SECTION 238129 - VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
	* + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
			1. SUMMARY
				1. Section includes complete VRF HVAC system(s) including, but not limited to[, delegated design and] the following components to make a complete operating system(s) according to requirements indicated:

Indoor, concealed, ceiling-mounted units for ducting.

Indoor, concealed, floor-mounted units for ducting.

Indoor, exposed, floor-mounted units.

Indoor, exposed, wall-mounted units.

Indoor, recessed, ceiling-mounted units.

Indoor, suspended, ceiling-mounted units.

Indoor, hydronic heat exchangers.

Indoor, dedicated outdoor air ventilation units.

Indoor, energy recovery ventilator.

Indoor, hydronic heat-pump units.

Indoor, hydronic heat recovery units.

Outdoor, air-source, heat-pump units.

Outdoor, air-source heat recovery units.

Heat recovery control units.

System controls.

System refrigerant and oil.

System condensate drain piping.

System hydronic piping.

System refrigerant piping.

Metal hangers and supports.

Metal framing systems.

Fastener systems.

Pipe stands.

Equipment stands.

Miscellaneous support materials.

Piping and tubing insulation.

System control cable and raceways.

* + - 1. DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

* + - * 1. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.
				2. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.
				3. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.
				4. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.
				5. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
				6. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
				7. Three-Pipe System Design: One high pressure refrigerant vapor line, one low pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One liquid line and refrigerant vapor line connect HRCUs to associated indoor units.
				8. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high and low pressure refrigerant between indoor units.
				9. VRF: Variable refrigerant flow.
			1. PREINSTALLATION MEETINGS

Retain "Preinstallation Conference" paragraph below if Work of this Section is extensive or complex enough to justify a conference.

* + - * 1. Preinstallation Conference: Conduct conference at **[Project site] <Insert location>**.
			1. SUBMITTALS
				1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer’s installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. Product Data: For each type of product.

Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor and outdoor units**[ and for HRCUs]**.

Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.

Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.

Include system operating sequence of operation in narrative form for each unique indoor- and outdoor-unit **[and HRCU ]control**.

Include description of control software features.

Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.

Include refrigerant type and data sheets showing compliance with requirements indicated.

For system design software.

Indicate location and type of service access.

* + - * 1. Shop Drawings: For VRF HVAC systems.

Include plans, elevations, sections, and **[mounting] [attachment]** details.

Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.

Include diagrams for power, signal, and control wiring.

Retain "Samples for Initial Selection" paragraph below to require Samples of finishes that are exposed.

* + - * 1. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.

Include a Sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.

Retain "Delegated-Design Submittals" paragraph below if design services have been delegated to Contractor.

* + - * 1. Delegated-Design Submittals:

Retain any of five subparagraphs below if corresponding delegated-design requirement is included in "Delegated Design" paragraph in "Performance Requirements" Article.

Include design calculations for selecting vibration isolators**[ and seismic restraints]** and for designing vibration isolation bases.

Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.

Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.

Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

**<Insert delegated-design submittal>**.

Retain "Coordination Drawings" paragraph below for situations where limited space necessitates maximum utilization for efficient installation of different components or if coordination is required for installation of products and materials by separate installers. Coordinate paragraph with other Sections specifying products listed below. Preparation of coordination drawings requires the participation of each trade involved in installations within the limited space.

* + - * 1. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

Suspended ceiling components.

Structural floors, roofs and associated members to which equipment, piping, **[ductwork, ]**cables, and conduit will be attached.

Size and location of initial access modules for acoustical tile.

Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.

Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.

Items penetrating finished ceiling including the following:

Luminaires.

Air outlets and inlets.

Speakers.

Sprinklers.

Service access panels.

**<Insert item>**.

* + - * 1. Qualification Data:

For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.

Retain copies of Installer certificates on-site and make available on request.

For VRF HVAC system manufacturer.

For VRF HVAC system provider.

Retain "Seismic Qualification Data" paragraph below if required by seismic criteria applicable to Project. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC." See ASCE/SEI 7 for certification requirements for equipment and components.

* + - * 1. Seismic Qualification Data: Certificates, for equipment, **<Insert products,>** accessories, and components, from manufacturer.

Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

Retain "Product Certificates" paragraph below to require submittal of product certificates from manufacturers.

* + - * 1. Product Certificates: For each type of product.

**<Insert list of products>**.

* + - * 1. Product Test Reports: Where tests are required, for each product, for tests performed by **[manufacturer and witnessed by a qualified testing agency] [or] [a qualified testing agency]**.
				2. Source quality-control reports.
				3. Field quality-control reports.
				4. Sample Warranties: For manufacturer's warranties.
			1. CLOSEOUT SUBMITTALS
				1. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.

Retain "Software and Firmware Operational Documentation" paragraph below for PC-based control systems.

* + - * 1. Software and Firmware Operational Documentation:

Software operating and upgrade manuals.

Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.

Device address list.

Printout of software application and graphic screens.

* + - 1. MAINTENANCE MATERIAL SUBMITTALS
				1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

Retain any of four subparagraphs below. Revise to suit Project.

Filters:

**[One] <Insert number>** set(s) for each unit with replaceable filters.

**[One] <Insert number>** set(s) for each unit type and unique size of washable filters.

Indoor Units: **[One] <Insert number>** for each unique size and type installed.

Controllers for Indoor Units: **[One] <Insert number>** for each unique controller type installed.

**<Insert maintenance material requirements>**.

* + - 1. QUALITY ASSURANCE
				1. Manufacturer Qualifications:

Nationally recognized manufacturer of VRF HVAC systems and products.

Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of **[five] [10] <Insert number>** years within time of bid.

VRF HVAC systems and products that have been successfully tested and in use on at least **[three] [five] <Insert number>** completed projects.

Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.

Having full-time in-house employees for the following:

Product research and development.

Product and application engineering.

Product manufacturing, testing, and quality control.

Technical support for system installation training, startup, commissioning, and troubleshooting of installations.

Director’s Representative training.

* + - * 1. Company Service Advisor Qualifications:

Authorized representative of, and trained by, VRF HVAC system manufacturer.

In-place facility located within **<Insert distance>** of Project.

Demonstrated past experience with products being installed for period within **[three] [five] <Insert number>** consecutive years before time of bid.

Demonstrated past experience on **[five] <Insert number>** projects of similar complexity, scope, and value.

Each person assigned to Project shall have demonstrated past experience.

Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.

Service and maintenance staff assigned to support Project during warranty period.

Product parts inventory to support ongoing system operation for a period of not less than **[five] <Insert number>** years after Substantial Completion.

VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

* + - * 1. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.

Installer certification shall be valid and current for duration of Project.

Retain copies of Installer certificates on-site and make available on request.

Each person assigned to Project shall have demonstrated past experience.

Demonstrated past experience with products being installed for period within **[three] [five] <Insert number>** consecutive years before time of bid.

Demonstrated past experience on **[five] <Insert number>** projects of similar complexity, scope, and value.

Retain "Mockups" paragraph below for sensitive applications to require advance review of the expected installation.

* + - * 1. Mockups: Build mockups to set quality standards for materials and execution.

Build mockups to show a finished installation for each of the following applications:

Retain either of first two subparagraphs below, or both. Revise to suit Project.

For each different indoor unit type with exposed surfaces viewable by occupants.

**<Insert mockup item>**.

Mockups **[shall be] [are]** operational.

Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

Retain subparagraph below if the intention is to make an exception to the default requirement in Section 014000 "Quality Requirements" for demolishing and removing mockups.

Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

* + - * 1. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.
			1. DELIVERY, STORAGE, AND HANDLING
				1. Deliver and store products in a clean and dry place.
				2. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
				3. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
				4. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.

Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.

* + - * 1. Replace installed products damaged during construction.
			1. WARRANTY

When warranties are required, verify with Director’s Representative's that warranties stated in this article are not less than remedies available to Director’s Representative under prevailing local laws.

* + - * 1. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.

Failures include, but are not limited to, the following:

Structural failures.

Faulty operation.

Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

**<Insert failure modes>**.

Verify available warranties and warranty periods for units and components.

Warranty Period:

For Compressor: **[Five] [Seven] [10] <Insert number>** year(s) from date of Substantial Completion.

For Parts, Including Controls: **[Five] [Seven] [10] <Insert number>** year(s) from date of Substantial Completion.

For Labor: **[Five] [Seven] [10] <Insert number>** year(s) from date of Substantial Completion.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. MANUFACTURERS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=13209) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Carrier Global Corporation.

Daikin AC (Americas), Inc.

Fujitec America, Inc.

Johnson Controls, Inc.

LG Electronics USA, Inc.; LG Electronics Inc.

Mitsubishi Electric & Electronics USA, Inc.

Panasonic Corporation of North America.

RectorSeal HVAC; a CSW Industrials Company.

Samsung HVAC.

Trane Company (The).

Approved equivalent.

* + - * 1. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:

Retain any of six subparagraphs below to suit Project.

Indoor and outdoor units, including accessories.

Controls and software.

HRCUs.

Refrigerant isolation valves.

Specialty refrigerant pipe fittings.

**<Insert products>**.

* + - 1. SYSTEM DESCRIPTION
				1. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, [HRCUs, ]outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

Revise options in first subparagraph below for system design. Include all three options to be least restrictive. See the Evaluations.

**[Two-pipe] [or] [three-pipe]** system design.

System(s) operation, **[air-conditioning] [heat pump] [or] [heat recovery]** as indicated on Drawings.

Each system with one refrigerant circuit shared by all indoor units connected to system.

* + - * 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
				2. AHRI Compliance: System and equipment performance certified according to AHRI 1230**[ and products listed in AHRI directory]**.
				3. ASHRAE Compliance:

ASHRAE 15: For safety code for mechanical refrigeration.

Retain "ASHRAE 62.1" subparagraph below to require compliance with ASHRAE 62.1.

ASHRAE 62.1: For indoor air quality.

Retain "ASHRAE 135" subparagraph below to require BACnet communication protocol.

ASHRAE 135: For control network protocol with remote communication.

Retain "ASHRAE/IES 90.1 Compliance" subparagraph below to require compliance with ASHRAE/IES 90.1.

ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

* + - * 1. UL Compliance: Comply with UL 1995.
			1. PERFORMANCE REQUIREMENTS

Retain "Delegated Design" paragraph below if Contractor is required to assume responsibility for design.

* + - * 1. Delegated Design: Engage a qualified professional to design complete and operational VRF HVAC system(s) complying with requirements indicated.

Provide system refrigerant calculations.

Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.

Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.

Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.

System Refrigerant Piping and Tubing:

Arrangement: Arrange piping to interconnect indoor units**[, HRCUs,]** and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.

Routing: Conceal piping above ceilings and behind walls to maximum extent possible.

Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.

System Controls:

Network arrangement.

Network interface with other building systems.

Product selection.

Sizing.

* + - * 1. Service Access:

Provide and document service access requirements.

Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.

Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.

If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.

Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.

Comply with OSHA regulations.

* + - * 1. System Design and Installation Requirements:

Design and install systems indicated according to manufacturer's recommendations and written instructions.

Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

Retain "System Adaptability to Future Changes" paragraph below to provide system with capability to accommodate minor changes in capacity without resizing and replacing refrigerant piping. Consult manufacturers to determine limitations.

* + - * 1. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.

Retain first subparagraph below if future changes are indicated on Drawings.

Future changes to system(s) indicated on Drawings.

Retain any of three subparagraphs below. Delete all if future changes are indicated on Drawings.

Each branch circuit shall accommodate addition of **[one] [two] <Insert number>** indoor unit(s) with unit capacity equal to **[largest] [smallest] [average] <Insert capacity requirement>** indoor unit connected to the branch circuit.

Each branch circuit shall accommodate deletion of **[one] [two] <Insert number>** indoor unit(s) with unit capacity equal to **[largest] [smallest] [average] <Insert capacity requirement>** indoor unit connected to the branch circuit.

**<Insert requirements for future changes>**.

* + - * 1. Isolation of Equipment: Provide isolation valves to isolate each **[HRCU, ]**indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.
				2. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:

Not less than **[50] [60] <Insert number>** percent.

Not more than **[130] [150] <Insert number>** percent.

Range acceptable to manufacturer.

* + - * 1. System Turndown: Stable operation down to **[20] <Insert number>** percent of outdoor-unit capacity.
				2. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.
				3. Outdoor Conditions:

Suitable for outdoor ambient conditions encountered.

Design equipment and supports to withstand wind loads of governing code **[and ASCE/SEI 7] <Insert requirement>**.

Retain first subparagraph below if applicable to Project.

Design equipment and supports to withstand snow and ice loads of governing code **[and ASCE/SEI 7] <Insert requirement>**.

Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.

Maximum System Operating Outdoor Temperature: **[See Drawings] <Insert value>**.

Minimum System Operating Outdoor Temperature: **[See Drawings] <Insert value>**.

Retain "Seismic Performance" paragraph below with "Seismic Qualification Data" paragraph in "Informational Submittals" Article for projects requiring seismic design. Delete paragraph if performance requirements are indicated on Drawings. Model building codes and ASCE/SEI 7 establish criteria for buildings subject to earthquake motions. Coordinate requirements with structural engineer.

* + - * 1. Seismic Performance: VRF HVAC system(s) shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7] <Insert requirement>**.

Retain first subparagraph below to define the term "withstand" as it applies to this Project. Definition varies with type of building and occupancy and is critical to valid certification. Option is used for essential facilities where equipment must operate immediately after an earthquake.

The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified[ and the system will be fully operational after the seismic event]."

For life-safety components required to function after an earthquake (such as fire-sprinkler systems, components that contain hazardous content, and storage racks in structures open to the public), the Component Importance Factor is 1.5. For other components, the Component Importance Factor is 1.0 unless the structure is in Seismic Use Group III and component is necessary for continued operation of facility or failure of component could impair continued operation of facility, in which case the Component Importance Factor is 1.5.

Component Importance Factor: **[1.5] [1.0] <Insert value>**.

See ASCE/SEI 7, Coefficients for Architectural Component Table and Seismic Coefficients for Mechanical and Electrical Components Table for requirements to be inserted in subparagraph below.

**<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

* + - * 1. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.

Indoor: **[See Drawings.] [Within design guidelines of "2015 ASHRAE HANDBOOK- HVAC Applications."] <Insert values.>**

Outdoor: **[See Drawings] [Within ordinance of governing authorities] <Insert values>**.

* + - * 1. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.
				2. Capacities and Characteristics: As indicated on Drawings.
			1. INDOOR, CONCEALED, CEILING-MOUNTED UNITS FOR DUCTING

If retaining option in "Description" paragraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

* + - * 1. Description: Factory-assembled**[ and -tested]** complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
				2. Cabinet:

Retain all options in "Material" subparagraph below to be least restrictive. Some manufacturer's products may not comply with only "Galvanized" or "painted" option.

Material: **[Galvanized] [or] [painted]** steel.

If retaining option in "Insulation" subparagraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

Insulation: Manufacturer's standard internal insulation**[, complying with ASHRAE 62.1,]** to provide thermal resistance and prevent condensation.

Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. DX Coil Assembly:

Coil Casing: Aluminum, galvanized, or stainless steel.

Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.

Coil Tubes: Copper, of diameter and thickness required by performance.

Expansion Valve: Electronic modulating type with linear or proportional characteristics.

Unit Internal Tubing: Copper tubing with brazed joints.

Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - * 1. Drain Assembly:

Pan: Non-ferrous material, with bottom sloped to low point drain connection.

Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.

Field Piping Connection: Non-ferrous material**[ with threaded NPT]**.

* + - * 1. Fan and Motor Assembly:

Fan(s):

Direct-drive arrangement.

Single or multiple fans connected to a common motor shaft and driven by a single motor.

Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.

Wheels statically and dynamically balanced.

Motor: Brushless dc or electronically commutated with permanently lubricated bearings.

Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.

Vibration Control: Integral isolation to dampen vibration transmission.

* + - * 1. Filter Assembly:

Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.

Efficiency: **[ASHRAE 52.2, MERV 7] [ASHRAE 52.2, MERV 11] [ASHRAE 52.2, MERV 13] <Insert efficiency>**.

"Media" subparagraph below describes two filter types: "replaceable" and "washable." Replaceable filters allow for higher filter efficiency. Washable filters have lower filter efficiency. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Media:**[ If more than one filter type is indicated, Contractor has option to choose.]**

Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

Washable: Manufacturer's standard filter with antimicrobial treatment.

* + - * 1. Unit Accessories:

Retain any of three subparagraphs below to provide unit with accessories required by application. Indicate units with accessories in unit equipment schedule on Drawings.

Outdoor Air Ventilation Kit: Connection, motorized damper, and control sized to allow sequence of operation indicated on Drawings.

Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

<Insert accessories>.

* + - * 1. Unit Controls:

Enclosure: Metal, suitable for indoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors:

Unit inlet air temperature.

Coil entering refrigerant temperature.

Coil leaving refrigerant temperature.

<Insert sensor>.

Retain "Field-Customizable I/O Capability" subparagraph below for special control strategies. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Field-Customizable I/O Capability:

Analog Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Outputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions:

Self-diagnostics.

Time delay.

Auto-restart.

External static pressure control.

Auto operation mode.

Manual operation mode.

Filter service notification.

Power consumption display.

Drain assembly high water level safety shutdown and notification.

Run test switch.

**<Insert function>**.

Communication: Network communication with other indoor and outdoor units.

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Metal, suitable for indoor locations.

Field Connection: Single point connection to power unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways.

* + - 1. INDOOR, CONCEALED, FLOOR-MOUNTED UNITS FOR DUCTING

If retaining option in "Description" paragraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

* + - * 1. Description: Factory-assembled**[ and -tested]** complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
				2. Cabinet:

Retain all options in "Material" subparagraph below to be least restrictive. Some manufacturer's products may not comply with only "Galvanized" or "painted" option.

Material: **[Galvanized] [or] [painted]** steel.

If retaining option in "Insulation" subparagraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

Insulation: Manufacturer's standard internal insulation**[, complying with ASHRAE 62.1,]** to provide thermal resistance and prevent condensation.

Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. DX Coil Assembly:

Coil Casing: Aluminum, galvanized, or stainless steel.

Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.

Coil Tubes: Copper, of diameter and thickness required by performance.

Expansion Valve: Electronic modulating type with linear or proportional characteristics.

Unit Internal Tubing: Copper tubing with brazed joints.

Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - * 1. Drain Assembly:

Pan: Non-ferrous material, with bottom sloped to low point drain connection.

Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.

Field Piping Connection: Non-ferrous material**[ with threaded NPT]**.

* + - * 1. Fan and Motor Assembly:

Fan(s):

Direct-drive arrangement.

Single or multiple fans connected to a common motor shaft and driven by a single motor.

Materials: Non-ferrous components or ferrous components with corrosion resistant finish.

Statically and dynamically balanced.

Motor: Brushless dc or electronically commutated with permanently lubricated bearings.

Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.

Vibration Control: Integral isolation to dampen vibration transmission.

* + - * 1. Filter Assembly:

Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.

Efficiency: **[ASHRAE 52.2, MERV 7] [ASHRAE 52.2, MERV 11] [ASHRAE 52.2, MERV 13] <Insert efficiency>**.

"Media" subparagraph below describes two filter types: "replaceable" and "washable." Replaceable filters allow for higher filter efficiency. Washable filters have lower filter efficiency. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Media:**[ If more than one filter type is indicated, Contractor has option to choose.]**

Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

Washable: Manufacturer's standard filter with antimicrobial treatment.

* + - * 1. Unit Accessories:

Retain any of three subparagraphs below to provide unit with accessories required by application. Indicate units with accessories in unit equipment schedule on Drawings.

Outdoor Air Ventilation Kit: Connection, motorized damper, and control sized to allow sequence of operation indicated on Drawings.

Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

**<Insert accessories>**.

* + - * 1. Unit Controls:

Enclosure: Metal, suitable for indoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors:

Unit inlet air temperature.

Coil entering refrigerant temperature.

Coil leaving refrigerant temperature.

**<Insert sensor>**.

Retain "Field-Customizable I/O Capability" subparagraph below for special control strategies. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Field-Customizable I/O Capability:

Analog Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Outputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions:

Self-diagnostics.

Time delay, auto-restart.

External static pressure control.

Auto operation mode.

Manual operation mode.

Filter service notification.

Power consumption display.

Drain assembly high water level safety shutdown and notification.

Run test switch.

**<Insert function>**.

Communication: Network communication with other indoor units and outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Metal, similar to enclosure, and suitable for indoor locations.

Field Connection: Single point connection to power unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways.

* + - 1. INDOOR, EXPOSED, FLOOR-MOUNTED UNITS

If retaining option in "Description" paragraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

* + - * 1. Description: Factory-assembled**[ and -tested]** complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
				2. Cabinet:

Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.

If retaining option in "Insulation" subparagraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

Insulation: Manufacturer's standard internal insulation**[, complying with ASHRAE 62.1,]** to provide thermal resistance and prevent condensation.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. DX Coil Assembly:

Coil Casing: Aluminum, galvanized, or stainless steel.

Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.

Coil Tubes: Copper, of diameter and thickness required by performance.

Expansion Valve: Electronic modulating type with linear or proportional characteristics.

Unit Internal Tubing: Copper tubing with brazed joints.

Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - * 1. Drain Assembly:

Pan: Non-ferrous material, with bottom sloped to low point drain connection.

Condensate Removal: Gravity.

If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.

Field Piping Connection: Non-ferrous material**[ with threaded NPT]**.

* + - * 1. Fan and Motor Assembly:

Fan(s):

Direct-drive arrangement.

Single or multiple fans connected to a common motor shaft and driven by a single motor.

Materials: Non-ferrous components or ferrous components with corrosion-resistant finish.

Statically and dynamically balanced.

Motor: Brushless dc or electronically commutated with permanently lubricated bearings.

Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.

Vibration Control: Integral isolation to dampen vibration transmission.

* + - * 1. Filter Assembly:

Access: Front, to accommodate filter replacement without the need for tools.

Efficiency: **<Insert efficiency>**.

Washable Media: Manufacturer's standard filter with antimicrobial treatment.

* + - * 1. Grille Assembly: Manufacturer's standard discharge grille**[ with field-adjustable air pattern]** mounted in top of unit cabinet.
				2. Unit Accessories:

Retain any of three subparagraphs below to provide unit with accessories required by application. Indicate units with accessories in unit equipment schedule on Drawings.

Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

**<Insert accessories>**.

* + - * 1. Unit Controls:

Enclosure: Manufacturer's standard, and suitable for indoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors:

Unit inlet air temperature.

Coil entering refrigerant temperature.

Coil leaving refrigerant temperature.

**<Insert sensor>**.

Retain "Field-Customizable I/O Capability" subparagraph below for special control strategies. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Field-Customizable I/O Capability:

Analog Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Outputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions:

Self-diagnostics.

Time delay.

Auto-restart.

External static pressure control.

Auto operation mode.

Manual operation mode.

Filter service notification

Power consumption display.

Drain assembly high water level safety shutdown and notification.

Run test switch.

**<Insert function>**.

Communication: Network communication with other indoor units and outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Manufacturer's standard, and suitable for indoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways.

* + - 1. INDOOR, EXPOSED, WALL-MOUNTED UNITS

If retaining option in "Description" paragraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

* + - * 1. Description: Factory-assembled**[ and -tested]** complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
				2. Cabinet:

Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.

If retaining option in "Insulation" subparagraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

Insulation: Manufacturer's standard internal insulation**[, complying with ASHRAE 62.1,]** to provide thermal resistance and prevent condensation.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. DX Coil Assembly:

Coil Casing: Aluminum, galvanized, or stainless steel.

Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.

Coil Tubes: Copper, of diameter and thickness required by performance.

Expansion Valve: Electronic modulating type with linear or proportional characteristics.

Unit Internal Tubing: Copper tubing with brazed joints.

Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - * 1. Drain Assembly:

Pan: Non-ferrous material, with bottom sloped to low point drain connection.

Condensate Removal: Gravity.

If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.

Field Piping Connection: Non-ferrous material**[ with threaded NPT]**.

* + - * 1. Fan and Motor Assembly:

Fan(s):

Direct-drive arrangement.

Single or multiple fans connected to a common motor shaft and driven by a single motor.

Fabricated from non-ferrous components or ferrous components with corrosion protection finish.

Wheels statically and dynamically balanced.

Motor: Brushless dc or electronically commutated with permanently lubricated bearings.

Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.

Vibration Control: Integral isolation to dampen vibration transmission.

* + - * 1. Filter Assembly:

Access: Front, to accommodate filter replacement without the need for tools.

Efficiency: <Insert efficiency>.

Washable Media: Manufacturer's standard filter with antimicrobial treatment.

* + - * 1. Grille Assembly: Manufacturer's standard discharge grille**[ with field-adjustable air pattern]** mounted in top [or front face ]of unit cabinet.
				2. Unit Accessories:

Retain any of three subparagraphs below to provide unit with accessories required by application. Indicate units with accessories in unit equipment schedule on Drawings.

Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

**<Insert accessories>**.

* + - * 1. Unit Controls:

Enclosure: Manufacturer's standard, and suitable for indoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult listed manufacturers for availability.

Factory-Installed Sensors: **[Unit inlet air temperature] [Coil entering refrigerant temperature] [Coil leaving refrigerant temperature] <Insert sensor>**.

Retain "Field-Customizable I/O Capability" subparagraph below for special control strategies. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Field-Customizable I/O Capability:

Analog Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Outputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, time delay, auto-restart**[, external static pressure control] [, auto operation mode] [, manual operation mode] [, filter service notification] [, power consumption display] [, drain assembly high water level safety shutdown and notification] [, run test switch] <Insert function>**.

Communication: Network communication with other indoor units and outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Manufacturer's standard, and suitable for indoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - 1. INDOOR, RECESSED, CEILING-MOUNTED UNITS

If retaining option in "Description" paragraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

* + - * 1. Description: Factory-assembled**[ and -tested]** complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
				2. Cabinet:

Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.

If retaining option in "Insulation" subparagraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

Insulation: Manufacturer's standard internal insulation**[, complying with ASHRAE 62.1,]** to provide thermal resistance and prevent condensation.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. DX Coil Assembly:

Coil Casing: Aluminum, galvanized, or stainless steel.

Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.

Coil Tubes: Copper, of diameter and thickness required by performance.

Expansion Valve: Electronic modulating type with linear or proportional characteristics.

Internal Tubing: Copper tubing with brazed joints.

Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - * 1. Drain Assembly:

Pan: Non-ferrous material, with bottom sloped to low point drain connection.

Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.

Field Piping Connection: Non-ferrous material**[ with threaded NPT]**.

* + - * 1. Fan and Motor Assembly:

Fan(s):

Direct-drive arrangement.

Single or multiple fans connected to a common motor shaft and driven by a single motor.

Fabricated from non-ferrous components or ferrous components with corrosion protection finish.

Wheels statically and dynamically balanced.

Motor: Brushless dc or electronically commutated with permanently lubricated bearings.

Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.

Vibration Control: Integral isolation to dampen vibration transmission.

* + - * 1. Filter Assembly:

Access: Bottom, to accommodate filter replacement without the need for tools.

Efficiency: **[ASHRAE 52.2, MERV 7] [ASHRAE 52.2, MERV 11] [ASHRAE 52.2, MERV 13] <Insert efficiency>**.

"Media" subparagraph below describes two filter types: "replaceable" and "washable." Replaceable filters allow for higher filter efficiency. Washable filters have lower filter efficiency. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Media:**[ If more than one filter type is indicated, Contractor has option to choose.]**

Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

Washable: Manufacturer's standard filter with antimicrobial treatment.

* + - * 1. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.

Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.

Retain "Discharge Pattern Adjustment" or "Discharge Pattern Closure" subparagraph below, or both, to provide grille assembly with additional features. Features indicated may not be available from all manufacturers on all products. Consult manufacturers for availability.

Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.

Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.

Retain "Motorized Vanes" or "Additional Branch Supply Duct Connection" subparagraph below, or both, to provide grille assembly with additional features. Features indicated may not be available from all manufacturers on all products. Consult manufacturers for availability.

Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.

Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.

* + - * 1. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.

Retain "Outdoor Air Ventilation Connection" paragraph below to provide unit with connection to a ducted outdoor air source. Feature may not be available from all manufacturers on all products. Consult manufacturers for availability.

* + - * 1. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.
				2. Unit Accessories:

Retain any of three subparagraphs below to provide unit with accessories required by application. Indicate units with accessories in unit equipment schedule on Drawings.

Outdoor Air Ventilation Kit: Connection, motorized damper, and control to satisfy unit control sequence of operation indicated on Drawings.

Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

<Insert accessories>.

* + - * 1. Unit Controls:

Enclosure: Manufacturer's standard, and suitable for indoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors: **[Unit inlet air temperature] [Coil entering refrigerant temperature] [Coil leaving refrigerant temperature] <Insert sensor>**.

Retain "Field-Customizable I/O Capability" subparagraph below for special control strategies. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Field-Customizable I/O Capability:

Analog Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Outputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, time delay, auto-restart**[, external static pressure control] [, auto operation mode] [, manual operation mode] [, filter service notification] [, power consumption display] [, drain assembly high water level safety shutdown and notification] [, run test switch] <Insert function>**.

Communication: Network communication with other indoor units and outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Manufacturer's standard, and suitable for indoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - 1. INDOOR, SUSPENDED, CEILING-MOUNTED UNITS

If retaining option in "Description" paragraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

* + - * 1. Description: Factory-assembled**[ and -tested]** complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
				2. Cabinet:

Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.

If retaining option in "Insulation" subparagraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

Insulation: Manufacturer's standard internal insulation**[, complying with ASHRAE 62.1,]** to provide thermal resistance and prevent condensation.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. DX Coil Assembly:

Coil Casing: Aluminum, galvanized, or stainless steel.

Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.

Coil Tubes: Copper, of diameter and thickness required by performance.

Expansion Valve: Electronic modulating type with linear or proportional characteristics.

Internal Tubing: Copper tubing with brazed joints.

Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - * 1. Drain Assembly:

Pan: Non-ferrous material, with bottom sloped to low point drain connection.

Condensate Removal: Gravity.

If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.

Field Piping Connection: Non-ferrous material**[ with threaded NPT]**.

* + - * 1. Fan and Motor Assembly:

Fan(s):

Direct-drive arrangement.

Single or multiple fans connected to a common motor shaft and driven by a single motor.

Fabricated from non-ferrous components or ferrous components with corrosion protection finish.

Wheels statically and dynamically balanced.

Motor: Brushless dc or electronically commutated with permanently lubricated bearings.

Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.

Vibration Control: Integral isolation to dampen vibration transmission.

* + - * 1. Filter Assembly:

Access: Front, to accommodate filter replacement without the need for tools.

Efficiency: **<Insert efficiency>**.

Washable Media: Manufacturer's standard filter with antimicrobial treatment.

* + - * 1. Discharge-Air Grille Assembly: Mounted in front of unit cabinet.

Discharge Pattern: One-way throw.

Retain one of two subparagraphs below to provide discharge-air grille assembly with additional features. Features indicated may not be available from all manufacturers on all products. Consult manufacturers for availability.

Discharge Pattern Adjustment: Field-adjustable limits for range of pattern.

Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.

* + - * 1. Return-Air Grille Assembly: Manufacturer's standard.

Retain "Outdoor Air Ventilation Connection" paragraph below to provide unit with connection to a ducted outdoor air source. Feature may not be available from all manufacturers on all products. Consult manufacturers for availability.

* + - * 1. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.
				2. Unit Accessories:

Retain any of three subparagraphs below to provide unit with accessories required by application. Indicate units with accessories in unit equipment schedule on Drawings.

Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

**<Insert accessories>**.

* + - * 1. Unit Controls:

Enclosure: Manufacturer's standard, and suitable for indoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors: **[Unit inlet air temperature] [Coil entering refrigerant temperature] [Coil leaving refrigerant temperature] <Insert sensor>**.

Retain "Field-Customizable I/O Capability" subparagraph below for special control strategies. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Field-Customizable I/O Capability:

Analog Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Outputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, time delay, auto-restart**[, external static pressure control] [, auto operation mode] [, manual operation mode] [, filter service notification] [, power consumption display] [, drain assembly high water level safety shutdown and notification] [, run test switch] <Insert function>**.

Communication: Network communication with other indoor units and outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Manufacturer's standard, and suitable for indoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - 1. INDOOR, HYDRONIC HEAT EXCHANGERS

If retaining option in "Description" paragraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

* + - * 1. Description: Factory-assembled**[ and -tested]** complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
				2. Cabinet:

Retain all options in "Material" subparagraph below to be least restrictive. Some manufacturer's products may not comply with only "Galvanized" or "painted" option.

Material: **[Galvanized] [or] [painted]** steel.

Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. Heat-Exchanger Assembly:

Single or dual, brazed plate heat exchanger with performance indicated on Drawings.

Expansion Valve: Electronic modulating type with linear or proportional characteristics.

Internal Tubing: Copper tubing with brazed joints.

Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

Drain: Hydronic side of assembly with drain connection at low point.

* + - * 1. Unit Accessories:

Strainer: Y-pattern strainer for installation on entering hydronic piping to unit.

**<Insert accessories>**.

* + - * 1. Unit Controls:

Enclosure: Metal, similar to enclosure, and suitable for indoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult listed manufacturers for availability.

Factory-Installed Sensors: **[Unit entering refrigerant temperature] [Unit leaving refrigerant temperature] [Unit entering-water temperature] [Unit leaving-water temperature] <Insert sensor>**.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, time delay, auto-restart, hydronic pump interlock**[, auto operation mode] [, manual operation mode] [, run test switch] [leaving-water set-point control] [entering- or leaving-water set-point control] [automatic water temperature control reset based on outdoor temperature] [automatic water temperature control reset based on a remote signal] <Insert function>**.

Communication: Network communication with other indoor units and outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Metal, similar to enclosure, and suitable for indoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - 1. INDOOR, DEDICATED OUTDOOR AIR VENTILATION UNITS

If retaining option in "Description" paragraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

* + - * 1. Description: Factory-assembled**[ and -tested]** complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

Specially designed for up to 100 percent outdoor air entering unit.

* + - * 1. Cabinet:

Retain all options in "Material" subparagraph below to be least restrictive. Some manufacturer's products may not comply with only "Galvanized" or "painted" option.

Material: **[Galvanized] [or] [painted]** steel.

If retaining option in "Insulation" subparagraph below, consult manufacturers to confirm they offer products that comply with requirement. Some manufacturer's products may not comply.

Insulation: Manufacturer's standard internal insulation**[, complying with ASHRAE 62.1,]** to provide thermal resistance and prevent condensation.

Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. DX Coil Assembly:

Coil Casing: Aluminum, galvanized, or stainless steel.

Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.

Coil Tubes: Copper, of diameter and thickness required by performance.

Expansion Valve: Electronic modulating type with linear or proportional characteristics.

Unit Internal Tubing: Copper tubing with brazed joints.

Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - * 1. DX Coil Assembly for Reheat Applications: Provide units with a reheat coil where indicated on Drawings.

Coil Casing: Aluminum, galvanized, or stainless steel.

Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.

Coil Tubes: Copper, of diameter and thickness required by performance.

Expansion Valve: Electronic modulating type with linear or proportional characteristics.

Unit Internal Tubing: Copper tubing with brazed joints.

Unit Internal Tubing Insulation: Manufacturer's standard insulation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - * 1. Drain Assembly:

Pan: Non-ferrous material, with bottom sloped to low point drain connection.

Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.

Field Piping Connection: Non-ferrous material**[ with threaded NPT]**.

* + - * 1. Fan and Motor Assembly:

Fan(s):

Direct-drive arrangement.

Single or multiple fans connected to a common motor shaft and driven by a single motor.

Fabricated from non-ferrous components or ferrous components with corrosion protection finish.

Wheels statically and dynamically balanced.

Motor: Brushless dc or electronically commutated with permanently lubricated bearings.

Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.

Vibration Control: Integral isolation to dampen vibration transmission.

* + - * 1. Filter Assembly:

Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.

Efficiency: **[ASHRAE 52.2, MERV 7] [ASHRAE 52.2, MERV 11] [ASHRAE 52.2, MERV 13] <Insert efficiency>**.

Replaceable Media: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

* + - * 1. Unit Accessories:

Motorized Inlet Damper Kit: Low-leakage damper with spring return electric actuator to fail closed on loss of power. Damper controlled by unit to open when unit is operating and close when unit off.

**<Insert accessories>**.

* + - * 1. Unit Controls:

Enclosure: Metal, similar to enclosure, and suitable for indoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors: **[Coil entering refrigerant temperature] [Coil leaving refrigerant temperature] [Unit entering-air temperature] [Unit leaving-air temperature] [Unit entering-air relative humidity] [Unit leaving-air relative humidity] <Insert sensor>**.

Retain "Field-Customizable I/O Capability" subparagraph below for special control strategies. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Field-Customizable I/O Capability:

Analog Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Outputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, time delay, auto-restart**[, external static pressure control] [, auto operation mode] [, manual operation mode] [, filter service notification] [, power consumption display] [, drain assembly high water level safety shutdown and notification] [, run test switch] <Insert function>**.

Communication: Network communication with other indoor units and outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Metal, similar to enclosure, and suitable for indoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - 1. INDOOR, ENERGY RECOVERY VENTILATOR
				1. Description: Factory-assembled**[ and -tested]** complete unit with components, wiring, and controls required for mating to ductwork, power, and controls field connections.
				2. Cabinet:

Material: Galvanized steel.

Insulation: Manufacturer's standard internal insulation**[, complying with ASHRAE 62.1]**.

Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. Damper Assemblies:

Outdoor Air Intake and Exhaust Air Discharge:

Low-leakage damper with spring return electric actuator to fail closed on loss of power.

Damper controlled by unit to open when unit is operating and close when unit off.

Energy Recovery Heat-Exchanger Bypass:

Low leakage damper with electric actuator with integral controls to bypass outdoor air around the energy recovery heat exchanger during times of favorable weather, and there is no energy-saving benefit to circulate air across the energy recovery heat exchanger.

* + - * 1. Fan and Motor Assemblies: Separate fan and motor assemblies for supply and exhaust airstreams with control for equal airflow.

Fan(s):

Direct-drive arrangement.

Fabricated from non-ferrous components or ferrous components with corrosion protection finish.

Wheels statically and dynamically balanced.

Motor: Brushless dc or electronically commutated with permanently lubricated bearings.

Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least **[50] <Insert number>** percent.

Vibration Control: Integral isolation to dampen vibration transmission.

* + - * 1. Filter Assemblies: Separate filter assemblies for outdoor air and exhaust airstreams entering energy recovery heat exchanger.

Access: To accommodate filter replacement without the need for tools.

Efficiency: **[ASHRAE 52.2, MERV 7] <Insert efficiency>**.

Replaceable Media: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

* + - * 1. Energy Recovery Heat Exchanger:

Total (sensible and latent) energy exchange between outdoor air and exhaust airstreams with performance indicated on Drawings.

Fixed element with no moving parts.

AHRI 1060 certified and bearing the AHRI labe1.

* + - * 1. Unit Accessories:

Retain any of two subparagraphs below to provide unit with accessories required by application. Indicate units with accessories in unit equipment schedule on Drawings.

Electric Duct Preheater:

Heater operation interlocked with energy recovery ventilator unit.

Heater with integral controls to control outdoor air temperature entering energy recovery ventilator unit to a temperature set-point determined by energy recovery ventilator unit manufacturer.

Listed and labeled.

**<Insert accessories>**.

* + - * 1. Unit Controls:

Enclosure: Metal, similar to enclosure, and suitable for indoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors:

Unit entering outdoor air temperature.

Unit leaving supply air temperature.

Unit entering exhaust air temperature.

Unit leaving exhaust air temperature.

Unit entering outdoor air relative humidity.

Unit leaving supply air relative humidity.

Unit entering exhaust air relative humidity.

Unit leaving exhaust air relative humidity.

**<Insert sensor>**.

Retain "Field-Customizable I/O Capability" subparagraph below for special control strategies. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

Field-Customizable I/O Capability:

Analog Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Inputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

Digital Outputs: **[Two] [Three] [Four] <Insert number>** for use in customizable control strategies.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, time delay, auto-restart**[, external static pressure control] [, local auto operation mode] [, auto operation through remote signal] [, manual operation mode] [, filter service notification] [, power consumption display] [, run test switch] <Insert function>**.

Communication: Network communication with other indoor units and outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Metal, similar to enclosure, and suitable for indoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - 1. INDOOR, HYDRONIC HEAT-PUMP UNITS
				1. Description: Factory -assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.

Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

All units installed shall be from the same product development generation.

* + - * 1. Cabinet:

Galvanized-steel construction.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

Internal cabinet cooling in subparagraph below may be available from only some manufacturers. Consult manufacturers for availability.

Internal Cabinet Cooling: Unit shall include integral cabinet cooling to maintain inside of cabinet within acceptable operating temperature for internal components.

If unit is not available with integral cooling, provide a field-installed indoor unit that is dedicated to provide cabinet cooling.

* + - * 1. Compressor and Motor Assembly:

One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to [15] <Insert number> percent of rated capacity.

Protection: Integral protection against the following:

High and low refrigerant pressure.

Low oil level.

High oil temperature.

Thermal and overload.

Voltage fluctuations.

Phase failure and phase reversal.

Short cycling.

**<Insert safeties>**.

Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.

Vibration Control: Integral isolation to dampen vibration transmission.

Oil management system to ensure safe and proper lubrication over entire operating range.

Crankcase heaters with integral control to maintain safe operating temperature.

Fusible plug.

* + - * 1. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
				2. Heat-Exchanger Assembly:

Brazed plate heat exchanger(s) with performance indicated on Drawings.

Testing: Factory pressure tested and verified to be without leaks.

Drain: Hydronic side of assembly with drain connection at low point.

* + - * 1. Unit Accessories:

Strainer: Y-pattern strainer for installation on entering hydronic piping to unit.

**<Insert accessories>**.

* + - * 1. Unit Controls:

Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors:

Entering-water temperature.

Leaving-water temperature.

Refrigerant suction temperature.

Refrigerant discharge temperature.

Outdoor air temperature.

Refrigerant high pressure.

Refrigerant low pressure.

Oil level.

**<Insert sensor>**.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, not less than 15 steps of capacity control, freeze protection sensor, proof of water flow**[, auto operation mode] [, manual operation mode] [, power consumption display] [, run test switch] [automatic control through a remote signal] <Insert function>**.

Communication: Network communication with indoor units and other outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - * 1. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for **[1000] <Insert number>** hours according to ASTM B117.
				2. Unit Piping:

Unit Tubing: Copper tubing with brazed joints.

Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - 1. INDOOR, HYDRONIC HEAT RECOVERY UNITS
				1. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

Specially designed for use in systems with simultaneous heating and cooling.

Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

All units installed shall be from the same product development generation.

* + - * 1. Cabinet:

Galvanized-steel construction.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

Internal cabinet cooling in subparagraph below may be available from only some manufacturers. Consult manufacturers for availability.

Internal Cabinet Cooling: Unit shall include integral cabinet cooling to maintain inside of cabinet within acceptable operating temperature for internal components.

If unit is not available with integral cooling, provide a field-installed indoor unit that is dedicated to provide cabinet cooling.

* + - * 1. Compressor and Motor Assembly:

One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to **[15] <Insert number>** percent of rated capacity.

Protection: Integral protection against the following:

High and low refrigerant pressure.

Low oil level.

High oil temperature.

Thermal and overload.

Voltage fluctuations.

Phase failure and phase reversal.

Short cycling.

**<Insert safeties>**.

Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.

Vibration Control: Integral isolation to dampen vibration transmission.

Oil management system to ensure safe and proper lubrication over entire operating range.

Crankcase heaters with integral control to maintain safe operating temperature.

Fusible plug.

* + - * 1. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
				2. Heat-Exchanger Assembly:

Brazed plate heat exchanger(s) with performance indicated on Drawings.

Testing: Factory pressure tested and verified to be without leaks.

Drain: Hydronic side of assembly with drain connection at low point.

* + - * 1. Unit Accessories:

Strainer: Y-pattern strainer for installation on entering hydronic piping to unit.

**<Insert accessories>**.

* + - * 1. Unit Controls:

Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors:

Entering-water temperature.

Leaving-water temperature.

Refrigerant suction temperature.

Refrigerant discharge temperature.

Outdoor air temperature.

Refrigerant high pressure.

Refrigerant low pressure.

Oil level.

**<Insert sensor>.**

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, not less than 15 steps of capacity control, freeze protection sensor, proof of water flow**[, auto operation mode] [, manual operation mode] [, power consumption display] [, run test switch] [automatic control through a remote signal] <Insert function>**.

Communication: Network communication with indoor units and other outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - * 1. Unit Hardware: Zinc-plated steel, or stainless steel.
				2. Unit Piping:

Unit Tubing: Copper tubing with brazed joints.

Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - 1. OUTDOOR, AIR-SOURCE HEAT-PUMP UNITS
				1. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.

Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

All units installed shall be from the same product development generation.

* + - * 1. Cabinet:

Galvanized steel and coated with a corrosion-resistant finish.

Coating with documented salt spray test performance of [1000] <Insert number> hours according to ASTM B117 surface scratch test (SST) procedure.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. Compressor and Motor Assembly:

One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to [15] <Insert number> percent of rated capacity.

Protection: Integral protection against the following:

High refrigerant pressure.

Low oil level.

High oil temperature.

Thermal and overload.

Voltage fluctuations.

Phase failure and phase reversal.

Short cycling.

**<Insert safeties>**.

Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.

Vibration Control: Integral isolation to dampen vibration transmission.

Oil management system to ensure safe and proper lubrication over entire operating range.

Crankcase heaters with integral control to maintain safe operating temperature.

Fusible plug.

* + - * 1. Condenser Coil Assembly:

Plate Fin Coils:

Casing: Aluminum, galvanized, or stainless steel.

Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.

Tubes: Copper, of diameter and thickness required by performance.

Retain "Aluminum Microchannel Coils" subparagraph below to give manufacturer the option to use an alternative to plate fin coils. Product has limited availability. Consult manufacturers for availability.

Aluminum Microchannel Coils:

Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.

Single- or multiple-pass arrangement.

Construct fins, tubes, and header manifolds of aluminum alloy.

Coating: **[None] [Corrosion resistant]**.

Retain "Hail Protection" subparagraph below if additional protection is required. Hail protection is typically an optional feature. Consult manufacturer.

Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

* + - * 1. Condenser Fan and Motor Assembly:

Fan(s): Propeller type.

Direct-drive arrangement.

Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.

**[Statically and ]**dynamically balanced.

Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.

Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.

Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

Speed Settings and Control: Variable speed with a speed range of least **[75] <Insert number>** percent.

Vibration Control: Integral isolation to dampen vibration transmission.

* + - * 1. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
				2. Unit Controls:

Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors:

Refrigerant suction temperature.

Refrigerant discharge temperature.

Outdoor air temperature.

Refrigerant high pressure.

Refrigerant low pressure.

Oil level.

**<Insert sensor>**.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection**[, auto operation mode] [, manual operation mode] [, night setback control] [, power consumption display] [, run test switch] [equalize run time between multiple same components] <Insert function>**.

Communication: Network communication with indoor units and other outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - * 1. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for **[1000] <Insert number>** hours according to ASTM B117.
				2. Unit Piping:

Unit Tubing: Copper tubing with brazed joints.

Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - 1. OUTDOOR, AIR-SOURCE HEAT RECOVERY UNITS
				1. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

Specially designed for use in systems with simultaneous heating and cooling.

Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

All units installed shall be from the same product development generation.

* + - * 1. Cabinet:

Galvanized steel and coated with a corrosion-resistant finish.

Coating with documented salt spray test performance of **[1000] <Insert number>** hours according to ASTM B117 surface scratch test (SST) procedure.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. Compressor and Motor Assembly:

One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to **[15] <Insert number>** percent of rated capacity.

Protection: Integral protection against the following:

High refrigerant pressure.

Low oil level.

High oil temperature.

Thermal and overload.

Voltage fluctuations.

Phase failure and phase reversal.

Short cycling.

**<Insert safeties>**.

Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.

Vibration Control: Integral isolation to dampen vibration transmission.

Oil management system to ensure safe and proper lubrication over entire operating range.

Crankcase heaters with integral control to maintain safe operating temperature.

Fusible plug.

* + - * 1. Condenser Coil Assembly:

Plate Fin Coils:

Casing: Aluminum, galvanized, or stainless steel.

Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.

Tubes: Copper, of diameter and thickness required by performance.

Retain "Aluminum Microchannel Coils" subparagraph below to give manufacturer the option to use an alternative to plate fin coils. Product has limited availability. Consult manufacturers for availability.

Aluminum Microchannel Coils:

Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.

Single- or multiple-pass arrangement.

Construct fins, tubes, and header manifolds of aluminum alloy.

Coating: **[None] [Corrosion resistant]**.

Retain "Hail Protection" subparagraph below if additional protection is required. Hail protection is typically an optional feature. Consult manufacturer.

Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

* + - * 1. Condenser Fan and Motor Assembly:

Fan(s): Propeller type.

Direct-drive arrangement.

Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.

**[Statically and ]** dynamically balanced.

Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.

Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.

Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

Speed Settings and Control: Variable speed with a speed range of least **[75] <Insert number>** percent.

Vibration Control: Integral isolation to dampen vibration transmission.

* + - * 1. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
				2. Unit Controls:

Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors:

Refrigerant suction temperature.

Refrigerant discharge temperature.

Outdoor air temperature.

Refrigerant high pressure.

Refrigerant low pressure.

Oil level.

**<Insert sensor>**.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection**[, auto operation mode] [, manual operation mode] [, night setback control] [, power consumption display] [, run test switch] [equalize run time between multiple same components] <Insert function>**.

Communication: Network communication with indoor units and other outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - * 1. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for **[1000] <Insert number>** hours according to ASTM B117.
				2. Unit Piping:

Unit Tubing: Copper tubing with brazed joints.

Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - 1. HEAT RECOVERY CONTROL UNITS (HRCUs)

Retain this article for VRF HVAC systems with simultaneous heating and cooling.

* + - * 1. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

Specially designed for use in systems with simultaneous heating and cooling.

Systems shall consist of one unit, or multiple unit that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

* + - * 1. Cabinet:

Galvanized-steel construction.

Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.

Mounting: Manufacturer-designed provisions for field installation.

Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

* + - * 1. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
				2. Refrigeration Assemblies and Specialties:

Specially designed by manufacturer for type of VRF HVAC system being installed, either two or three pipe.

Each refrigerant branch circuit shall have refrigerant control valve(s) to control refrigerant flow.

Spares: Each heat recovery control unit shall include at least **[one] [two] <Insert number>** branch circuit port(s) for future use.

Each system piping connection upstream of heat recovery unit shall be fitted with an isolation valve to allow for service to any heat recovery control unit in the system without interrupting operation of the system.

Each branch circuit connection shall be fitted with an isolation valve and capped service port to allow for service to any individual branch circuit without interrupting operation of the system.

If not available as an integral part of the heat recovery control unit, isolation valves shall be field installed adjacent to the unit pipe connection.

* + - * 1. Unit Controls:

Enclosure: Manufacturer's standard, and suitable for indoor locations.

Factory-Installed Controller: Configurable digital control.

"Factory-Installed Sensors" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Factory-Installed Sensors: **<Insert sensor>**.

"Features and Functions" subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.

Features and Functions: Self-diagnostics, fuse protection, **<Insert function>**.

Communication: Network communication with indoor units and outdoor unit(s).

Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

* + - * 1. Unit Electrical:

Enclosure: Metal, similar to enclosure, and suitable for indoor locations.

Field Connection: Single point connection to power entire unit and integral controls.

Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.

Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

Raceways: Enclose line voltage wiring in **[metal ]**raceways to comply with NFPA 70.

* + - * 1. Unit Piping:

Unit Tubing: Copper tubing with brazed joints.

Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.

Field Piping Connections: Manufacturer's standard.

Factory Charge: Dehydrated air or nitrogen.

Testing: Factory pressure tested and verified to be without leaks.

* + - 1. SYSTEM CONTROLS
				1. General Requirements:

Network: Indoor units**[, HRCUs,]** and outdoor units shall include integral controls and connect through a **[TIA-485A] [or] [manufacturer-selected] <Insert network type>** control network.

Network Communication Protocol: **[Manufacturer proprietary] [or] [open]** control communication between interconnected units.

Retain "Integration with Building Automation System" subparagraph below if controls for VRF HVAC system are required to communicate with other building automation system. Only ASHRAE 135 is indicated. Consult manufacturers if integration in other system protocols is required.

Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:

Ethernet connection via RJ-45 connectors and port with transmission at **[100] <Insert value>** Mbps or higher.

Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least **[5 minutes] <Insert time>** of battery backup operation after a power loss.

Integration shall include **[control] [monitoring] [scheduling] [change of value notifications] <Insert requirements>**.

**<Insert requirements>**.

Operator Interface:

Operators shall interface with system and unit controls through the following:

Operator interfaces integral to controllers.

Retain any of first three subparagraphs below as applicable. Coordinate with "Integration with Building Automation System" subparagraph and requirements in "Central Controllers" paragraph.

Director’s Representative -furnished PC connected to central controller(s).

Web interface through web browser software.

Integration with Building Automation System.

Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:

On/off control.

Temperature set-point adjustment.

**<Insert feature>**.

Retain "VRF HVAC System Operator Software for PC" paragraph below to require software for operators to monitor and control VRF HVAC system(s) through a single, dedicated Director’s Representative -furnished PC.

* + - * 1. VRF HVAC System Operator Software for PC:

Retain any of 16 subparagraphs below to include features and functions for software installed on PC. Some requirements may not be available from some manufacturers. Consult manufacturers for availability. If Project has multiple controller types, each with different features and functions, revise to suit requirements for each different type and indicate application of each type on Drawings.

Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Director’s Representative -furnished PC.

Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.

Plan views shall show building plans with location of indoor units and identification superimposed on plans.

Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.

Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.

Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.

Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.

Supports Multiple Languages: **[English] [or] [French] [Spanish] <Insert language>**.

Supports Imperial and Metric Temperature Units: **[Fahrenheit] [or] [Celsius] [Fahrenheit and Celsius]**.

Displays service notifications and error codes.

Monitors and displays up to **[3000] <Insert number>** item error history and **[10000] <Insert number>** item operation history for regular reporting and further archiving.

Monitors and displays cumulative operating time of indoor units.

Able to disable and enable operation of individual controllers for indoor units.

Information displayed on individual controllers shall also be available for display.

Information displayed for outdoor units, including refrigerant high and low pressures **[percent capacity] <Insert outdoor unit displays>**.

Retain "Central Controllers" paragraph below to require centralized control of VRF HVAC system(s) from a central controller location.

* + - * 1. Central Controllers:

Retain any of 12 subparagraphs below to include features and functions for controllers. Some requirements may not be available from some manufacturers. Consult manufacturers for availability. If Project has multiple controller types, each with different features and functions, revise to suit requirements for each different type and indicate application of each type on Drawings.

Centralized control for all indoor and outdoor units from a single central controller location.

Include multiple interconnected controllers as required.

Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.

Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

Sets schedule for daily, weekly, and annual events.

Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.

Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.

Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.

Service diagnostics tool.

Able to disable and enable operation of individual controllers for indoor units.

Information displayed on individual controllers shall also be available for display through central controller.

Information displayed for outdoor units, including refrigerant high and low pressures **[percent capacity] <Insert outdoor unit displays>**.

Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.

Operator interface through a backlit, high-resolution color display touch panel**[ and web accessible through standard web browser software]**.

Retain "Wired Controllers for Indoor Units" paragraph below for controllers that are wired to indoor units.

* + - * 1. Wired Controllers for Indoor Units:

Retain any of 23 subparagraphs below to include features and functions for controllers. Some requirements may not be available from some manufacturers. Consult manufacturers for availability. If Project has multiple controller types, each with different features and functions, revise to suit requirements for each different type and indicate application of each type on Drawings.

Single controller capable of controlling multiple indoor units as group.

Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.

Multiple Language: **[English] [or] [French] [Spanish] <Insert language>**.

Temperature Units: **[Fahrenheit] [or] [Celsius] [Fahrenheit and Celsius]**.

On/Off: Turns indoor unit on or off.

Hold: Hold operation settings until hold is released.

Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.

Temperature Display: 1-degree increments.

Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between <Insert temperature range>.

Relative Humidity Display: 1 percent increments.

Relative Humidity Set-Point: Adjustable in 1 percent increments between **<Insert relative humidity range>**.

Fan Speed Setting: Select between available options furnished with the unit.

Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.

Seven-day programmable operating schedule with up to **[five] [eight] <Insert number>** events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.

Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.

Occupancy detection.

Service Notification Display: "Filter" **<Insert notifications>**.

Service Run Tests: Limit use by service personnel to troubleshoot operation.

Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.

User and Service Passwords: Capable of preventing adjustments by unauthorized users.

Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.

Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

**<Insert features and functions>**.

Retain "Wireless Controllers for Indoor Units" paragraph below for indoor unit local controllers that are wireless.

* + - * 1. Wireless Controllers for Indoor Units:

Retain any of 23 subparagraphs below to include features and functions for controllers. Some requirements may not be available from some manufacturers. Consult manufacturers for availability. If Project has multiple local controller types, each with different features and functions, revise to suit requirements for each different type and indicate application of each type on Drawings.

Wireless Communication:

Controller communicates to remote-mounted receiver that is wired to indoor unit(s).

Include receivers with wireless controllers as required to complete installation.

Low-voltage power required for receivers shall be powered through non-polar connections to indoor unit.

One wireless controller shall be capable of communicating with one or multiple receivers to control one or multiple indoor units as a group.

Controller Battery Life: **[Three] <Insert number>** years.

Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.

Multiple Language: **[English] [or] [French] [Spanish] <Insert language>**.

Temperature Units: **[Fahrenheit] [or] [Celsius] [Fahrenheit and Celsius]**.

On/Off: Turns indoor unit on or off.

Hold: Hold operation settings until hold is released.

Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.

Temperature Display: 1-degree increments.

Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between **<Insert temperature range>**.

Relative Humidity Display: 1 percent increments.

Relative Humidity Set-Point: Adjustable in 1 percent increments between **<Insert relative humidity range>**.

Fan Speed Setting: Select between available options furnished with the unit.

Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.

Seven-day programmable operating schedule with up to **[five] [eight] <Insert number>** events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.

Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.

Occupancy detection.

Service Notification Display: "Filter" **<Insert notifications>**.

Service Run Tests: Limit use by service personnel to troubleshoot operation.

Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.

User and Service Passwords: Capable of preventing adjustments by unauthorized users.

Setting stored in non-volatile memory to ensure that settings are not lost if power is lost. Battery for date and time only.

**<Insert features and functions>**.

* + - 1. SYSTEM REFRIGERANT AND OIL
				1. Refrigerant:

As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.

ASHRAE 34, **[Class A1] [or] <Insert classification>** refrigerant classification.

All listed manufacturers currently use R-410a. Some manufacturers are evaluating alternative refrigerants that are less harmful to the environment. Consult manufacturers for currently available refrigerants.

**[R-410a] [or] <Insert refrigerant>**.

* + - * 1. Oil:

As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

* + - 1. SYSTEM CONDENSATE DRAIN PIPING
				1. If more than one material is listed, material selection is Contractor's option.
				2. Copper Tubing:

Drawn-Temper Tubing: According to **[ASTM B88, Type L] [ASTM B88, Type M]** or Type DWV according to ASTM B306.

Wrought-Copper Fittings: ASME B16.22.

Wrought-Copper Unions: ASME B16.22.

Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux according to ASTM B813.

* + - * 1. CPVC plastic pipe according to ASTM F441, Schedule 40, with socket-type pipe fittings according to ASTM F438 and solvent cement according to ASTM F493.
				2. PVC plastic pipe according to ASTM D1785, Schedule 40, with socket-type pipe fittings according to ASTM D2466 and solvent cement according to ASTM D2564, primer according to ASTM F656.
			1. SYSTEM HYDRONIC PIPING

Retain this article if VRF HVAC system includes hydronic equipment.

* + - * 1. Comply with requirements in Section 232113 "Hydronic Piping" for system piping requirements.
			1. SYSTEM REFRIGERANT PIPING
				1. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.

If retaining "Refrigerant Piping" paragraph below, delete paragraph above.

* + - * 1. Refrigerant Piping:

Copper Tube: **[ASTM B280, Type ACR] <Insert material>**.

Wrought-Copper Fittings: ASME B16.22.

Brazing Filler Metals: AWS A5.8.

* + - * 1. Refrigerant Tubing Kits:

Furnished by VRF HVAC system manufacturer.

Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.

Standard one-piece length for connecting to indoor units.

Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.

Factory Charge: **[Dehydrated air or nitrogen] [or] <Insert charge>**.

* + - * 1. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.
				2. Refrigerant Isolation Ball Valves:

Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.

Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.

Valve Connections: Flare or sweat depending on size.

* + - 1. METAL HANGERS AND SUPPORTS
				1. Copper Tube Hangers:

Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.

Hanger Rods: Continuous-thread rod, nuts, and washer made of **[galvanized or copper-coated steel] [stainless steel] <Insert material>**.

* + - * 1. Plastic Pipe Hangers:

Description: MSS SP-58, Types 1 through 58, galvanized-steel, factory-fabricated components.

Hanger Rods: Continuous-thread rod, nuts, and washer made of **[galvanized steel] [stainless steel] <Insert material>**.

* + - 1. METAL FRAMING SYSTEMS
				1. MFMA Manufacturer Metal Framing Systems:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

ABB, Electrification Business.

Cooper B-line; brand of Eaton, Electrical Sector.

Flex-Strut Inc.

G-Strut.

Haydon Corporation.

MIRO Industries.

Unistrut; Atkore International.

Wesanco, Inc.

Approved equivalent.

Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.

Standard: Comply with MFMA-4 factory-fabricated components for field assembly.

Channels: Continuous slotted **[carbon-steel] [stainless steel, Type 304] [stainless steel, Type 316] [extruded-aluminum] <Insert material>** channel with inturned lips.

Channel Width: Selected for applicable load criteria.

Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.

Hanger Rods: Continuous-thread rod, nuts, and washer made of **[galvanized steel] <Insert material>** for use indoors and of **[stainless steel] <Insert material>** for use outdoors.

Metallic Coating for Use Indoors: **[No coating] [Electroplated zinc] [Hot-dip galvanized] [Gold (yellow zinc dichromate) galvanized]**.

Plastic Coating for Use Outdoors: **[PVC] <Insert plastic type>**.

* + - 1. FASTENER SYSTEMS

Verify suitability of fasteners in this article for use in lightweight concrete or concrete slabs less than 4 inches thick.

* + - * 1. Powder-Actuated Fasteners: Threaded, zinc-coated steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
				2. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

Indoor Applications: **[Zinc-coated] [or] [stainless]** steel.

Outdoor Applications: Stainless steel.

* + - 1. PIPE STANDS

Pipe stands in this article require calculating and detailing at each use.

* + - * 1. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
				2. Compact Pipe Stand:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Eberl Iron Works, Inc.

MIRO Industries.

PHP Systems/Design.

RectorSeal HVAC; a CSW Industrials Company.

Approved equivalent.

Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.

Hardware: Galvanized steel or polycarbonate.

Accessories: Protection pads.

* + - * 1. Low-Profile, Single-Base, Single-Pipe Stand:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=13706) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Eberl Iron Works, Inc.

MIRO Industries.

PHP Systems/Design.

Approved equivalent.

Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.

Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.

Vertical Members: Two, **[galvanized] [stainless]**-steel, continuous-thread 1/2-inch rods.

Horizontal Member: Adjustable horizontal, **[galvanized-steel] [stainless steel]** pipe support channels.

Pipe Supports: **[Roller] [Strut clamps] [Clevis hanger] [Swivel hanger]**.

Hardware: **[Galvanized] [Stainless]** steel.

Accessories: Protection pads.

Height: **[12 inches above roof] <Insert lesser dimension above roof>**.

* + - * 1. High-Profile, Single-Base, Single-Pipe Stand:

Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

Eberl Iron Works, Inc.

MIRO Industries.

PHP Systems/Design.

Approved equivalent.

Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

Base: Single vulcanized rubber or molded polypropylene.

Vertical Members: Two, **[galvanized-steel] [stainless steel]**, continuous-thread 1/2-inch rods.

Horizontal Member: One, adjustable height, **[galvanized-steel] [or] [stainless steel]** pipe support slotted channel or plate.

Pipe Supports: **[Roller] [Clevis hanger] [Swivel hanger]**.

Hardware: **[Galvanized] [Stainless]** steel.

Retain first or second option in "Accessories" subparagraph below if retaining "Clevis hanger" or "Swivel hanger" option in "Pipe Supports" subparagraph.

Accessories: Protection pads**[, 1/2-inch continuous-thread galvanized-steel rod] [, 1/2-inch continuous-thread stainless-steel rod]**.

Height: **[36 inches above roof] <Insert lesser dimension above roof>**.

* + - * 1. High-Profile, Multiple-Pipe Stand:

[Manufacturers:](http://www.specagent.com/Lookup?ulid=13709) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Eberl Iron Works, Inc](http://www.specagent.com/Lookup?uid=123457165928).

[MIRO Industries](http://www.specagent.com/Lookup?uid=123457165930).

[PHP Systems/Design](http://www.specagent.com/Lookup?uid=123457165931).

[RectorSeal HVAC; a CSW Industrials Company](http://www.specagent.com/Lookup?uid=123457165929).

Approved equivalent.

Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

Bases: Two or more; **[vulcanized rubber] [molded polypropylene] <Insert material>**.

Vertical Members: Two or more, **[galvanized-steel] [stainless steel]** channels.

Horizontal Members: One or more, adjustable height, **[galvanized-steel] [stainless steel]** pipe support.

Pipe Supports: **[Roller] [Strut clamps] [Clevis hanger] [Swivel hanger]**.

Hardware: **[Galvanized] [Stainless]** steel.

Retain option in "Accessories" subparagraph below if retaining "Clevis hanger" or "Swivel hanger" option in "Pipe Supports" subparagraph.

Accessories: Protection pads**[, 1/2-inch continuous-thread rod]**.

Height: **[36 inches above roof] <Insert lesser dimension above roof>**.

* + - * 1. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.
			1. OUTDOOR EQUIPMENT STANDS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=13840) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

[Eberl Iron Works, Inc](http://www.specagent.com/Lookup?uid=123457165934).

[MIRO Industries](http://www.specagent.com/Lookup?uid=123457165932).

[RectorSeal HVAC; a CSW Industrials Company](http://www.specagent.com/Lookup?uid=123457165933).

Approved equivalent.

* + - * 1. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof-supported outdoor equipment components, without roof membrane penetration, in a prefabricated system that can be modularly assembled on-site.
				2. Foot Material: Rubber or polypropylene.
				3. Rails Material: Hot-dip galvanized carbon steel.
				4. Wind/Sliding Load Resistance: Up to **[100 mph] <Insert value>** minimum.
			1. MISCELLANEOUS SUPPORT MATERIALS
				1. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

Properties: Nonstaining, noncorrosive, and nongaseous.

Design Mix: 5000-psi, 28-day compressive strength.

* + - * 1. Structural Steel: ASTM A36, carbon-steel plates, shapes, and bars; galvanized.
				2. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.
			1. PIPING AND TUBING INSULATION

Retain reference to Section 230719 "HVAC Piping Insulation" if piping insulation for VRF systems is included within that Section, and delete paragraphs in this article that describe piping insulation requirements. If describing piping insulation requirements in this article, delete reference to Section 230719 "HVAC Piping Insulation." Retain other paragraphs to suit Project.

* + - * 1. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.
				2. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:

Flexible Elastomeric Insulation:

Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.

Indoors: **[1/2 inch] [3/4 inch] [1 inch] <Insert dimension>** thick.

Outdoors: **[1/2 inch] [3/4 inch] [1 inch] <Insert dimension>** thick.

Field-Applied Jacket:

Concealed: None required.

Indoors, Exposed to View: **[None required] [PVC, 20 mils thick] [PVC, color selected by Architect, 20 mils thick] <Insert jacket>**.

Outdoors, Exposed to View: **[None required] [Aluminum, smooth, 0.020 inch thick] <Insert jacket>**.

* + - * 1. Refrigerant Tubing Insulation and Jacket Requirements:

Flexible Elastomeric Insulation:

Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.

Indoors: **[1 inch] <Insert dimension>** thick.

Outdoors: **[1 inch] <Insert dimension>** thick.

Field-Applied Jacket:

Concealed: None required.

Indoors, Exposed to View: **[None required] [PVC, 20 mils thick] [PVC, color selected by Architect, 20 mils thick] <Insert jacket>**.

Outdoors, Exposed to View: **[None required] [Aluminum, smooth, 0.020 inch thick] <Insert jacket>**.

* + - * 1. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

Retain "PVC Jacket Adhesive" paragraph below if retaining PVC in "Field-Applied Jacket" subparagraphs.

* + - * 1. PVC Jacket Adhesive: Compatible with PVC jacket.

Retain "Metal Jacket Flashing Sealants" paragraph below if retaining aluminum in "Field-Applied Jacket" subparagraphs.

* + - * 1. Metal Jacket Flashing Sealants:

Materials shall be compatible with insulation materials, jackets, and substrates.

Fire- and water-resistant, flexible, elastomeric sealant.

Service Temperature Range: Minus 40 to plus 250 deg F.

Color: Aluminum.

* + - 1. SYSTEM CONTROL CABLE
				1. Cable Rating: Listed and labeled for application according to NFPA 70.

Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

Flame Travel Distance: 60 inches or less.

Peak Optical Smoke Density: 0.5 or less.

Average Optical Smoke Density: 0.15 or less.

Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

* + - * 1. Low-Voltage Control Cabling:

Paired Cable: NFPA 70, Type CMG.

One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.

PVC insulation.

Braided or foil shielded.

PVC jacket.

Flame Resistance: Comply with UL 1685.

Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.

PVC insulation.

Braided or foil shielded.

PVC jacket.

NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.

Flame Resistance: Comply with NFPA 262.

* + - * 1. TIA-485A Network Cabling:

TIA-485A communications require a single twisted pair for half-duplex communications. Some manufacturers use two twisted pairs to provide full duplex. See manufacturer's data to determine the wiring requirements. Circuit is limited to a distance of not more than 4000 feet.

Standard Cable: NFPA 70, Type CMG.

Paired, **[one pair] [two pairs]**, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.

PVC insulation.

Unshielded.

PVC jacket.

Flame Resistance: Comply with UL 1685.

Plenum-Rated Cable: NFPA 70, Type CMP.

Paired, **[one pair] [two pairs]**, No. 22 AWG, stranded (7x30) tinned-copper conductors.

Fluorinated ethylene propylene insulation.

Unshielded.

Fluorinated ethylene propylene jacket.

NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.

Flame Resistance: NFPA 262.

* + - * 1. Ethernet Network Cabling: TIA-568-C.2 Category **[6] [6a] <Insert category>** cable with **[RJ-45] <Insert connector type>** connectors.

Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.

Conductors: 100-ohm, 23 AWG solid copper.

Shielding: **[Unshielded twisted pairs (UTP)] [Shielded twisted pairs (FTP)]**.

Cable Rating: By application.

Jacket: **[White] [Gray] [Blue] [Yellow] <Insert color>** thermoplastic.

* + - * 1. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.
			1. MATERIALS
				1. Steel:

ASTM A36/A36M for carbon structural steel.

ASTM A568/A568M for steel sheet.

* + - * 1. Stainless Steel:

Manufacturer's standard grade for casing.

Manufacturer's standard type, ASTM A240 for bare steel exposed to airstream or moisture.

* + - * 1. Galvanized Steel: ASTM A653.
				2. Aluminum: ASTM B209.

Retain first paragraph below if corrosion-resistant coating is specified in Section 230546 "Coatings for HVAC." Retain "Corrosion-Resistant Coating" paragraph below if corrosion-resistant coating options are cited in "Condenser Coil Assembly" paragraphs and if corrosion-resistant coating is specified in this Section. Determine availability with HVAC system manufacturers.

* + - * 1. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

Retain "Corrosion-Resistant Coating" paragraph below if corrosion-resistant coating options are cited in "Condenser Coil Assembly" paragraphs in the "Outdoor, Air-Source Heat-Pump Units" and "Outdoor, Air-Source Heat Recovery Units" articles and if corrosion-resistant coating is specified in this Section. Determine availability with air-conditioner manufacturers.

* + - * 1. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a **[3000] <Insert time>**-hour salt-spray test according to ASTM B117.

Standards:

ASTM B117 for salt spray.

ASTM D2794 for minimum impact resistance of 100 in-lb.

ASTM B3359 for cross-hatch adhesion of 5B.

Application: **[Immersion] [Spray]**.

Thickness: **[1 mil] <Insert value>**.

Gloss: Minimum gloss of 60 on a 60-degree meter.

* + - 1. SOURCE QUALITY CONTROL
				1. Factory Tests: Test and inspect factory-assembled equipment.
				2. Equipment will be considered defective if it does not pass tests and inspections.
				3. Prepare test and inspection reports for historical record. Submit reports only if requested.
1. EXECUTION
	* + 1. EXAMINATION
				1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
				2. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.
				3. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.

Retain first paragraph below for units requiring ductwork.

* + - * 1. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.
				2. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
				3. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.
				4. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
				5. Proceed with installation only after unsatisfactory conditions have been corrected.
			1. EQUIPMENT INSTALLATION, GENERAL
				1. Clearance:

Maintain manufacturer's recommended clearances for service and maintenance.

Maintain clearances required by governing code.

* + - * 1. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.

Retain subparagraph below to require involvement of manufacturer's service representative in installation of field-installed components.

Loose components shall be installed by **[manufacturer's service representative] [or] [system Installer under supervision of manufacturer's service representative]**.

Retain "Equipment Restraint Installation" paragraph below for installation of equipment with seismic restraints, without vibration isolation devices, and without concrete bases.

* + - * 1. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
			1. INSTALLATION OF INDOOR UNITS
				1. Install units to be level and plumb while providing a neat and finished appearance.
				2. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.
				3. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
				4. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
				5. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
				6. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
				7. Provide lateral bracing if needed to limit movement of suspended units to not more than [0.25 inch] <Insert dimension>.
				8. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.
				9. Floor-mounted units located in **[mechanical] <Insert room type>** rooms.

Retain first paragraph below if units are to be installed on a support structure other than a concrete base. Indicate design of support structure on Drawings.

* + - * 1. Install floor-mounted units on support structure indicated on Drawings.

Retain three paragraphs below to require equipment to be installed on cast-in-place concrete equipment bases.

* + - * 1. Install floor-mounted units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
				2. Attachment: Install hardware for proper attachment to supported equipment.
				3. Grouting: Place grout under equipment supports and make bearing surface smooth.
			1. INSTALLATION OF OUTDOOR UNITS
				1. Install units to be level and plumb while providing a neat and finished appearance.

Retain any of three paragraphs below.

Retain first paragraph below if outdoor units are to be installed on support structures indicated on Drawings.

* + - * 1. Install outdoor units on support structures indicated on Drawings.

Retain "Pad-Mounted Installations" paragraph below to require equipment to be installed on cast-in-place concrete equipment bases.

* + - * 1. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.

Grouting: Place grout under equipment supports and make bearing surface smooth.

Retain "Roof-Mounted Installations" paragraph below to require outdoor units to be installed on equipment supports integrated with roofing installation.

* + - * 1. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, stainless-steel fasteners.
			1. GENERAL REQUIREMENTS FOR PIPING INSTALLATION

Indicate piping locations and arrangements on Drawings if such were used in sizing and other design considerations.

* + - * 1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.
				2. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
				3. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
				4. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.
				5. Install piping and tubing to permit valve servicing.
				6. Install piping and tubing at indicated slopes.
				7. Install piping and tubing free of sags.
				8. Install fittings for changes in direction and branch connections.
				9. Install piping and tubing to allow application of insulation.
				10. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.
				11. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
				12. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."
			1. INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING
				1. General Requirements for Drain Piping and Tubing:

Install a union in piping at each threaded unit connection.

Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.

If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:

Details indicated on Drawings.

Manufacturer's requirements.

Governing codes.

In the absence of requirements, comply with requirements of ASHRAE handbooks.

Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.

Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

* + - * 1. Gravity Drains:

Slope piping from unit connection toward drain termination at a constant slope of not less than **[one] [two] <Insert number>** percent.

* + - * 1. Pumped Drains:

If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

* + - 1. INSTALLATION OF HYDRONIC PIPING
				1. Comply with requirements for hydronic pipe and tubing specified in Section 232113 "Hydronic Piping."
				2. Comply with requirements for hydronic specialties specified in Section 232116 "Hydronic Piping Specialties."
				3. Comply with requirements for ball valves specified in Section 230523.12 "Ball Valves for HVAC Piping."
				4. Comply with requirements for check valves specified in Section 230523.14 "Check Valves for HVAC Piping."
				5. Install continuous-thread hanger rods and **[elastomeric] [spring]** hangers of size required to support equipment weight.

Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC." Fabricate brackets or supports as required.

Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

* + - * 1. Where installing piping and tubing adjacent to equipment, allow space for service and maintenance.
			1. INSTALLATION OF REFRIGERANT PIPING
				1. Refrigerant Tubing Kits:

Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.

Support tubing using hangers and supports indicated at intervals not to exceed **[5 feet] <Insert dimension>**. Minimum rod size, 1/4 inch.

Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.

* + - * 1. Install refrigerant piping according to ASHRAE 15 and governing codes.
				2. Select system components with pressure rating equal to or greater than system operating pressure.
				3. Install piping as short and direct as possible, with a minimum number of joints and fittings.
				4. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
				5. Install refrigerant piping and tubing in protective conduit where installed belowground.
				6. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.
				7. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:

Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.

Install horizontal suction lines with a uniform slope downward to compressor.

Install traps to entrain oil in vertical runs.

Liquid lines may be installed level.

* + - * 1. When brazing, remove or protect components that could be damaged by heat.
				2. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.
				3. Joint Construction:

Ream ends of tubes and remove burrs.

Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.

Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.

Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

* + - 1. INSTALLATION OF METAL HANGERS AND SUPPORTS

Retain first paragraph below for projects in areas that require seismic restraints.

* + - * 1. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
				2. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
				3. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
				4. Comply with MFMA-103 for metal framing system selections and applications that are not specified.
				5. Fastener System Installation:

Verify suitability of fasteners in first two subparagraphs below for use in lightweight concrete or concrete slabs less than 4 inches thick.

Install powder-actuated fasteners, for use in lightweight concrete or concrete slabs less than 4 inches thick, in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

Pipe stand in "Pipe Stand Installation" paragraph below requires calculating and detailing at each use.

* + - * 1. Pipe Stand Installation:

Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

* + - * 1. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
				2. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
				3. Install lateral bracing with pipe hangers and supports to prevent swaying.
				4. Install building attachments within concrete slabs or attach to structural steel.

Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

* + - * 1. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
				2. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
				3. Piping and Tubing Insulation:

Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

Shield Dimensions for Pipe: Not less than the following:

NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.

* + - * 1. Horizontal-Piping Hangers and Supports: Install the following types:

Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.

Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu if individual clevis hangers.

Pipe stands for horizontal pipes located outdoors.

Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

Maximum spacing in "Horizontal Piping Hanger Spacing and Rod Size" paragraph below is from MSS SP-69, "Pipe Hangers and Supports - Selection and Application," and the International Mechanical Code. If hanger spacing is determined by local codes that differ from MSS SP-69 and the International Mechanical Code, delete paragraph. Contractor is then obligated to comply with the maximum spacing required by authorities having jurisdiction.

* + - * 1. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:

Sizes through NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.

NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.

NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.

NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.

NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

* + - * 1. Plastic Pipe Hanger and Support Spacing:

Space hangers and supports according to pipe manufacturer's written instructions for service conditions.

Maximum spacing, 5 feet; minimum rod size, 1/4 inch.

* + - * 1. Vertical-Piping Clamps: Install the following types:

Extension Pipe or Riser Clamps (MSS Type 8).

Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): If longer ends are required for riser clamps.

* + - * 1. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed **[5 feet] [10 feet] <Insert dimension>**.
				2. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.
				3. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.
				4. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
				5. Trim excess length of continuous-thread hanger and support rods to [**1 inch**] <**Insert dimension**>.
				6. Hanger-Rod Attachments: Install the following types:

Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

* + - * 1. Building Attachments: Install the following types:

Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.

Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

C-Clamps (MSS Type 23): For structural shapes.

Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

Light (MSS Type 31): 750 lb.

Medium (MSS Type 32): 1500 lb.

Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

* + - 1. INSTALLATION OF PIPING AND TUBING INSULATION
				1. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Installation to maintain a continuous vapor barrier.
				2. Insulation Installation on Pipe Fittings and Elbows:

Install mitered sections of pipe insulation.

Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

* + - * 1. Insulation Installation on Valves and Pipe Specialties:

Install preformed valve covers manufactured of same material as pipe insulation when available.

When preformed valve covers are unavailable, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

* + - * 1. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

* + - * 1. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.
			1. INSTALLATION OF DUCT, ACCESSORIES, AND AIR OUTLETS

Retain this article for VRF HVAC systems that include equipment with duct connections.

* + - * 1. Where installing ductwork adjacent to equipment, allow space for service and maintenance.
				2. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."
				3. Comply with requirements for nonmetal ducts specified in Section 233116 "Nonmetal Ducts."
				4. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."
				5. Comply with requirements for flexible ducts specified in Section 233346 "Flexible Ducts."
				6. Comply with requirements for air diffusers specified in Section 233713.13 "Air Diffusers."
				7. Comply with requirements for registers and grilles specified in Section 233713.23 "Registers and Grilles."
			1. ELECTRICAL INSTALLATION
				1. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.
				2. To extent electrical power is required for system equipment, components, and controls, and is not indicated on Drawings and addressed in the Specifications, the design for such electrical power shall be delegated to VRF HVAC system provider.

Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no additional cost to Director’s Representative.

* + - * 1. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
				2. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
				3. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
				4. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.

Nameplate shall be laminated phenolic layers of black with engraved white letters. Letters at least 1/2 inch high.

Locate nameplate or label where easily visible.

* + - * 1. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or revised in this Section.

Retain one of first two subparagraphs below.

Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

Outlet boxes for cables shall be no smaller than 4 inches square by **[1-1/2 inches] [2-1/8 inches]** deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.

Flexible metal conduit shall not be used.

* + - * 1. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
				2. Install manufactured conduit sweeps and long-radius elbows if possible.
				3. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
			1. SOFTWARE
				1. Cybersecurity:

Software:

Coordinate security requirements with **[IT department] [CIO] <Insert entity responsible for IT security>**.

Ensure that latest stable software release is installed and properly operating.

Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.

Hardware:

Coordinate location and access requirements with **[IT department] [CIO] <Insert entity responsible for IT security>**.

Enable highest level of wireless encryption that is compatible with Director’s Representative 's ICT network.

Disable dual network connections.

* + - 1. INSTALLATION OF SYSTEM CONTROL CABLE
				1. Comply with NECA 1.
				2. Installation Method:

Install cables in raceways except as follows:

Within equipment and associated control enclosures.

Retain one of first two subparagraphs below, or both, to allow open cable methods.

In accessible ceiling spaces where open cable installation method may be used.

In gypsum board partitions where cable may be enclosed within wall cavity.

Conceal raceway and cables except in unfinished spaces.

* + - * 1. General Requirements for Cabling:

Comply with TIA-568-C Series of standards.

Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."

Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.

Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable.

Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.

Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.

Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.

Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.

Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.

Support: Do not allow cables to lie on removable ceiling tiles or access panels.

Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

Provide strain relief.

Keep runs short. Allow extra length for connecting to terminals.

Do not bend cables in a radius less than 10 times the cable OD.

Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.

Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

* + - * 1. Balanced Twisted-Pair Cable Installation:

Comply with TIA-568-C.2.

Do not untwist balanced twisted-pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

* + - * 1. Open-Cable Installation:

Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than [30 inches] <Insert dimension> apart.

Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

* + - * 1. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.
			1. FIRESTOPPING
				1. Comply with requirements in Section 078413 "Penetration Firestopping."
				2. Comply with TIA-569-D, Annex A, "Firestopping."
				3. Comply with BICSI TDMM, "Firestopping" Chapter.
			2. GROUNDING INSTALLATION

Retain one or both paragraphs in this article.

* + - * 1. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
				2. For low-voltage control cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
			1. IDENTIFICATION
				1. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."
				2. Identify system electrical **[and controls ]**components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

* + - 1. FIELD QUALITY CONTROL
				1. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.

Field service shall be performed by **[an employee] [or] [a factory-trained and -authorized company service advisor]** of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.

Retain first subparagraph below if retaining only "an employee" option in subparagraph above.

Additional company service advisors may assist with completion of certain activities only if supervised by manufacturer's employee. A company service advisor shall not provide assistance without manufacturer's employee supervision.

Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.

Retain any of first five subparagraphs below. Delete or add additional visits required.

First Visit: Kick-off meeting.

Second Visit: At approximately **[25] <Insert number>** percent completion of system(s).

Third Visit: At approximately **[50] <Insert number>** percent completion of system(s).

Fourth Visit: At approximately **[75] <Insert number>** percent completion of system(s).

Fifth Visit: Final inspection before system startup.

Kick-off Meeting:

Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.

Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.

Meeting shall cover the following as a minimum requirement:

Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.

Manufacturer's installation requirements specific to systems being installed.

Review of all relevant VRF HVAC system submittals, including delegated-design submittals.

Required field activities related installation of VRF HVAC system.

Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.

Site Visits: Activities for each site visit shall include the following:

Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.

Offer technical support to Installer and related trades as related to VRF system(s) being installed.

Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.

Advise and if necessary assist Installer with updating related refrigerant calculations and system documentation.

Issue a report for each visit, documenting the visit.

Report to include name and contact information of individual making the visit.

Date(s) and time frames while on-site.

Names and contact information of people meeting with while on-site.

Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.

Final Inspection before Startup:

Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according to manufacturer's requirements and ready for final inspection.

All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.

Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.

Inspection reports for indoor units shall include, but not be limited to, the following:

Unit designation on Drawings.

Manufacturer model number.

Serial number.

Network address, if applicable.

Each equipment setting.

Mounting, supports, and restraints properly installed.

Proper service clearance provided.

Wiring and power connections correct.

Line-voltage reading(s) within acceptable range.

Wiring and controls connections correct.

Low-voltage reading(s) within an acceptable range.

Controller type and model controlling unit.

Controller location.

Temperature settings and readings within an acceptable range.

Humidity settings and readings within an acceptable range.

Condensate removal acceptable.

Fan settings and readings within an acceptable range.

Unit airflow direction within an acceptable range.

If applicable, fan external static pressure setting.

Filter type and condition acceptable.

Noise level within an acceptable range.

Refrigerant piping properly connected and insulated.

Condensate drain piping properly connected and insulated.

If applicable, ductwork properly connected.

If applicable, external interlocks properly connected.

Remarks.

Inspection reports for outdoor units shall include, but not be limited to, the following:

Unit designation on Drawings.

Manufacturer model number.

Serial number.

Network address, if applicable.

Each equipment setting.

Mounting, supports, and restraints properly installed.

Proper service clearance provided.

Wiring and power connections correct.

Line-voltage reading(s) within acceptable range.

Wiring and controls connections correct.

Low-voltage reading(s) within an acceptable range.

Condensate removal acceptable.

Noise level within an acceptable range.

Refrigerant piping properly connected and insulated.

Condensate drain piping properly connected and insulated.

Remarks.

Retain first subparagraph below for indoor, dedicated outdoor air ventilation unit inspection reports.

Inspection reports for indoor, dedicated outdoor air ventilation units shall include, but not be limited to, the following:

Unit designation on Drawings.

Manufacturer model number.

Serial number.

Network address, if applicable.

Each equipment setting.

Mounting, supports, and restraints properly installed.

Proper service clearance provided.

Wiring and power connections correct.

Line-voltage reading(s) within acceptable range.

Wiring and controls connections correct.

Low-voltage reading(s) within an acceptable range.

Controller type and model controlling unit.

Controller location.

Temperature settings and readings within an acceptable range.

Humidity settings and readings within an acceptable range.

Condensate removal acceptable.

Fan settings and readings within an acceptable range.

Fan external static pressure setting.

Filter type and condition acceptable.

Noise level within an acceptable range.

Refrigerant piping properly connected and insulated.

Condensate drain piping properly connected and insulated.

Automatic dampers properly installed and operating.

Ductwork properly connected.

If applicable, external interlocks properly connected.

Remarks.

Retain first subparagraph below for energy recovery ventilator inspection reports.

Inspection reports for energy recovery ventilators shall include, but not be limited to, the following:

Unit designation on Drawings.

Manufacturer model number.

Serial number.

Network address, if applicable.

Each equipment setting.

Mounting, supports, and restraints properly installed.

Proper service clearance provided.

Wiring and power connections correct.

Line-voltage reading(s) within acceptable range.

Wiring and controls connections correct.

Low-voltage reading(s) within an acceptable range.

Controller type and model controlling unit.

Controller location.

Temperature settings and readings within an acceptable range.

Humidity readings.

Condensate removal acceptable.

Fan settings and readings within an acceptable range.

Fan external static pressure setting.

Filter type and condition acceptable.

Noise level within an acceptable range.

Automatic dampers properly installed and operating.

Ductwork properly connected.

If applicable, external interlocks properly connected.

Remarks.

Retain first subparagraph below for hydronic unit inspection reports.

Inspection reports for hydronic units shall include, but not be limited to, the following:

Unit designation on Drawings.

Manufacturer model number.

Serial number.

Network address, if applicable.

Each equipment setting.

Mounting, supports, and restraints properly installed.

Proper service clearance provided.

Wiring and power connections correct.

Line-voltage reading(s) within acceptable range.

Wiring and controls connections correct.

Low-voltage reading(s) within an acceptable range.

Controller type and model controlling unit.

Controller location.

Temperature settings and readings within an acceptable range.

Condensate removal acceptable.

Noise level within an acceptable range.

Refrigerant piping properly connected and insulated.

Hydronic piping properly connected and insulated.

Proof of water flow checked for proper operation.

Condensate drain piping properly connected and insulated.

If applicable, external interlocks properly connected.

Remarks.

Installer shall provide manufacturer with the requested documentation and technical support during inspection.

Installer shall correct observed deficiencies found by the inspection.

Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.

If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved and systems are deemed ready for startup.

Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.

* + - * 1. Perform the following tests and inspections with the assistance of manufacturer's service representative:

Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

* + - * 1. Refrigerant Tubing Positive Pressure Testing:

Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.

After completion of tubing installation, pressurize tubing systems to a test pressure of not less than **[1.2] [1.5] <Insert value>** times VRF HVAC system operating pressure, but not less than **[600 psig] <Insert value>**, using **[dry nitrogen] <Insert test medium>**.

Successful testing shall maintain a test pressure for a continuous and uninterrupted period of **[24] <Insert number>** hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.

Prepare test report to record the following information for each test:

Name of person starting test, company name, phone number, and e-mail address.

Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.

Detailed description of extent of tubing tested.

Date and time at start of test.

Test pressure at start of test.

Outdoor temperature at start of test.

Name of person ending test, company name, phone number, and e-mail address.

Date and time at end of test.

Test pressure at end of test.

Outdoor temperature at end of test.

Remarks:

Submit test reports for Project record.

* + - * 1. Refrigerant Tubing Evacuation Testing:

Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.

After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of **[500] <Insert value>** microns.

Successful testing shall maintain a test pressure for a continuous and uninterrupted period of **[one] <Insert number>** hour(s) with no change.

Prepare test report to record the following information for each test:

Name of person starting test, company name, phone number, and e-mail address.

Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.

Detailed description of extent of tubing tested.

Date and time at start of test.

Test pressure at start of test.

Outdoor temperature at start of test.

Name of person ending test, company name, phone number, and e-mail address.

Date and time at end of test.

Test pressure at end of test.

Outdoor temperature at end of test.

Remarks:

Submit test reports for Project record.

Upon successful completion of evacuation testing, system shall be charged with refrigerant.

* + - * 1. System Refrigerant Charge:

Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.

Installer shall charge system following VRF HVAC system manufacturer's written instructions.

System refrigerant charging shall be witnessed by system manufacturer's representative.

Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

* + - * 1. Products will be considered defective if they do not pass tests and inspections.
				2. Prepare test and inspection reports.
			1. STARTUP SERVICE
				1. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.

Service representative shall be **[an employee] [or] [a Company Field Advisor per OGS Spec Section 014216]** of VRF HVAC system manufacturer.

Complete startup service of each separate system.

Complete system startup service according to manufacturer's written instructions.

* + - * 1. Startup checks shall include, but not be limited to, the following:

Check control communications of equipment and each operating component in system(s).

Check each indoor unit's response to demand for cooling and heating.

Check each indoor unit's response to changes in airflow settings.

Check each indoor unit**[, HRCU,]** and outdoor unit for proper condensate removal.

Check sound levels of each indoor**[ and outdoor]** unit.

**<Insert startup check>**.

* + - * 1. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.

Installer shall correct deficiencies found during startup service for reverification.

* + - * 1. System Operation Report:

After completion of startup service, manufacturer shall issue a report for each separate system.

Report shall include complete documentation describing each startup check, the result, and any corrective action required.

Manufacturer shall electronically record not less than **[two] <Insert number>** hours of continuous operation of each system and submit with report for historical reference.

All available system operating parameters shall be included in the information submitted.

Retain "Witness" paragraph below to require independent witness of startup service.

* + - * 1. Witness:

Invite **[Director’s Representative] [and] [Commissioning Agent]** to witness startup service procedures.

Provide written notice not less than **[20] <Insert number>** business days before start of startup service.

* + - 1. ADJUSTING
				1. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.
				2. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.
				3. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.

Retain "Occupancy Adjustments" paragraph below to provide additional on-site assistance. Consult Director’s Representative to determine if additional occupancy adjustments is needed.

* + - * 1. Occupancy Adjustments: When requested within **[12] <Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two] <Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.
			1. PROTECTION
				1. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
				2. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.
				3. Protect equipment from electrical damage. Replace equipment suffering electrical damage.
				4. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.
			2. MAINTENANCE SERVICE

Retain this article to require on-going maintenance service after Substantial Completion. Verify with Director’s Representative that maintenance service is required for Project.

* + - * 1. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include **[12] <Insert duration>** months' full maintenance by **[skilled employees of system Installer] [who are] [manufacturer's authorized service representative].** Include **[two] [four] <Insert number>** service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
			1. SOFTWARE SERVICE AGREEMENT

Retain this article to require software updates for a period after Substantial Completion. Services in this article may not be allowed for publicly funded projects. Consult Director’s Representative to determine if software agreement is required.

* + - * 1. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for **[two] <Insert number>** years.
				2. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within **[two] <Insert number>** years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

Upgrade Notice: At least **[30] <Insert number>** days to allow Director’s Representative to schedule and access the system and to upgrade computer equipment if necessary.

* + - 1. DEMONSTRATION
				1. Engage a VRF HVAC system manufacturer's **[employed training instructor] [or] [Company Field Advisor per OGS Spec Section 014216]** to train Director’s Representative 's maintenance personnel to adjust, operate, and maintain entire system.
				2. Instructor:

Instructor shall be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.

Instructor's credentials shall be submitted for review by **[Commissioning Agent] [Director’s Representative]** before scheduling training.

Instructor(s) **[primary] [sole]** job responsibility shall be Director’s Representative training.

Instructor(s) shall have not less than **[three] <Insert number>** years of training experience with VRF HVAC system manufacturer and past training experience on at least **[three] <Insert number>** projects of comparable size and complexity.

* + - * 1. Schedule and Duration:

Schedule training with Director’s Representative at least **[20] <Insert number>** business days before first training session.

Training shall occur before Director’s Representative occupancy.

Training shall be held at mutually agreed date and time during normal business hours.

Each training day shall not exceed **[eight] <Insert number>** hours of training. Daily training schedule shall allow time for **[one] <Insert number>**-hour lunch period and **[15] <Insert number>**-minute break after every **[two] <Insert number>** hours of training.

Perform not less than **[eight] [16] [24] <Insert number>** total hours of training.

* + - * 1. Location: Director’s Representative shall provide a suitable on-site location to host classroom training.

Consult Director’s Representative to determine the number of attendees to be included in "Training Attendees" paragraph below.

* + - * 1. Training Attendees: Assume **[three] <Insert number>** people.
				2. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.
				3. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.
				4. Training Materials: Provide training materials in electronic format to each attendee.

Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.

Video record each classroom training session and submit an electronic copy to Director’s Representative before requesting Director’s Representative acceptance of training.

* + - * 1. Acceptance: Obtain **[Commissioning Agent] [or] [Director’s Representative]** written acceptance that training is complete and requirements indicated have been satisfied

END OF SECTION 238129