SECTION 23 83 23.16 - RADIANT-HEATING ELECTRIC MATS

NVENT NUHEAT MAT FLOOR HEATING SYSTEM

PART 1 GENERAL

1.1 SUMMARY

A. Section includes UL Listed and CSA Certified floor heating systems.

1.2 REFERENCES

A. Reference Standards
1. UL515 – Electrical Resistance Heat Tracing for Commercial Applications
2. IEEE 515.1-2012 Standard for the Testing, Design, Installation & Maintenance of Electric Resistance Trace Heating for Commercial Applications.
3. CSA Standard C22.2 No. 130-03 Requirements for Electrical Resistance Heating Cables & Heating Device Sets
4. NFPA 70 - National Electrical Code
5. CSA Standard C22.1 – Canadian Electrical Code
6. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI—current edition)
7. UL 1693, Second Edition
8. UL 1683, Issue No. 2
9. NEC Article 424 Floor Warming Systems
10. AMERICAN SOCIETY for TESTING & MATERIALS (ASTM—current edition)

1.3 SYSTEM DESCRIPTION

A. System Description: Electric radiant floor heating system consisting of a resistance heating wire bonded in a pre-configured pattern between two porous layers of fabric and thermostat(s) with built-in Class A GFCI protection.
1. The pre-formed electric floor heating product is manufactured to fit the shape of the heated floor area, without the need for on-site alterations or configuration, to ensure evenly distributed warmth throughout the heated floor area.
2. Heating product thickness shall not exceed 1/8 inch (3.2 mm).
3. The heating products must be protected by a minimum, non-pro-rated, 25-year warranty.
4. This system must be approved for use under ceramic tile, marble, other natural stone, laminate, engineered wood, and luxury vinyl floor coverings.
5. Thermostat must have built-in class A GFCI protection, floor sensing and ambient air sensing capabilities.

3.2 INSTALLATION

A. Install wall and ceiling unit heaters to comply with NFPA 90A.

B. Install wall and ceiling unit heaters level and plumb.

C. For heaters with wall thermostat, install heater in wall electrical box at a height required to meet American with Disabilities Act, Fair Housing Act or other Federal, State and Local codes having jurisdiction. Wiring between thermostat and heater shall be in metallic conduit

D. Wiring to comply with applicable Sections of Division 26

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7. Disconnect/contactor

8. Automatic thermal reset cut-out

9. Transformer Voltage as required for unit size (fused on secondary and grounded

10. Fan interlocked with heating coil to prevent coil from being activated with fan running.

11. Heater shall be complete with electrical components, devices, accessories, etc required for full compliance with the latest edition of the National Electric Code and State and Local authorities having jurisdiction.

E. Fan

1. Propeller type arranged for draw-thru air flow design to provide uniform air movement over entire heating element surface.

2. Aluminum blades mounted on hub

3. Fan wheel directly mounted to motor shaft

F. Motor

1. Manufacturers standard design permanently lubricated and thermally protected

2. See Division 23; Section titled "Common Motor Requirements for HVAC Equipment" for additional requirements

G. Electrical Components, Devices, Accessories; Listed and labeled as defined in latest edition of NFPA 70 by a qualified testing agency and marked for intended location and application.

H. Controls; Factory wired unit mounted (with plug for tamperproof installation) or wall mounted thermostat as scheduled on drawings. Heater manufacturer to provide wall mounted thermostat (line or low voltage as required for heater wiring.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive wall and ceiling heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

D. For recessed units, coordinate wall and/or ceiling opening required for heater with Contractor responsible wall or ceiling construction.

3. Trane

4. Markel Products

5. Chromalox

6. Berko

B. General

1. Incremental wall or ceiling mounted with factory-finished enclosure fans, motors, coils and grille.

2. Heating Medium; Resistance electric

3. Mounting configuration; Wall (surface), Wall (recessed), Ceiling (surface) and Ceiling (recessed).

4. Unit shall be UL listed

C. Enclosure

1. Heavy duty steel with removable front panels fastened with tamperproof fasteners

2. Stamped-steel grille or extruded aluminum bar grille (18 gauge) as scheduled on drawings

3. Design for surface mounting or recessed mounting as schedule on drawings

4. Factory finished with a baked enamel paint over manufacturer's standard prime coating. Finished color selected by Architect from manufacturer's standard colors.

5. Surface mounting box (color to match front panel)

6. Recessed trim kit for recessed units as required

D. Coils

1. Capacity as scheduled on drawings

2. Coil design; Resistance type nichrome elements with open wire design or industrial grade finned sheathed tubular elements per manufacturers standard design concept

3. Heating elements shall terminate in a terminal box

4. Heating element design shall be free from expansion, noise and 60Hz hum

5. Electrical Input; See schedule on drawings for heater voltage and phase requirements.

6. Single point of electrical connection for both heating elements and fan

SECTION 23 82 39.19 - WALL AND CEILING HEATERS (ELECTRIC)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

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

B. Shop Drawings:

1. Include plans, elevations, sections, and details.

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

3. Include details of anchorages and attachments to structure and to supported equipment.

4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.

5. Wiring Diagrams: Power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide product of manufacturer scheduled on drawings or one of the following:

1. Qmark

2. Indeeco

1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.

H. Acceptance: Obtain Commissioning Agent and Owner written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 23 81 29

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3.16 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.17 DEMONSTRATION

A. Engage a VRF HVAC system manufacturer's factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.

B. Instructor:

1. 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.
2. Instructor's credentials shall be submitted for review by Commissioning Agent before scheduling training.
3. Instructor(s) primary job responsibility shall be Owner training.
4. Instructor(s) shall have not less than three years of training experience with VRF HVAC system manufacturer and past training experience on at least three projects of comparable size and complexity.

C. Schedule and Duration:

1. Schedule training with Owner at least 20 business days before first training session.
2. Training shall occur before Owner occupancy.
3. Training shall be held at mutually agreed date and time during normal business hours.
4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for one-hour lunch period and 15-minute break after every two hours of training.
5. Perform not less than 16 total hours of training.

D. Location: Owner shall provide a suitable on-site location to host classroom training.

E. 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.

F. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training. Include 8 hours of on-site and 8 hours of classroom training.

G. Training Materials: Provide training materials in electronic format to each attendee.

a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.13 ADJUSTING

A. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.

C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.

D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.14 PROTECTION

A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.

B. 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.

C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.

D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.15 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include three 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.

E. System Refrigerant Charge:

1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
3. System refrigerant charging shall be witnessed by system manufacturer's representative.
4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

F. Products will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.12 STARTUP SERVICE

A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.

1. Service representative shall be a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Startup checks shall include, but not be limited to, the following:

1. Check control communications of equipment and each operating component in system(s).
2. Check each indoor unit's response to demand for cooling and heating.
3. Check each indoor unit's response to changes in airflow settings.
4. Check each indoor unit**,** HRCU**,** and outdoor unit for proper condensate removal.
5. Check sound levels of each indoor and outdoor units.

C. 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.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.

4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.
    g. Name of person ending test, company name, phone number, and e-mail address.
    h. Date and time at end of test.
    i. Test pressure at end of test.
    j. Outdoor temperature at end of test.
    k. Remarks:

5. Submit test reports for Project record.
6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.

5) Each equipment setting.
6) Mounting, supports, and restraints properly installed.
7) Proper service clearance provided.
8) Wiring and power connections correct.
9) Line-voltage reading(s) within acceptable range.
10) Wiring and controls connections correct.
11) Low-voltage reading(s) within an acceptable range.
12) Condensate removal acceptable.
13) Noise level within an acceptable range.
14) Refrigerant piping properly connected and insulated.
15) Condensate drain piping properly connected and insulated.
16) Remarks.

f. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
g. Installer shall correct observed deficiencies found by the inspection.
h. 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.
i. 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.
j. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.

B. Perform the following tests and inspections with the assistance of manufacturer's service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.5 times VRF HVAC system operating pressure, but not less than 600 psig (4137 kPa), using dry nitrogen.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.

5. Final Inspection before Startup:

   a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according manufacturer's requirements and ready for final inspection.
   b. 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.
   c. 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.
   d. Inspection reports for indoor units shall include, but not be limited to, the following:

      1) Unit designation on Drawings.
      2) Manufacturer model number.
      3) Serial number.
      4) Network address, if applicable.
      5) Each equipment setting.
      6) Mounting, supports, and restraints properly installed.
      7) Proper service clearance provided.
      8) Wiring and power connections correct.
      9) Line-voltage reading(s) within acceptable range.
      10) Wiring and controls connections correct.
      11) Low-voltage reading(s) within an acceptable range.
      12) Controller type and model controlling unit.
      13) Controller location.
      14) Temperature settings and readings within an acceptable range.
      15) Humidity settings and readings within an acceptable range.
      16) Condensate removal acceptable.
      17) Fan settings and readings within an acceptable range.
      18) Unit airflow direction within an acceptable range.
      19) If applicable, fan external static pressure setting.
      20) Filter type and condition acceptable.
      21) Noise level within an acceptable range.
      22) Refrigerant piping properly connected and insulated.
      23) Condensate drain piping properly connected and insulated.
      24) If applicable, ductwork properly connected.
      25) If applicable, external interlocks properly connected.
      26) Remarks.

   e. Inspection reports for outdoor units shall include, but not be limited to, the following:

      1) Unit designation on Drawings.
      2) Manufacturer model number.
      3) Serial number.
      4) Network address, if applicable.

e. Fifth Visit: Final inspection before system startup.

3. Kick-off Meeting:

a. 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.
b. 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.
c. Meeting shall cover the following as a minimum requirement:

1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
2) Manufacturer's installation requirements specific to systems being installed.
3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.
4) Required field activities related installation of VRF HVAC system.
5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.

4. Site Visits: Activities for each site visit shall include the following:

a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
d. Advise and if necessary assist Installer with updating related refrigerant calculations and system documentation.
e. Issue a report for each visit, documenting the visit.

1) Report to include name and contact information of individual making the visit.
2) Date(s) and time frames while on-site.
3) Names and contact information of people meeting with while on-site.
4) 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.

a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.9 GROUNDING INSTALLATION

A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control cabling, comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.10 IDENTIFICATION

A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 23 05 53 "Identification for HVAC Piping and Equipment."

B. Identify system electrical and controls components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.11 FIELD QUALITY CONTROL

A. 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.

1. Field service shall be performed by a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.

a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.

2. 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.

a. First Visit: Kick-off meeting.
b. Second Visit: At approximately 25 percent completion of system(s).
c. Third Visit: At approximately 50 percent completion of system(s).
d. Fourth Visit: At approximately 75 percent completion of system(s).

3.8 INSTALLATION OF REFRIGERANT PIPING

A. Refrigerant Tubing Kits:

1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.
2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet (1.5 m). Minimum rod size, 1/4 inch (6.4 mm).
3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.

B. Install refrigerant piping according to ASHRAE 15 and governing codes.

C. Select system components with pressure rating equal to or greater than system operating pressure.

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

E. 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 08 31 13 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

F. Install refrigerant piping and tubing in protective conduit where installed belowground.

G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.

H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:

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

I. When brazing, remove or protect components that could be damaged by heat.

J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.

K. Joint Construction:

1. Ream ends of tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

1. Install a union in piping at each threaded unit connection.
2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
3. 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:

    a. Details indicated on Drawings.
    b. Manufacturer's requirements.
    c. Governing codes.
    d. In the absence of requirements, comply with requirements of ASHRAE handbooks.

4. 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.
5. 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.

B. Gravity Drains:

1. Slope piping from unit connection toward drain termination at a constant slope of not less than one percent.

C. Pumped Drains:

1. 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.

3.7 INSTALLATION OF HYDRONIC PIPING

A. Comply with requirements for hydronic pipe and tubing specified in Section 23 21 13 "Hydronic Piping."

B. Comply with requirements for hydronic specialties specified in Section 23 21 16 "Hydronic Piping Specialties."

C. Install continuous-thread hanger rods and hangers of size required to support equipment weight.
1. Comply with requirements for hangers and supports specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."

D. Where installing piping and tubing adjacent to equipment, allow space for service and maintenance.

C. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete" or Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."

1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Grouting: Place grout under equipment supports and make bearing surface smooth.

D. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 07 72 00 "Roof Accessories." Anchor units to supports with removable, stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

A. 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.

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

C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping and tubing to permit valve servicing.

F. Install piping and tubing at indicated slopes.

G. Install piping and tubing free of sags.

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

I. Install piping and tubing to allow application of insulation.

J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 05 17 "Sleeves and Sleeve Seals for HVAC Piping."

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

A. General Requirements for Drain Piping and Tubing:

F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.

G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

A. Clearance:

1. Maintain manufacturer's recommended clearances for service and maintenance.
2. Maintain clearances required by governing code.

B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.

3.3 INSTALLATION OF INDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. 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 (10 mm).

C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.

E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.

F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.

G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch (13 mm).

H. For wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.

3.4 INSTALLATION OF OUTDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Install outdoor units on support structures indicated on Drawings.

c. Unshielded.
d. Fluorinated ethylene propylene jacket.
e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
f. Flame Resistance: NFPA 262.

D. Ethernet Network Cabling: TIA-568-C.2 Category 6 cable with RJ-45 connectors.

1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
2. Conductors: 100-ohm, 23 AWG solid copper.
3. Shielding: Unshielded twisted pairs (UTP) or Shielded twisted pairs (FTP).
4. Cable Rating: By application.
5. Jacket: White, Gray, Blue, or Yellow thermoplastic.

E. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.14 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect factory-assembled equipment.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.

D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.

E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.

1. 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.

    a. Flame Travel Distance: 60 inches (1520 mm) or less.
    b. Peak Optical Smoke Density: 0.5 or less.
    c. Average Optical Smoke Density: 0.15 or less.

2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
3. 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.

B. Low-Voltage Control Cabling:

1. Paired Cable: NFPA 70, Type CMG.

    a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
    b. PVC insulation.
    c. Braided or foil shielded.
    d. PVC jacket.
    e. Flame Resistance: Comply with UL 1685.
2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

    a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
    b. PVC insulation.
    c. Braided or foil shielded.
    d. PVC jacket.
    e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
    f. Flame Resistance: Comply with NFPA 262.

C. TIA-485A Network Cabling:

1. Standard Cable: NFPA 70, Type CMG.

    a. Paired, one pair twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
    b. PVC insulation.
    c. Unshielded.
    d. PVC jacket.
    e. Flame Resistance: Comply with UL 1685.
2. Plenum-Rated Cable: NFPA 70, Type CMP.

    a. Paired, one pair No. 22 AWG, stranded (7x30) tinned-copper conductors.
    b. Fluorinated ethylene propylene insulation.

2.9 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 refrigerant classification.
3. R-410a

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.10 SYSTEM CONDENSATE DRAIN PIPING

A. Comply with requirements in Section 23 21 13 "Hydronic Piping" for system piping requirements.

2.11 SYSTEM REFRIGERANT PIPING

A. Comply with requirements in Section 23 23 00 "Refrigerant Piping" for system piping requirements.

B. 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.

C. Refrigerant Isolation Ball Valves:

1. 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.
2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
3. Valve Connections: Flare or sweat depending on size.

2.12 PIPING AND TUBING INSULATION

A. Comply with requirements in Section 23 07 19 "HVAC Piping Insulation" for system piping insulation requirements.

2.13 SYSTEM CONTROL CABLE

A. Cable Rating: Listed and labeled for application according to NFPA 70.

D. Wireless Controllers for Indoor Units (if required):

1. Wireless Communication:

a. Third-Party controller communicates to remote-mounted receiver that is wired to indoor unit(s).

1) Include receivers with wireless controllers as required to complete installation.
2) Low-voltage power required for receivers shall be powered through non-polar connections to indoor unit.

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

2. Controller Battery Life: Three years.
3. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
4. Language: English
5. Temperature Units: Fahrenheit.
6. On/Off: Turns indoor unit on or off.
7. Hold: Hold operation settings until hold is released.
8. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
9. Temperature Display: 1-degree increments.
10. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments
11. Relative Humidity Display: 1 percent increments.
12. Relative Humidity Set-Point: Adjustable in 1 percent increments
13. Fan Speed Setting: Select between available options furnished with the unit.
14. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
15. Seven-day programmable operating schedule with up to eight events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
16. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
17. Occupancy detection.
18. Service Notification Display: "Filter"
19. Service Run Tests: Limit use by service personnel to troubleshoot operation.
20. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
21. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
22. Setting stored in non-volatile memory to ensure that settings are not lost if power is lost. Battery for date and time only.

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

4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
11. Operator interface through a backlit, high-resolution color display touch panel.

C. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English
4. Temperature Units: Fahrenheit
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between
10. Fan Speed Setting: Select between available options furnished with the unit.
11. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
12. Seven-day programmable operating schedule with up to eight events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
13. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
14. Occupancy detection.
15. Service Notification Display: "Filter"
16. Service Run Tests: Limit use by service personnel to troubleshoot operation.
17. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
18. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
19. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
20. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

2.8 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units, HRCUs, and outdoor units shall include integral controls and connect through a manufacturer-selected control network.
2. Network Communication Protocol: Manufacturer-proprietary control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:

    a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
    b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
    c. Integration shall include control, monitoring, and scheduling.

4. Operator Interface:

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

        1) Operator interfaces integral to controllers.
        2) Owner-furnished PC connected to central controller(s).
        3) Web interface through web browser software.
        4) Integration with Building Automation System.

    b. 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:

        1) On/off control.
        2) Temperature set-point adjustment.

B. Central Controllers:

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

    a. Include multiple interconnected controllers as required.

2. 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.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

    a. Sets schedule for daily, weekly, and annual events.

3. Spares: Each heat recovery control unit shall include at least one branch circuit port(s) for future use.
4. 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.
5. 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.

    a. 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.

E. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:
4. Features and Functions:
    a. Self-diagnostics,
    b. fuse protection,
5. Communication: Network communication with indoor units and outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

F. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

G. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

3. Disconnecting Means: Field-installed circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. 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 hours according ASTM B 117.

J. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.7 HEAT RECOVERY CONTROL UNITS (HRCUs or BSBs)

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

1. Specially designed for use in systems with simultaneous heating and cooling.
2. 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.

B. Cabinet:

1. Galvanized-steel construction.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

D. Refrigeration Assemblies and Specialties:

1. Specially designed by manufacturer for type of VRF HVAC system being installed, either two or three pipe.
2. Each refrigerant branch circuit shall have refrigerant control valve(s) to control refrigerant flow.

2. 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.
3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
6. Vibration Control: Integral isolation to dampen vibration transmission.

F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection. Provide a dedicated hot gas refrigerant circuit at bottom of condenser coil used to cool inverter so that no auxiliary drain pan heater is required. If there is no a dedicated inverter cooling circuit, condensing unit will require aux drain pan heater.

G. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Refrigerant suction temperature.
    b. Refrigerant discharge temperature.
    c. Outdoor air temperature.
    d. Refrigerant high pressure.
    e. Refrigerant low pressure.
    f. Oil level.

4. Features and Functions:
    a. Self-diagnostics,
    b. time delay,
    c. auto-restart,
    d. fuse protection,
    e. auto operation mode,
    f. manual operation mode,
    g. night setback control,
    h. run test switch
    i. equalize run time between multiple same components
5. Communication: Network communication with indoor units and other outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive, vapor injection and turndown to 15 percent of rated capacity.
2. Protection: Integral protection against the following:

    a. High refrigerant pressure.
    b. Low oil level.
    c. High oil temperature.
    d. Thermal and overload.
    e. Voltage fluctuations.
    f. Phase failure and phase reversal.
    g. Short cycling.

3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:

    a. Casing: Aluminum, galvanized, or stainless steel.
    b. Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
    c. Tubes: Copper, of diameter and thickness required by performance.

    d. Hydrophylic coating with documented salt spray test performance of 1000 hours according to ASTM B 117 surface scratch test (SST) procedure.

2. Corrosion Protection: Coating with documented salt spray test performance of 1000 hours according ASTM B 117 surface scratch test (SST) procedure.
3. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.

    a. Direct-drive arrangement.
    b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
    c. Statically and dynamically balanced.

j. Run test switch.

6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

K. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Field-installed circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

2.6 OUTDOOR, AIR-SOURCE CONDENSING UNITS – 3 PHASE POWER (HEAT PUMP AND/OR HEAT RECOVERY)

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

1. Provide heat pump units as designated on Drawings.

2. Heat Pump Units are 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.

3. Heat Recovery Units are specially designed for use in systems with simultaneous heating and cooling.
4. 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.
5. All units installed shall be from the same product development generation.

B. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.

a. Coating with documented salt spray test performance of 1000 hours according to ASTM B 117 surface scratch test (SST) procedure.

2. Mounting: Manufacturer-designed provisions for field installation.
3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

G. Discharge-Air Grille Assembly: Manufacturer's standard discharge grille with field-adjustable air pattern mounted in unit cabinet.

1. For Ceiling-Mounted Units:
   a. Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.
   b. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
   c. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.
   d. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
   e. Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.

H. Return-Air Grille Assembly for Ceiling-Mounted Units: Manufacturer's standard grille mounted in bottom of unit cabinet.

I. Unit Accessories:

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

J. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:
   a. Unit inlet air temperature.
   b. Coil entering refrigerant temperature.
   c. Coil leaving refrigerant temperature.
4. Field-Customizable I/O Capability:
   a. Digital Inputs: One.
5. Features and Functions:
   a. Self-diagnostics.
   b. Time delay.
   c. Auto-restart.
   d. External static pressure control.
   e. Auto operation mode.
   f. Manual operation mode.
   g. Filter service notification
   h. Power consumption display.
   i. Drain assembly high water level safety shutdown and notification.

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

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal:
   a. Unit-mounted pump or other integral lifting mechanism for ceiling units, capable of lifting drain water to an elevation above top of cabinet.
   b. Condensate Overflow Protection: Provide high-level condensate safety shutoff and alarm.

3. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):

   a. Direct-drive arrangement.
   b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
   c. Materials: Non-ferrous components or ferrous components with corrosion-resistant finish.
   d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. 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.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access:
   a. Bottom for ceiling-mounted units.
   b. Provide access to accommodate filter replacement without the need for tools.
2. Media:
   a. Washable for ceiling-suspended units. Manufacturer's standard filter with antimicrobial treatment.

   b. Replaceable for ceiling-mounted units.
      1) Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
      2) Minimum Efficiency: ASHRAE 52.2, MERV 14, unless otherwise noted on drawings.
      3) Provide accessory filter kit and/or filter box if necessary, to provide the required MERV 14 rating.

h. Power consumption display.
i. Drain assembly high water level safety shutdown and notification.
j. Run test switch.

6. Communication: Network communication with other indoor and outdoor units.
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Field-installed circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

2.5 INDOOR UNITS – DUCTLESS (WALL-MOUNTED, CEILING-MOUNTED CASSETTE)

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

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.

d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. 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.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
2. Minimum Efficiency (Ceiling-Mounted Units): ASHRAE 52.2, MERV 14, unless otherwise noted on drawings.
3. Provide accessory filter kit and/or filter box if necessary, to provide the required MERV 14 rating.
4. Media:

a. Replaceable (Ceiling-Mounted Units): Extended surface, panel, or cartridge with antimicrobial treatment fiber media.

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

H. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

a. Unit inlet air temperature.
b. Coil entering refrigerant temperature.
c. Coil leaving refrigerant temperature.

4. Field-Customizable I/O Capability:
a. Digital Inputs: One.

5. Features and Functions:

a. Self-diagnostics.
b. Time delay.
c. Auto-restart.
d. External static pressure control.
e. Auto operation mode.
f. Manual operation mode.
g. Filter service notification.

2.4 INDOOR UNITS – DUCTED (CEILING-MOUNTED)

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

B. Cabinet:

1. Material: Galvanized steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Galvanized steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Condensate Overflow Protection: Provide high-level condensate safety shutoff and alarm.
4. Field Piping Connection: Non-ferrous material.

E. Fan and Motor Assembly:

1. Fan(s):

a. Direct-drive arrangement.
b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.