q) Heat recovery unit shall be designed for installation in a conditioned environment per
specifications.
r) Heat recovery unit shall employ a liquid bypass valve.
s) Heat recovery unit shall have (2) two-position refrigerant valves per port.
t) Heat recovery unit shall have a balancing valve to control the pressure between the high pressure and low pressure pipe during mode switching to minimize any change-over pressure related sounds.

u) Heat recovery unit shall employ an electronic expansion valve to ensure proper sub cooling of the refrigerant.

v) Heat recovery unit shall contain one double spiral sub-cooling heat exchanger per port.

w) Heat recovery unit shall not require a condensate drain or connection.

x) Heat recovery unit shall be internally factory insulated.

y) All field refrigerant lines between outdoor unit and heat recovery unit and from heat recovery unit to indoor unit shall be field ACR tubing, insulated per building or energy code and as instructed by the manufacture.

z) The VRF manufacturer shall provide published documentation that specifically allows the installation of field provided isolation valves on all pipes connected to the Heat recovery unit to allow the servicing of heat recovery units, refrigerant circuit or the replacement of heat recovery unit without evacuating the balance of the piping system.

5.02 Factory Installed Controls

a) Heat recovery unit(s) shall have factory installed unit mounted control boards and integral microprocessor to communicate with other devices in the VRF system.

b) Heat recovery unit shall communicate with the indoor units via a 2-conductor shielded communications cable terminated using a daisy chain configuration (see instructions regarding the termination of the shield).

c) The contractor is instructed to review the Electrical and ATC drawings and specifications for other items or tasks which this contractor is or may be responsible to provide materials and or labor under this contract. Failure to do so will not relieve this contractor of their responsibility to provide such materials and or labor and in no case shall this contractor be further compensated as a result.