

SECTION 230130- HVAC DUCT SYSTEM CLEANING

1. GENERAL

A. SCOPE OF WORK

- (1) This Section includes the requirement for cleaning of the existing supply air conveyance systems as noted on the Drawings and described below.

B. RELATED WORK SPECIFIED ELSEWHERE

- (1) Drawings and general provisions of the Contract, including General and Supplementary Conditions and Divisions 00 and 01 Specification Sections, apply to this Section. The Contractor shall be responsible for the removal of visible surface contaminants and deposits from within the existing HVAC system supply air ductwork in accordance with these specifications.

C. SUBMITTALS

- (1) After carefully reviewing the site and requirements, submit a complete work action outline similar to item A. Scope of Work above for review by the Engineer.

D. QUALITY ASSURANCE

- (1) Contractor Qualifications: Contractor must be a certified member of the National Air Duct Cleaners Association (NADCA), and the Indoor Air Quality Association (IAQA).

E. COORDINATION

- (1) Perform cleaning at appropriate time in project as to not interfere with other trades or the progress of the work, or existing occupants working in the building.

F. APPLICABLE STANDARDS

- (1) National Air Duct Cleaners Association (NADCA) "ACR-2006, Assessment, Cleaning and Restoration of HVAC Systems, ", 2001.
- (2) National Air Duct Cleaners Association (NADCA), "Understanding Microbial, Contamination in HVAC Systems," 1996.
- (3) National Air Duct Cleaners Association (NADCA), "Introduction to HVAC System Cleaning services," 2002.
- (4) National Air Duct Cleaners Association (NADCA) Standard 05 "Requirements for the Installation of Service Openings in HVAC Systems, "1997.

- (5) Underwriters Laboratories (UL), UL Standard 181.
- (6) American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 62, Ventilation for Acceptable Indoor Air Quality.
- (7) Environmental Protection Agency (EPA), "Building Air Quality," December 1991.
- (8) Sheet Metal and Air Conditioning Contractor's National Association (SMANCA):' HVAC Duct Construction Standards — Metal and Flexible," 1985.

2. EXECUTION

A. EXAMINATION

- (1) Prior to the commencement of any cleaning work, the cleaning Contractor shall perform a visual inspection of the system to be cleaned to determine appropriate methods, tools, and equipment required to satisfactorily complete this project. Provide video and/or photo report of before and after conditions at multiple areas.
- (2) Contractor shall conduct a site evaluation, and establish a specific, coordinated plan which details how each area of the building will be protected during the various phases of the project.

B. GENERAL CLEANING REQUIREMENTS

- (1) Containment: Debris removed during cleaning shall be collected and precautions must be taken to ensure that Debris is not otherwise dispersed outside the HVAC system during the cleaning process.
- (2) Particulate Collection: where the particulate collection equipment is exhausting inside the building, HEPA filtration with 99.97% collection efficiency for 0.3-micron size (or greater) particles shall be used. When the particulate collection equipment is exhausting outside the building, Mechanical Cleaning operations shall be undertaken only with particulate collection equipment in place, including adequate filtration to contain debris removed from the HVAC system. When the particulate collection equipment is exhausting outside the building, precautions shall be taken to locate the equipment down wind and away from all air intakes and other points of entry into any building.
- (3) Controlling Odors: Measures shall be employed to control odors and/or mists vapors during the cleaning process.
- (4) Component Cleaning: Cleaning methods shall be employed such that all components must be visibly clean as defined per NADCA applicable standards. Upon completion, all components shall be returned to those settings recorded just prior to cleaning operations.
- (5) Air-Volume Control devices: Dampers and any air-directional mechanical devices inside

the HVAC system must have their position marked beforehand so that they can be returned to their pre-cleaning position.

- (6) Service Openings: The Contractor shall utilize service openings, as required for proper cleaning, at various points of the HVAC system for physical mechanical entry, and inspection.
 - a. Contractor shall utilize the existing service openings already installed in the HVAC system where possible.
 - b. Additional openings shall be created by the Contractor as outlined on the Drawings to assist in plenum cleaning.
 - c. The Contractor shall remove and reinstall ceiling sections to gain access to HVAC systems during the cleaning process.

C. SANITIZING AND CLEANING

- (1) Antimicrobial Agents and Coatings:
 - a. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.
 - b. Antimicrobial treatments and coatings shall be applied after the system is rendered clean.
 - c. Apply antimicrobial agents and coatings directly onto surfaces of interior ductwork.
 - d. Sanitizing agent products shall be registered by the EPA as specifically intended for use in HVAC systems and ductwork.

D. HEALTH AND SAFETY

- (1) Safety Standards: Cleaning Contractor shall comply with applicable federal, state, and local requirements for protecting the safety of the Contractor's employees, building occupants, and the environment. In particular, all applicable standards of the Occupational Safety and Health Administrations (OSHA) shall be followed when working in accordance with this specification.
- (2) Occupant Safety: No processes of materials shall be employed in such a manner that they will introduce additional hazards into occupied spaces.

END OF SECTION 230130

SECTION 230200 - HVAC EQUIPMENT AND HYDRONIC SPECIALTIES

1. GENERAL

- A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.
- B. The Contractor shall provide in complete working order the following heating, ventilation and air conditioning equipment located as indicated and installed, connected and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.
- C. Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklist.
- D. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include air handling units, boilers, chillers, cooling towers, VFDs, etc.
- E. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90 and/or International Energy Conservation Code 2012, whichever is more stringent.
- F. Installation of all heating, ventilating and air conditioning systems shall be performed by a master HVAC contractor licensed in the state the work will be performed.
- G. Note to Suppliers and Manufacturers Representative furnishing proposals for equipment for the project:
 - (1) Review the Controls Section of these Specifications (if applicable) to determine controls to be furnished by the equipment manufacturer, if any. The Contractor shall provide all controls with equipment unless specifically listed otherwise.
 - (2) Review the section of these specifications entitle: SHOP DRAWINGS, DESCRIPTIVE LITERATURE, MAINTENANCE MANUALS, PARTS LISTS, SPECIAL KEYS, TOOLS, ETC., and provide all documents called for therein.
 - (3) Ensure that the equipment which you propose to furnish may be installed, connected, placed in operation and easily maintained at the location and in the space allocated for it.
 - (4) Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

- (5) Where manufacturers' temperature controls are specified, they shall be in full compliance with International Mechanical Code Section 606 including automatic smoke shut down provisions.
- (6) Provide factory start-up on site by a factory representative (not a third-party contractor) for all HVAC equipment, including pumps, VFDS, boilers, chillers, cooling towers, heat pumps, rooftop units, etc. Submit factory start-up reports to the Engineer.
- (7) Provide training to the Owner by a factory representative for each type of equipment. Training shall be a minimum of eight (8) hours on site and the Engineer shall be notified one (1) week in advance of the training. Training shall only occur when the systems are complete and 100% functional. All training shall be videotaped.
- (8) Review the Section on Motor Starters and Electrical Requirements for Mechanical Equipment.
- (9) Requirements for motors controlled by variable frequency drives:
 - a. All motors shall be inverter duty rated.
 - b. Motors less than 100 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. One shaft grounding ring and related hardware shall be provided on drive end or non-drive end of motor per manufacturer's instructions. These shall be factory mounted and installed on the exterior of the motor to allow for visual inspection. Ground motor frame per manufacturer's instructions. Install kit in strict accordance with manufacturer's instructions.
 - c. Motors greater than 100 HP to 1000 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. Provide shaft grounding ring on drive end and non-drive end of motor per manufacturer's instructions. Additionally, provide insulated bearing journals to further reduce risk of current dissipation through bearings. Ground motor frame per manufacturer's instructions. Install kit in strict accordance with manufacturer's instructions.
- (10) All condensate producing equipment shall be provided with a condensate trap as recommended by the equipment manufacturer and a condensate overflow switch.
- (11) Provide low ambient and all required controls and accessories on all HVAC equipment to ensure they can provide cooling during the winter season.
- (12) All outdoor HVAC equipment shall be provided with hail guards.
- (13) Provide a complete air tight enclosure with opening door that seals air tight for all filters on air moving equipment.

- (14) All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.

2. EQUIPMENT

A. VENTILATING FANS

- (1) Ventilating fans shall be of the type, capacity, size, etc. here-in-after scheduled. Catalog numbers are listed as design criteria only. Alternate selections will be accepted provided quality, function, etc. are equivalent. All fans shall be UL listed, complete with all required disconnects and starters and shall be AMCA rated and certified. Model numbers listed are Greenheck, acceptable alternates are Captive Air, Loren-Cook, or approved alternate. The Architect shall select the color for all exposed fans.

(2) Selection

Refer to the schedule on the plans.

B. COMBINATION VARIABLE FREQUENCY DRIVE / DISCONNECT (VFD) FOR MOTORS 50 HP AND LESS

(1) Manufacturers

- a. Danfoss Graham VLT 6000 Series, Reliance, Yaskawa, Emerson, ABB, or approved equal.

(2) General

- a. Furnish complete variable frequency VFDs as specified herein for the fans and pumps designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. VFD shall be housed in a metal NEMA enclosure of type according to the installation and operating conditions at the job site. The VFD's UL listing shall allow mounting in plenum or other air handling compartments. If a NEMA 12 enclosure is required for the plenum rating, the manufacturer must supply a NEMA 12 rated VFD.
- b. The VFD shall have integral disconnecting means to disconnect power to device in accordance with NEC.
- c. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor derating.
- d. With the motor's rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or

without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

- e. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.
- f. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be assembled by the manufacturer, which shall be UL-508 certified for the building and assembly of option panels. Assembly of the option panels by a third-party panel shop is not acceptable. The appropriate UL stickers shall be applied to both the VFD and option panel, in the case where these are not contained in one panel. When these VFDs are to be located in Canada, CSA or C-UL certifications shall apply. Both VFD and option panel shall be manufactured in ISO 9001 certified facilities.
- g. The VFD shall have a dual 5% DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics and protect the drive from power line transients. The reactor shall be non-saturating (linear) to provide full harmonic filtering throughout the entire load range. VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load, where harmonic performance is most critical.
- h. The VFD's full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.
- i. The VFD shall be able to provide full torque at any selected frequency from 29 Hz to base speed to allow driving direct drive fans without derating.
- j. An automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continually monitor the motor's speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.
- k. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.
- l. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.
- m. Galvanic and/or optical isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.

- n. VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.
- o. VFD supplier shall coordinate with motor supplier to ensure that all motors 20 horsepower and greater are provided with grounding bushings.

(3) Protective Features

- a. A minimum of Class 20 ² I t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.
- b. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, overvoltage, undervoltage, VFD overtemperature and motor overtemperature. The VFD shall display all faults in plain English. Codes are not acceptable.
- c. Protect VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output with an input voltage as low as 164 V AC for 208/230-volt units, 313 V AC for 460-volt units, and 394 volts for 600 volts units.
- d. The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.
- e. VFD package shall include semi-conductor rated input fuses to protect power components.
- f. To prevent breakdown of the motor winding insulation, the VFD shall be designed to comply with IEC Part 34-17. Otherwise the VFD manufacturer must ensure that inverter rated motors are supplied.
- g. VFD shall include a “signal loss detection” circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC, and shall be programmable to react as desired in such an instance.
- h. VFD shall function normally when the keypad is removed while the VFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.
- i. VFD shall catch a rotating motor operating forward or reverse up to full speed.
- j. VFD shall be rated for 100,000 amp interrupting capacity (AIC).

- k. VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.
- l. VFD shall continue to operate without faulting until input voltage reaches 300 V AC on 208/230-volt units, 539 V AC on 460-volt units, and 690 volts on 600-volt units.

(4) Interface Features

- a. Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VFD and determine the speed reference.
- b. The VFD shall be able to be programmed to provide a 24 V DC output signal to indicate that the VFD is in Auto/Remote mode.
- c. The VFD shall provide digital manual speed control. Potentiometers are not acceptable.
- d. Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet away using standard 9-pin cable.
- e. The keypads for all sizes of VFDs shall be identical and interchangeable.
- f. To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters.
- g. Display shall be programmable to display in 9 languages including English, Spanish and French.
- h. The display shall have four lines, with a minimum of 20 characters on three lines and a minimum of eight large characters on one line.
- i. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
- j. A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD eliminating the need for macros.
- k. As a minimum, the following points shall be controlled and/or accessible:
 - 1) VFD Start/Stop
 - 2) Speed reference
 - 3) Fault diagnostics
 - 4) Meter points
 - (a) Motor power in HP
 - (b) Motor power in kW
 - (c) Motor kW-hr

- (d) Motor current
 - (e) Motor voltage
 - (f) Hours run
 - (g) Feedback signal #1
 - (h) Feedback signal #2
 - (i) DC link voltage
 - (j) Thermal load on motor
 - (k) Thermal load on VFD
 - (l) Heatsink temperature
- l. Four additional Form C 230-volt programmable relays shall be available for factory or field installation within the VFD.
 - m. Two set-point control interface (PID control) shall be standard in the unit. VFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.
 - n. Floating point control interface shall be provided to increase/decrease speed in response to contact closures.
 - o. Four simultaneous displays shall be available. They shall include frequency or speed, run time, output amps and output power. VFDs unable to show these four displays simultaneously shall provide panel meters.
 - p. Sleep mode shall be provided to automatically stop the VFD when its speed drops below set "sleep" level for a specified time. The VFD shall automatically restart when the speed command exceeds the set "wake" level.
 - q. The sleep mode shall be functional in both follower mode and PID mode.
 - r. Run permissive circuit shall be provided to accept a "system ready" signal to ensure that the VFD does not start until dampers or other auxiliary equipment are in the proper state for VFD operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the VFD to start.
 - s. The following displays shall be accessible from the control panel in actual units: Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kW-hr, Output Voltage, DC Bus Voltage, VFD Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.). VFD will read out the selected engineering unit either in a linear, square or cubed relationship to output frequency as appropriate to the unit chosen.
 - t. The display shall be programmed to read in inches of water column (in-wg) for an air handler application, pressure per square inch (psi) for a pump application, and temperature (°F) for a cooling tower application.
 - u. VFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.

- v. If the temperature of the VFD's heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD's heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.
- w. The VFD shall have temperature controlled cooling fans for quiet operation and minimized losses.
- x. The VFD shall store in memory the last 10 faults and related operational data.
- y. Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- z. Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of VFD status.
 - aa. Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltages (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.
 - bb. Two programmable 0 to 20 mA analog outputs shall be provided for indication of VFD status. These outputs shall be programmable for output speed, frequency, current and power. They shall also be programmable to provide a selected 24 V DC status indication.
 - cc. Under fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed.
 - dd. On motors connected to variable frequency drives, 20hp or greater in size. Provide grounding bushings to prevent arcing.

(5) Interface with Building Automation System/Direct Digital Control System

- a. VFD manufacturer shall provide an interface to the BAS/DDC system. Manufacturer shall coordinate as required with the Controls Contractor. Provide Bacnet, Lonworks, FLN, Modbus, or any other interface required for a complete and operational system.
- b. Provide mode of operation to BAS/DDC system (hand, off, auto, etc.). BAS/DDC graphic shall highlight or produce pop-up graphic when VFD is in hand or off. Also, provide all points to BAS/DDC identified in section (4).K of this Specification.

(6) Adjustments

- a. VFD shall have an adjustable carrier frequency in steps of not less than 0.1 kHz to allow tuning the VFD to the motor.

- b. Sixteen preset speeds shall be provided.
- c. Four acceleration and four deceleration ramps shall be provided. Accel and decel time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.
- d. Four current limit settings shall be provided.
- e. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: under voltage, overvoltage, current limit and inverter overload.
- f. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.
- g. An automatic "on delay" may be selected from 0 to 120 seconds.

(7) Service Conditions

- a. Ambient temperature, -10 to 40°C (14 to 104°F), without derating.
- b. 0 to 95% relative humidity, non-condensing.
- c. Elevation to 3,300 feet without derating.
- d. AC line voltage variation, -10 to +10% of nominal with full output.
- e. No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

(8) Quality Assurance

- a. To ensure quality and minimize infantile failures at the jobsite, the complete VFD shall be tested by the manufacturer. The VFD shall operate a dynamometer at full load and speed and shall be cycled during the test.
- b. All optional features shall be functionally tested at the factory for proper operation.

(9) Submittals

- a. Submit manufacturer's performance data including dimensional drawings, power circuit diagrams, installation and maintenance manuals, warranty description, VFD's FLA rating, certification agency file numbers and catalog information.

The specification lists the minimum VFD performance requirements for this project. Each supplier shall list any exceptions to the specification. If no departures from the specification are identified, the supplier shall be bound by the specification.

- a. Harmonic filtering. The seller shall, with the aid of the buyer's electrical power single line diagram, providing the data required by IEEE-519, perform an analysis to initially demonstrate the supplied equipment will meet the IEEE standards after installation. If, as a result of the analysis, it is determined that additional filter equipment is required to meet the IEEE recommendations, then the cost of such equipment shall be included in the bid. A harmonic analysis shall be submitted with the approval drawings to verify compliance with the latest version of IEEE-519 voltage and current distortion limits as shown in table 10.2 and 10.3 at the point of common coupling (PCC). The PCC shall be defined as the consumer-utility interface or primary side of the main distribution transformer.

(10)Start-Up Service

- a. The manufacturer shall provide on-site start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system. Provide start-up report to Engineer.

(11)Warranty

- a. The VFD shall be warranted by the manufacturer for a period of 36 months from date of shipment. The warranty shall include parts, labor, travel costs and living expenses incurred by the manufacturer to provide factory authorized on-site service. The warranty shall be provided by the VFD manufacturer.

(12)Examination

- a. Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for VFD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer's recommendations shall be verified.
- b. The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

3. FACTORY START-UP REPORTS

- A. Provide factory start-up on site by a factory representative (not a third-party contractor) for all HVAC equipment, including pumps, VFD's, boilers, chillers, cooling towers, heat pumps, rooftop units, etc. Submit factory start-up reports to the Engineer. The Mechanical Contractor and the Controls Contractor shall have a representative on site to correct all deficiencies noted by the

factory representative. For each deficiency noted, documentation of corrective action taken shall be submitted to Engineer.

4. HVAC SYSTEM START-UP PROCEDURE

A. GENERAL

- (1) The goal of this procedure is for a few units to run as much as possible with the coils as cold as possible to "wring out" the water and allow it to drain away in the condensate drain pans. Allowing all units to cycle on and off, running for short periods of time, does not dehumidify the air in the building. Starting the system without following the steps outlined will raise the relative humidity in the building and most likely cause condensation on some of the building surfaces and HVAC system that the Contractor will be responsible to correct.
- (2) The high humidity and condensation occurs in buildings at start up primarily because the building is only partly occupied (or not occupied) when the HVAC system is started. Most people believe that the answer to this problem is to turn the thermostats down very low. The assumption is that cold air will not hold moisture. That is not true. What happens is that the thermostats are quickly satisfied thermally because there is very little cooling load on the building and the cooling equipment. The terminal units then only have to run for a very short period of time to keep the thermostats satisfied and the relative humidity of the air is in fact raising. The goal is to cause the moist air to pass over coils which are cooling it and drying it without allowing more moist air to be introduced into the building.
- (3) To reduce the always present high humidity start-up problem, we have devised this start-up procedure that will minimize the adverse effects of the start-up. As the building sits at start-up, all of the walls, floor, and ceilings are saturated with moisture from the air and also moisture is being released from the drying paint and curing concrete and mortar.
- (4) The following procedure will slowly bring down the temperature and humidity in the lightly loaded building. It will also allow the HVAC equipment to more closely match the actual building load without students and equipment in use.

To reach these goals we require the following:

- (1) Set 1/3 of the units (approximately every third unit) on 74°F (no lower). Set the other thermostats for a cooling setpoint of 90°F so the units will not cool. Override the controls so that the fans in all units will circulate air.
- (2) Leave all of the interior doors open to allow the air to mix throughout the building.
- (3) Close all exterior windows and doors.
- (4) Turn off all exhaust fans and outside air units. Outside air unit exhaust and outside air dampers shall be closed.

(5) Leave all of the lights on in the building to provide a cooling load.

(6) Provide portable electric heaters or dehumidifiers in any room that shows signs of condensation.

END OF SECTION 230200

SECTION 230300 - CONDENSATE DRAINAGE SYSTEM (FOR COOLING EQUIPMENT)

1. GENERAL

- A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this section of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- B. The Contractor shall provide a complete condensate drainage system to carry all condensate discharge from all cooling equipment from the building. Condensate system shall be installed in accordance with IMC. Provide condensate overflow switch for all condensate producing equipment.
- C. Pipe installation and fabrication shall be in accordance with the section of these specifications entitled PIPE, PIPE FITTINGS AND PIPE SUPPORT and as hereinafter specified.
- D. All piping shall be installed concealed, unless specifically noted otherwise and shall be installed under slabs or underground only when specifically indicated.
- E. Lines installed in ceiling spaces shall be held at the maximum possible elevation and shall be coordinated with all other trades to avoid conflicts.
- F. Condensate drain lines shall be pitched 1/4 inch per foot and installed with cleanout plugs at each change in direction and/or at thirty (30) foot intervals. Where this minimum pitch cannot be attained, contact Engineers.
- G. Horizontal runs of condensate drain lines shall be supported at six (6) foot intervals maximum, or more frequently where required to prevent sags and low spots.
- H. Lengths of horizontal lines shall be held at a minimum due to potential lint collection.
- I. Provide condensate traps in accordance with the manufacturer's recommendations.

2. MATERIAL

- A. Refer to Section of these Specifications entitled: PIPE, PIPE FITTINGS AND SUPPORT.

3. INSULATION

- A. Refer to Section of these Specifications entitled: INSULATION - MECHANICAL.

END OF SECTION 230300

SECTION 231100 - REGISTERS, GRILLES, DIFFUSERS & LOUVERS

1. REGISTERS, GRILLES AND DIFFUSERS

A. GENERAL

Alternate register, grille, & diffuser selections, other than manufacturers and models listed below, will be accepted, provided quality, function and characteristics are equivalent. Acceptable alternates are Price, Titus, Metalaire, Nailor, Carnes, Anemostat, Kruegar, and Tuttle & Bailey. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes shall be selected by the Architect. If Architect elects not to select color, all colors shall be off-white. Factory color samples shall be submitted with shop drawings.

B. SELECTION

Refer to the Selections Scheduled on the Drawings.

END OF SECTION 231100

SECTION 231200 - SHEET METAL AND FLEXIBLE DUCT

1. GENERAL

- A. The Contractor's attention is directed to the General and Special Conditions, General Requirements-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.
- B. This branch of the work includes all materials, labor and accessories for the fabrication and installation of all sheet metal work as shown on the drawings and/or as specified herein. Where construction methods for various items are not indicated on the drawings or specified herein, all such work shall be fabricated and installed in accordance with the recommended methods outlined in the latest edition of SMACNA's HVAC Duct Construction Standards, Metal and Flexible, and its subsequent addenda. HVAC duct systems shall be fabricated and installed in accordance with the SMACNA duct construction standards (SMACNA-HVAC and SMACNA-Seismic) including Appendix B of the Seismic Restraint Manual Guidelines for Mechanical Systems. These references and plate numbers shall be used by the Engineer for required sheet metal thicknesses and final acceptance of methods of fabrication, hanging, accessories, etc. All equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.
- C. Ductwork shall be constructed and installed per the latest edition of the International Mechanical Code.
- D. Ductwork shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic to prohibit dust and dirt from entering the installed ductwork, air handling unit, terminal devices, etc. Provide temporary filters on all return grilles and duct openings if the units are running prior to the building being satisfactorily cleaned. Do not install the ductwork if the building is not "dried-in". If this is required, the open ends of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.

Prior to purchase and fabrication of ductwork (shop fabricated or manufactured), the Contractor shall coordinate installations with new and existing conditions. Notify the Engineer if there are any discrepancies for resolution.

- E. Provide a SMACNA duct cleanliness level "C" per the latest SMACNA standards. [Refer to LEED / Healthcare Requirements]
- F. If separate filter grilles are specified for an HVAC unit the Contractors shall remove any unit mounted filters and blank off the unused filter access opening with sheet metal and seal air tight.

- G. Wall Penetrations: Where ducts penetrate interior or exterior walls, the walls shall be sealed air tight. Refer to the sleeving, cutting, patching, and repairing section of the specifications for additional requirements.
- H. Duct dimensions indicated are required inside clear dimensions. Plan duct layouts for adequate insulation and fitting clearance.
- I. Prior to purchase/shipment of the ductwork, manufacturer shall provide as part of the submittal process scaled, field coordinated AutoCAD drawings of the complete system to be furnished. Drawings will indicate all system components including fittings, ductwork and manifolds. Drawings shall be available in an electronic format.

2. LOW PRESSURE DUCTWORK

A. General (Low Pressure)

- (1) Double turning vanes shall be installed in all square turns and in any other locations indicated.
- (2) Provide a “high efficiency” type take-off with round damper (Flexmaster STOD-B03 or approved equal) for all round duct branches from a rectangular main to a GRD. Refer to the detail on the drawings for all installation requirements.
- (3) Cross-break all ducts where any duct section dimension or length is 18" or larger.
- (4) Air volume dampers shall be installed in each duct branch takeoffs and/or where indicated, whichever is more stringent. All such dampers shall be accessible without damage to finishes or insulation and shall be provided where required for proper system balance.
- (5) Splitter dampers shall be provided in all rectangular supply air duct tees. Damper blade operator shall extend a minimum two inches thru the insulation.
- (6) Unless otherwise dimensioned on the drawings, all diffusers, registers and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc. Locate all supply, return and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.
- (7) Ducts shall be hung by angles, rods, 18 ga. minimum straps, trapezes, etc., in accordance with SMACNA's recommended practices. Duct supports shall not exceed 12 ft intervals. There shall be no less than one set of hangers for each section of ductwork. Where ductwork contains filter sections, coils, fans or other equipment or items, such equipment or items shall be hung independently of ductwork with rods or angles. Do not suspend ducts from purlins or other weak structural members where no additional weight may be applied. If in doubt, consult the structural engineer.

- (8) Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.
- (9) All ductwork connections, fittings, joints, etc., including longitudinal and transverse joints, seams and connections shall be sealed. Seal with medium pressure, smooth-textured, water based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, nonflammable, and rated to 15" wg. Apply per manufacturer's recommendations. Contractors shall ensure no exposed sharp edges or burrs on ductwork.
- (10) All angular turns shall be made with the radius of the center line of the duct equivalent to 1.5 times the width of the duct.
- (11) Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans, coils, VAV boxes, fan sections of air handling units, at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.
- (12) Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.
- (13) The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.
- (14) All fans and other vibrating equipment shall be suspended by independent vibration isolators.
- (15) The interior surface of the ductwork connecting to return/exhaust air grilles shall be painted flat black. The ductwork shall be painted a minimum of 24" starting from the grille.

B. Materials (Low Pressure Single Wall)

- (1) Ductwork, plenums and other appurtenances shall be constructed of the following:
 - a. Steel sheets, zinc coated, Federal Specification 00-S-775, Type I, Class E & ASTM A93-59T with G-90 zinc coating or aluminum alloy sheets 3003, Federal Specification AA-A-359, Temper H-14. Utilize Aluminum in MRI Scan Rooms or NMR Room applications.
 - b. Exposed ductwork in finished spaces requiring insulation such as gymnasiums, etc., shall be dual wall ductwork.

- (2) Ductwork, plenums and other appurtenances shall be constructed of the materials of the minimum weights or gauges as required by the latest SMACNA 2" W.G. Standard or the below table, whichever is more stringent. When gauge thickness differs, the heavier gauge shall be selected. The below table shall serve as a minimum:

ROUND DUCT		RECTANGULAR DUCT	
DIA., INCHES	GAUGE	WIDTH, INCHES	GAUGE
3 TO 12	26	UP TO 12	26
12 TO 18	24	13 TO 30	24
19 TO 28	22	31 TO 54	22
29 TO 36	20	55 TO 84	20
37 TO 52	18	85 AND ABOVE	18

C. Materials (Low Pressure Double Wall Ductwork)

- (1) Install Double Wall Ductwork in the following areas:
 - a. At all locations indicated on drawings.
- (2) Furnish and install where indicated double wall duct. The double wall duct shall be Eastern Sheet Metal, United McGill, Semco or approved equivalent. The duct shall have an inner shell, a 1-inch layer of fiberglass insulation and an outer pressure shell.
- (3) Ductwork outer shell shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Any ductwork exposed to view shall be constructed of G90 galvanized steel, 20 gauge, and shall be supported as required with aircraft cables and self-tightening locks. Ductwork shall be constructed as specified in LOW PRESSURE DUCTWORK.
- (4) Inner shell for spiral pipe shall be a perforated inner liner. The inner liner shall have 3/32" perforation with an overall open area of 23%.
- (5) Inner shell for fittings shall be galvanized steel. All fittings shall be manufactured by the same manufacturer as the spiral pipe. Fittings shall be constructed a minimum of 22 Ga.
- (6) The fiberglass liner shall have a maximum thermal conductivity (k) factor of 0.27 btu per hour per square foot per degree Fahrenheit per inch thickness at 75-degree F ambient temperature.
- (7) All double wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange which shall consist of a 1.5 outer flange and an inner secondary flange which

shall keep the inner flange concentric and eliminate inner wall connections. Flanges requiring inner couplings will not be allowed, no insulation shall be exposed to the airstream at the connections.

- (8) All grille and register taps shall be factory manifolded. Field installed taps will not be allowed. Manifolded taps may be tack welded and caulked for appearance. Only taps for grilles and registers may be provided this way. All other fittings shall be full body welded.

D. Miscellaneous (Low Pressure)

(1) Un-insulated Flexible ductwork (Use Only Where Indicated)

- a. Un-insulated flexible ductwork shall be corrugated aluminum. No sections shall be greater than five feet in length. Ductwork shall be UL rated and in accordance with IMC.
- b. Flexible ductwork installed in a return or exhaust or other negative static pressure application shall be rated for installation in negative pressure systems.

(2) Insulated Flexible Duct (Use Only Where Indicated)

- a. Owens/Corning or equivalent, 1 ½" inch thick fiberglass insulation; flexible liner; with aluminum pigment vinyl vapor barrier facing. Insulated flexible duct shall meet Fire Hazards Standards of NFPA 90A and IMC, flame spread not to exceed 25, smoke develop and fuel contributed not to exceed 50 when tested in accordance with ASTM-E84. Minimum R-value of 6.0, tested in accordance with ASTM C177.71. Flexible duct may be used only for runouts and no sections shall be more than five feet in length.
- b. When flexible duct is located in areas where it will be visible because the ceiling allows views to the ductwork above, the flexible duct shall be black. The black color shall be factory coloring and not field applied.
- c. Flexible duct shall not be used in areas where there is no ceiling.
- d. Flexible ductwork installed in a return or exhaust or other negative static pressure application shall be rated for installation in negative pressure systems

- (3) Flexible Connectors: Duro-Dyne, Ventfabrics, Inc., U.S. Rubber or equivalent; conforming to NFPA Pamphlet No. 90-A; neoprene coated glass fabric; 20 oz. for low pressure ducts secured with snap lock.

- (4) Turning Vanes: Duro-Dyne or equivalent fabricated as recommended by SMACNA: noiseless when in place without mounting projections in ducts. All turning vanes shall be double blade type.

- (5) Splitter Damper: Splitter damper shall be constructed of 16-gauge galvanized steel. Provide with operating hardware by Ventfabrics, Inc. to include damper blade bracket, ball joint

bracket and operator shaft. Operator shall extend two inches from duct to allow for external insulation, where required. Regulator shall seal operator shaft air tight. Install hardware as recommended by manufacturer.

- (6) Access Doors; In Ductwork: Flexmaster TBSM, Air Balance, Vent Products or equal. Access doors for rectangular ducts shall be 16"x16" where possible. Otherwise install as large an access door as height permits by 16" in length. Door shall be 1" thick double-wall insulated with continuous hinge and cam lock. Provide in ducts where indicated or where required for servicing equipment whether indicated or not. Provide a hinged access door in duct adjacent to all fire, smoke and control dampers for the purpose of determining position. Access doors shall also be provided on each side of duct coils (water, electric, steam, etc.) and downstream side of VAV boxes and CAV boxes.
- (7) Architectural Access Doors in Ceilings or Walls: Provide where required to access equipment, dampers, valves, filters, etc. Provide Kees D Panel, Cesco, Milcor or equal. Panels shall be 24"x24" in size and constructed with 16 gauge galvanized steel for door and frame. In finished areas, provide with primed steel with 1" border to accept architectural specified finish. In Mechanical, Electrical, or service spaces, provide brushed satin finish with 1" border. Door shall include three (3) screwdriver operated cam latches and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors. For fire rated units, provide manufacturer's standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to ensure a complete project.
- (8) Security Architectural Access Doors in Walls: Provide where required to access equipment, dampers, valves, filters, etc. Provide Kees SSAP Panel, Cesco, Milcor or equal. Panels shall be 24"x24" in size and constructed with 12-gauge steel for door and frame. In finished areas, provide with primed steel with 1" border to accept architectural specified finish. In Mechanical, Electrical, or service spaces, provide brushed satin finish with 1" border. Door shall include key-operated cylinder dead bolt lock (coordinate cylinders and keys with Owner to match facility standards) and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors and straps. For fire rated units, provide manufacturer's standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to ensure a complete project.
- (9) Volume Dampers (Rectangular): Ruskin, Model MD35 or Empco, Air Balance; Louvers and Dampers, Titus, Carnes, Cesco/Advanced Air, Creative Metals, United Air, Pottorf rectangular volume dampers. Frames shall be 4" x 1" x 16-gauge galvanized steel. Blades shall be opposed blade 16-gauge galvanized steel with triple crimped blades on 6" centers. Linkage shall be concealed in jamb. Bearings shall be 1/2" nylon. Maximum single section size shall be 48" wide and 72" high. Provide with Ventfabrics 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.

- (10) Volume Dampers (Round): Ruskin, Model MDRS25 or, Empco, Air Balance; Louvers and Dampers, Titus, Carnes, Cesco/Advanced Air, Creative Metals, United Air, Pottorff round volume dampers. Dampers shall be butterfly type consisting of circular blade mounted to axle. Frames shall be 20-gauge steel, 6" long. Damper blades shall be 20-gauge galvanized steel. Axle shall be 3/8"x6" square plated steel. Bearing shall be 3/8" nylon. Provide with Ventfabrics 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.
- (11) Fire Dampers: Fire dampers shall comply with IMC and shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1-1/2 or 3-hour fire protection rating as required by fire wall. Damper shall have a 165°F fusible link, and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing 16-gauge minimum steel sleeves, angles, other materials, practices required to provide an installation equipment to that utilized by the manufacturer when dampers were tested at UL. Installation shall be in accordance with the damper manufacturer's instructions. **All fire dampers shall be dynamic. Static fire dampers are not allowed.** Provide velocity level and pressure level as required for application (if in doubt, contact Engineer). Fire dampers shall be Ruskin Type DIBD for 1-1/2-hour rating or Ruskin Type DIBD 23 for a 3-hour rating. Other acceptable manufacturers are Air Balance, Prefco, Greenheck, Nailor, or Safe Air. Provide an access door for fire damper reset at all fire damper locations.
- (12) Motor Driven Smoke Dampers – Air Foil Blade: Provide Ruskin SD60 smoke damper where required by the locations of smoke partitions or as shown on the plans, whichever is more stringent. Other acceptable manufacturers are Air Balance or Pottorff. All smoke dampers shall be three inches larger than HVAC duct in each direction. Frame shall be a minimum of 18-gauge galvanized steel formed into a structural hat channel shaper with tabbed corners for reinforcement. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14-gauge equivalent thickness, on 6" maximum centers. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type. Each smoke damper shall be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close under HVAC system operating conditions) with pressures of at least the maximum possible of the HVAC system in the closed position, and the system maximum duct air velocity in the open position. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Actuator to be mounted outside of air stream. The pressure drop shall not be greater than .16" wg @ 2500 FPM when tested by an independent laboratory. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

(13) Motor Driven Fire/Smoke Dampers – Air Foil Blade: Fire damper shall be constructed and tested in accordance with UL Safety Standard 555. The damper shall be Ruskin FSD60. Other acceptable manufacturers are Air Balance or Pottorff. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14-gauge equivalent thickness, on 6" maximum centers. Frame is to be a minimum of 16-gauge galvanized steel, rollformed into a structural hat shape channel. Frame seals shall consist of flexible, compression type stainless steel. The damper and actuator electric shall be rated to an elevated temperature of 250 degrees F or 350 degrees F. In addition, the damper must be factory supplied with actuator and sleeve to comply with the requirements of UL 555S. These dampers shall have been constructed and tested in compliance with U.L. Standard 555 and U.L. Standard 555S, current editions. The pressure drop shall not be greater than .25 in.wg. At 2500 fpm when tested by an independent laboratory. Each damper shall bear an approved U.L. label identifying its classification as a Dynamic Rated Fire Damper (Static Rated dampers are not acceptable), and shall further be classified by U.L. as a Leakage Rated Damper for use in Smoke Control Systems. Each damper shall have a 1-1/2-hour fire protection rating, 212EF U.L. Listed fusible link and a leakage class I. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Provide factory supplied caulked sleeve, 20 gauge on dampers through 84" wide and 18 gauge above 84" wide. Actuator to be mounted outside of air stream. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

(14) Motor Driven Control Dampers – Provide Ruskin Model CD50 air foil damper as shown on the plans. Frame shall be a minimum of 16-gauge galvanized steel formed into a structural hat channel shaper with tabbed corners for reinforcement. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14-gauge equivalent thickness, 6 inches wide. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type. Blade seals shall be equal to Ruskinprene. Leakage Rating shall be Pressure/Class 1.

3. MEDIUM PRESSURE DUCTWORK

A. General (Medium Pressure)

- (1) All ductwork connections, fittings, joints, etc., shall be sealed. Seal with high velocity, smooth-textured, water based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15" wg. Apply per manufacturer's recommendations.
- (2) Ductwork shall be installed per SMACNA Medium or High-Pressure Manual, whichever is applicable. (Latest Edition shall apply.)
- (3) All hanger straps shall be 18 ga. minimum with reinforcement angles installed in strict accordance with SMACNA. Flat oval ducts shall be installed with 2"x2"x1/4" angles on top and bottom ducts 18" wide and larger. Use 1"x1"x3/16" angles on ducts under 18" wide.

- (4) Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA or the duct manufacturer, and/or as indicated. Test openings shall be placed at the discharge of all air handling units and at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.
- (5) Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panels at each fire damper located and sized so as to allow hand reset of each fire damper. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. Where access doors are installed in insulated ductwork, the access door shall be the insulated type.

B. Materials (Medium Pressure Single Wall)

- (1) All round, rectangular, and oval medium pressure ductwork for systems above 1.5" W.G. shall be Eastern Sheet Metal, United McGill or Semco or equal with construction as required by the latest SMACNA Standard (Refer to required pressure rating of the duct system as outlined in the Duct Schedule of this spec section).
- (2) Any ductwork exposed to view shall be double wall and constructed of galvanized steel. Galvanized metal shall be prepped and clean prior to painting. Coordinate with General Contractor.

Ductwork shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Ductwork shall be constructed of materials of the minimum weights or gauges as required by the latest SMACNA Standard (Refer to required pressure rating of the duct system as outlined in the Duct Schedule of this spec section) or the below table. When gauge thickness differs, the heavier gauge shall be selected. The below table shall serve as a minimum:

ROUND DUCT (or Equivalent Diameter for Flat Oval)		RECTANGULAR DUCT	
DIA., INCHES	GAUGE	WIDTH, INCHES	GAUGE
3 TO 14	26	UP TO 12	26
15 TO 26	24	13 TO 30	24
27 TO 36	22	31 TO 54	22
37 TO 50	20	55 TO 84	20
52 TO 60	18	85 AND ABOVE	18

- (3) All medium pressure duct fittings shall be fabricated by the same manufacturer as the spiral pipe. Contractor or field fabricated fittings shall not be accepted. Duct fittings shall be constructed per the latest SMACNA standard (Refer to required pressure rating of the duct system as outlined in the Duct Schedule of this spec section) with continuous welds. Take-off fittings shall be combination type tees (Eastern Sheet Metal Model "CB" or equal). Straight or angle tees are not acceptable. Fittings shall be constructed of the following minimum gauges:

ROUND DUCT (or Equivalent Diameter for Flat Oval)		RECTANGULAR DUCT	
DIA., INCHES	GAUGE	WIDTH, INCHES	GAUGE
3 TO 50	20	UP TO 36	20
51 TO 60	18	37 TO 60	18
61 TO 84	16	61 AND ABOVE	16

- (4) All single wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange on all ductwork greater than 24 inches in size.

C. Materials (Medium pressure Double Wall)

- (1) Furnish and install where indicated by drawings or specifications medium pressure double wall duct. The double wall duct shall be United McGill Acoustic K27, SEMCO, Dixie or approved equivalent. The duct shall have a **[perforated inner liner. The inner liner shall have 3/32" perforation with an overall open area of 23%.] [solid galvanized steel inner liner]**, an intermediate layer of fiberglass insulation minimum 1" thick and an outer pressure shell. Duct shall be of spiral lock seam construction fabricated from galvanized steel meeting ASTM-A527 standard. The duct insulation shall have minimum R-value of 6.0. Medium pressure double wall fittings shall have the same construction features as the double wall duct. Duct shall be constructed of G90 Galvanized steel. Outer shell of ductwork shall be constructed of the minimum gauges specified above for single wall medium pressure ductwork.
- (2) All double wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange which shall consist of a 1.5 outer flange and an inner secondary flange which shall keep the inner flange concentric and eliminate inner wall connections. Flanges requiring inner couplings will not be allowed, no insulation shall be exposed to the airstream at the connections.

D. Miscellaneous (Medium pressure)

- (1) Flexible Connectors: Duro-Dyne, Ventfabrics, U.S. Rubber or equivalent; conforming to NFPA Pamphlet No. 90-A or IMC, whichever is more stringent; neoprene coated glass fabric; 30 oz.

for medium pressure ducts secured with bolted angles. Provide flexible connectors at inlet and outlet of air handling equipment to accommodate a minimum of three times the operating pressure of the system.

- (2) Architectural Access Doors In Ceilings or Walls: Provide where required to access equipment, dampers, valves, filters, etc. Provide Kees D Panel, Cesco, Milcor or equal. Panels shall be 24"x24" in size and constructed with 16 gauge galvanized steel for door and frame. In finished areas, provide with primed steel with 1" border to accept architectural specified finish. In Mechanical, Electrical, or service spaces, provide brushed satin finish with 1" border. Door shall include three (3) screwdriver operated cam latches and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors. For fire rated units, provide manufacturer's standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to ensure a complete project.
- (3) Security Architectural Access Doors in Walls: Provide where required to access equipment, dampers, valves, filters, etc. Provide Kees SSAP Panel, Cesco, Milcor or equal. Panels shall be 24"x24" in size and constructed with 12-gauge steel for door and frame. In finished areas, provide with primed steel with 1" border to accept architectural specified finish. In Mechanical, Electrical, or service spaces, provide brushed satin finish with 1" border. Door shall include key-operated cylinder dead bolt lock (coordinate cylinders and keys with Owner to match facility standards) and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors and straps. For fire rated units, provide manufacturer's standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to ensure a complete project.
- (4) Fire Dampers: Fire dampers shall comply with IMC and shall be constructed and tested in accordance with UL Safety Standard 555. Each fire damper shall have a 1-1/2 or 3-hour fire protection rating as required by fire wall. Damper shall have a 165°F fusible link, and shall include a UL label in accordance with established UL labeling procedures. Fire damper shall be equipped for vertical or horizontal installation as required by the location shown. Fire dampers shall be installed in wall and floor openings utilizing 16-gauge minimum steel sleeves, angles, other materials, practices required to provide an installation equipment to that utilized by the manufacturer when dampers were tested at UL. Installation shall be in accordance with the damper manufacturer's instructions. **All fire dampers shall be dynamic. Static fire dampers are not allowed.** Provide velocity level and pressure level as required for application (if in doubt, contact Engineer). Fire dampers shall be Ruskin Type DIBD for 1-1/2-hour rating or Ruskin Type DIBD 23 for a 3-hour rating. Other acceptable manufacturers are Air Balance, Prefco, Greenheck, Nailor, or Safe Air. Provide an access door for fire damper reset at all fire damper locations.
- (5) Motor Driven Smoke Dampers – Air Foil Blade: Provide Ruskin SD60 smoke damper where required by the locations of smoke partitions or as shown on the plans, whichever is more

stringent. Other acceptable manufacturers are Air Balance or Pottorff. Frame shall be a minimum of 18-gauge galvanized steel formed into a structural hat channel shaper with tabbed corners for reinforcement. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14-gauge equivalent thickness, on 6" maximum centers. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type. Each smoke damper shall be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close under HVAC system operating conditions) with pressures of at least the maximum possible of the HVAC system in the closed position, and the system maximum duct air velocity in the open position. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Actuator to be mounted outside of air stream. The pressure drop shall not be greater than .16" wg @ 2500 FPM when tested by an independent laboratory. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

- (6) Motor Driven Fire/Smoke Dampers – Air Foil Blade: Fire damper shall be constructed and tested in accordance with UL Safety Standard 555. The damper shall be Ruskin FSD60. Other acceptable manufacturers are Air Balance or Pottorff. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14-gauge equivalent thickness, on 6" maximum centers. Frame is to be a minimum of 16-gauge galvanized steel, rollformed into a structural hat shape channel. Frame seals shall consist of flexible, compression type stainless steel. The damper and actuator electric shall be rated to an elevated temperature or 250 degrees F or 350 degrees F. In addition, the damper must be factory supplied with actuator and sleeve to comply with the requirements of UL 555S. These dampers shall have been constructed and tested in compliance with U.L. Standard 555 and U.L. Standard 555S, current editions. The pressure drop shall not be greater than .25 in.wg. At 2500 fpm when tested by an independent laboratory. Each damper shall bear an approved U.L. label identifying its classification as a Dynamic Rated Fire Damper (Static Rated dampers are not acceptable), and shall further be classified by U.L. as a Leakage Rated Damper for use in Smoke Control Systems. Each damper shall have a 1-1/2-hour fire protection rating, 212EF U.L. Listed fusible link and a leakage class I. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls for exact type. Provide factory supplied caulked sleeve, 20 gauge on dampers through 84" wide and 18 gauge above 84" wide. Actuator to be mounted outside of air stream. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements
- (7) Motor Driven Control Dampers – Provide Ruskin Model CD60 air foil damper as shown on the plans. Frame shall be a minimum of 16-gauge galvanized steel formed into a structural hat channel shaper with tabbed corners for reinforcement. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14-gauge equivalent thickness, 6 inches

wide. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type. Blade seals shall be equal to Ruskinprene. Leakage Rating shall be Pressure/Class 1.

(8) Access Doors; In Rectangular Medium Pressure Ductwork: Flexmaster TBSM, Air Balance, Vent Products or equal. Access doors for rectangular ducts shall be 16"x16" where possible. Otherwise install as large an access door as height permits by 16" in length. Door shall be 1" thick double-wall insulated with continuous hinge and cam lock. Provide in ducts where indicated or where required for servicing equipment whether indicated or not. Provide a hinged access door in duct adjacent to all fire, smoke and control dampers for the purpose of determining position.

(9) Access Doors; In Round or Oval Medium Pressure Ductwork: All access doors in round or oval medium pressure ductwork shall be screw and gasketed type. Screws shall be maximum 4 inches on centers. Access door sizes shall be as follows:

DUCT DIAMETER	OPENING SIZE
3-4 inches	4" x 10"
5-6 inches	6" x 10"
7-24 inches	10" x 16"
26-36 inches	16" x 16"
Over 36 inches	16" x 22"

4. DRYER VENT

- A. All dryer ducting shall be a minimum of 4" in diameter. Refer to the drawings for exact duct sizing.
- B. Dryer vent ductwork shall be rigid metal 20-gauge aluminum duct. Duct joints shall be installed so that the male end of the duct points in the direction of the airflow. Joints shall be secured with metal tape (not duct tape). Do not use rivets or screws in the joints or anywhere else in the duct as these will incur lint collection
- C. Length of concealed rigid metal ducting shall not exceed the allowable length of 35 feet. Deduct 5 feet from the allowable length for every 4" 90-degree elbow and 4" 2.5 feet for every 45-degree fitting. lengths may vary per local codes and dryer manufacturer's recommendations. Install per 2012 IMC Section 504 Clothes Dryer Exhaust. Provide a complete, working in-line booster fan system, including power, if the maximum allowable duct length is exceeded.
- D. Flexible transition hose connection at the dryer shall be the aluminum flexible duct type. Do not use the plastic or vinyl.
- E. Termination of dryer venting shall be to the exterior with a proper hood or roof jack equipped with a backdraft damper. Hood/jack shall be painted with suitable exterior grade paint and color per the Owner's direction. Small orifice metal screening shall not be part of the hood or roof jack as this will trap lint and block the opening. The hood opening shall point down and maintain a

minimum of 12 inches of clearance between the bottom of the hood and the ground or other obstruction.

5. DUCT SCHEDULE

A. Supply Ducts:

(1) Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, downstream of Terminal Units:

- a. Pressure Class: Positive **2**-inch wg Refer to Low Pressure requirements as outlined in section 2 of this spec.
- b. Minimum SMACNA Seal Class: **A**.
- c. SMACNA Leakage Class for Rectangular: **24**.
- d. SMACNA Leakage Class for Round and Flat Oval: **12**.

(2) Ducts Connected to Variable-Air Volume Air-Handling Units RTU-1:

- a. Pressure Class: Positive **4**-inch wg Refer to medium pressure standards as outlined in section 3 of this spec.
- b. Minimum SMACNA Seal Class: **A**.
- c. SMACNA Leakage Class for Rectangular: **6**.
- d. SMACNA Leakage Class for Round and Flat Oval: **3**.

B. Return Ducts:

(1) Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, downstream of Terminal Units:

- a. Pressure Class: Negative 2-inch wg Refer to Low Pressure requirements as outlined in section 2 of this spec.
- b. Minimum SMACNA Seal Class: **A**.
- c. SMACNA Leakage Class for Rectangular: **24**.
- d. SMACNA Leakage Class for Round and Flat Oval: **12**.

(2) Ducts Connected to Air-Handling Units RTU-1:

- a. Pressure Class: Negative **2**-inch wg Refer to **Low Pressure requirements as outlined in section 2 of this spec.**
- b. Minimum SMACNA Seal Class: **A**.
- c. SMACNA Leakage Class for Rectangular: **24**.
- d. SMACNA Leakage Class for Round and Flat Oval: **12**.

C. Exhaust/Relief Ducts:

(1) Ducts Connected to Exhaust Fans EF-1, EF-2, EF-3, EF-4:

- a. Pressure Class: Negative **2**-inch wg Refer to **Low Pressure requirements as outlined in section 2 of this spec.**

- b. Minimum SMACNA Seal Class: **A**.
- c. SMACNA Leakage Class for Rectangular: **24**.
- d. SMACNA Leakage Class for Round and Flat Oval: **12**.

12. Air Leakage Testing of the Ductwork Systems

- A. It is the intent of this section to ensure the ductwork installed has minimal air leakage.
- B. Air leakage testing shall be accomplished by an AABC or NEBB certified company. Refer to the Test & Balance specifications.
- C. It is the intent to test all ductwork. The duct systems which will require testing are as follows:
(Note to Designer to edit.)
 - (1) All supply air duct systems
 - (2) All exhaust air duct systems.
- D. Do not insulate the supply air systems prior to testing.
- E. The maximum allowable air leakage rate for each system tested must conform to SMACNA required leakage class rating as specified in section 11, DUCT SCHEDULE, of this spec.
- F. The entire supply air ductwork system shall be tested with some exceptions. On VAV systems, the medium pressure ductwork upstream of the VAV boxes shall only be tested. Cap the duct at the inlet to the VAV box.
- G. All return and exhaust air sheet metal ductwork associated with the system shall be tested. Flexible ductwork shall not be tested. Cap the main duct prior to the central equipment fan connection. Also cap the branch ducts which serve the diffusers, after the round branch air volume with sheet metal caps. Seal caps well to damper to avoid air loss at this location. This air loss, from the caps, is included in the noted leakage rate.
- H. The noted allowable leakage rate is the total allowable. It shall include leakage associated with the following:
 - (1) All ductwork as described in above paragraphs.
 - (2) Access doors
 - (3) Volume dampers
 - (4) Relief air doors
 - (5) Smoke dampers

- (6) Fire dampers
- (7) Fire smoke dampers
- (8) End caps used to seal ducts
- I. If any duct system fails a test, the contractor shall reseal the system. It shall then be retested until the duct system meets the leakage allowable at no additional cost to the owner.
- J. Carefully select the ductwork construction requirements and the type of duct sealant to be used as required to meet the leakage allowances. The sheet metal duct pressure classification is a minimum only. The contractor shall select the appropriate sheet metal pressure classification, duct sealant class and duct sealant materials to meet the project air leakage allowances.
- K. Whenever the systems are being leak tested by the Test & Balance Contractor, a representative from the Mechanical Contractor shall be present to assist.

END OF SECTION 231200

SECTION 237219 – FIXED PLATE AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

1. GENERAL

A. Scope

1. Mechanical HVAC ventilation equipment shall contain a fixed plate type energy recovery system, preinstalled and tested by the manufacturer. Energy Wall™ is the basis of design.
2. Furnish owner's manuals covering installation, maintenance, and operation.
3. Manufacturer shall warrant the energy recovery system to be free from defects in materials and workmanship for a period of 5 years after installation.

2. PRODUCT

A. Technology

1. The energy recovery system shall be based on a high efficiency fixed plate type energy recovery core with dynamic heat and moisture transfer.

B. Sustainability

1. All materials used in the energy recovery cores shall be natural and 100% recyclable. Use of exotic materials, chemicals, or rare earth elements is unacceptable.
2. The energy recovery cores must be constructed in a sustainable way, producing no hazardous effluent or unrecyclable waste.

C. Energy Recovery Cores

1. The energy recovery cores shall be constructed using an advanced energy transfer membrane capable of transferring both heat and moisture between air streams with at least 70% total efficiency when installed and operated according to the manufacturer's recommendations.
2. The energy transfer membrane shall be made of a specially formulated paper, processed to form a semi-permeable membrane that creates a positive barrier between air streams, while facilitating the transfer of heat and moisture across the membrane.
3. The energy recovery cores shall be made of an energy transfer membrane that is machine folded, with layers separated by a machine folded corrugated net poly-spacer that provides the proper support and separation to the membrane layers, while producing sufficient air turbulence to increase energy transfer efficiency and prevent particulate buildup.
4. The energy recovery core's membrane layers shall be ultrasonically bonded, without the use of chemicals, tapes or adhesives, to form clear air passages. The energy transfer membrane shall be impregnated with Lithium Chloride to actively facilitate the transfer of moisture between air streams and provide microbicide effect.
5. The energy transfer membrane shall act as a natural microbicide, actively killing up to 95% of microbes on contact and preventing cross-contamination between air streams. The microbicide action shall be documented by an appropriate third party testing laboratory. Microbial growth prevention treatments are not sufficient.

6. The energy transfer cores shall be capable of operating from 0° to 140°F, and will be frost-proof down to -40°F, and shall survive temperatures from -40°F to +150°F without damage.
7. The energy recovery cores shall be innumerable washable and rechargeable in salt water without any loss of performance.
8. The housing of the energy recovery cores shall be constructed of a suitable material capable of protecting the energy transfer core and preventing corrosion.

D. Energy Recovery System

1. The energy recovery system shall be constructed of corrosion proof materials, with double wall construction.
2. The energy recovery system shall be capable of field assembly using hand-transportable modules carried or hand-trucked to the installation site. Rooftop installation shall not require a rig or crane.
3. The energy recovery system shall be capable of any orientation to allow supply and return duct connections to face horizontal, downward, or upward.
4. The energy recovery system shall support the connection of multiple modules with a single connection for each airstream.
5. The energy recovery system shall support the connection of multiple modules with a single connection for controls and high voltage power.
6. The energy recovery system shall consist of single or multiple fixed plate energy recovery cores designed for counter-flow operation within each core. Cross-flow cores are less efficient and are therefore unacceptable.
7. The energy recovery system shall have no moving parts or active seals required for operation, other than bypass dampers.
8. The energy recovery system shall be capable of minimum total efficiencies of 70% when installed and operated in accordance with manufacturer's guidelines and recommendations.
9. The energy recovery media shall demonstrate fire and smoke spread ratings matching UL 900 criteria.

3. EXECUTION

A. General

1. The energy recovery system shall be installed in accordance with the manufacturer's recommendations and applicable published documents.
2. Commissioning of the system shall be by a qualified, factory trained representative or qualified, licensed contractor, and shall include a training session for owner's maintenance personnel if requested.
3. Energy recovery system shall be Energy Wall™, as manufactured by:

Energy Wall, LLC
1102 New Holland Ave. Lancaster,

PA 17601
www.EnergyWall.com

SECTION 238129 – VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

1. GENERAL

A. SYSTEM DESCRIPTION R2-SERIES (SIMULTANEOUS HEAT/COOL)

1. Per the equipment schedule, the variable capacity, heat pump heat recovery air conditioning system basis of design is Mitsubishi Electric CITY MULTI VRF (Variable Refrigerant Flow) zoning system(s).
2. Acceptable alternative manufacturers, assuming compliance with these equipment specifications, are Daikin, Panasonic, and Hitachi. Contractor bidding an alternate manufacturer does so with full knowledge that that manufactures product may not be acceptable or approved and that contractor is responsible for all specified items and intents of this document without further compensation.
3. Simultaneous heating/cooling (heat recovery) systems shall consist of an outdoor unit, BC (Branch Circuit) Controller (or comparable branch devices), multiple indoor units, and an integral DDC (Direct Digital Controls) system. Each indoor unit or group of indoor units shall be capable of operating in any mode independently of other indoor units or groups. System shall be capable of changing mode (cooling to heating, heating to cooling) with no interruption to system operation. To ensure owner comfort, each indoor unit or group of indoor units shall be independently controlled and capable of changing mode automatically when zone temperature strays 1.8 degrees F from set point for ten minutes.
4. No additional branch circuit controllers (or comparable branch devices) than shown on the drawings/schedule may be connected to any one outdoor unit. Contractors proposing alternate systems requiring more branch devices than those included as the basis of design are responsible for additional piping & electrical costs and are required to identify additional costs & installation time required of other trades with their bid.

B. QUALITY ASSURANCE

1. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label.
2. All wiring shall be in accordance with the National Electrical Code (N.E.C.).
3. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
4. All units must meet or exceed the 2010 Federal minimum efficiency requirements and the ASHRAE 90.1 efficiency requirements for VRF systems. Efficiency shall be published in accordance with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1230.
5. System start-up supervision shall be a required service to be completed by the manufacturer or a duly authorized, competent representative that has been factory trained in system configuration and operation. The representative shall provide proof of manufacturer certification indicating successful completion within no more than two (2) years prior to system installation. This certification shall be included as part of the equipment and/or controls submittals.

C. DELIVERY, STORAGE AND HANDLING

1. Unit shall be stored and handled according to the manufacturer's recommendation.

2. WARRANTY

1. The CITY MULTI units shall be covered by the manufacturer's limited warranty for a period of one (1) year parts and seven (7) year compressor to the original owner from date of installation.
2. Installing contractor shall meet manufacturer requirements to obtain extended manufacturer's limited parts and compressor warranty for a period of ten (10) years to the original owner from date of installation. This warranty shall not include labor.
3. Manufacturer shall have a minimum of fifteen (15) years continuous experience providing VRF systems in the U.S. market.
4. All manufacturer technical and service manuals must be readily available for download by any local contractor should emergency service be required. Registering and sign-in requirements which may delay emergency service reference are not allowed.
5. The CITY MULTI VRF system shall be installed by a contractor with extensive CITY MULTI install and service training. The mandatory contractor service and install training should be performed by the manufacturer.

3. OUTDOOR UNITS - R2-SERIES STANDARD EFFICIENCY (HEAT RECOVERY)

A. GENERAL

1. The outdoor unit modules shall be air-cooled, direct expansion (DX), multi-zone units used specifically with VRF components described in this section and Part 5 (Controls). The outdoor unit modules shall be equipped with a single compressor which is inverter-driven and multiple circuit boards—all of which must be manufactured by the branded VRF manufacturer. Each outdoor unit module shall be completely factory assembled, piped and wired and run tested at the factory.
2. Outdoor unit systems may be comprised of multiple modules with differing capacity if a brand other than basis of design is proposed. All units requiring a factory supplied twinning kits shall be piped together in the field, without the need for equalizing line(s). If an alternate manufacturer is selected, any additional material, cost, and labor to install additional lines shall be incurred by the contractor. Contractor responsible for ensuring alternative brand compatibility in terms of availability, physical dimensions, weight, electrical requirements, etc.
3. Outdoor unit shall have a sound rating no higher than 66.5 dB(A) individually or 69.5 dB(A) twinned. Units shall have a sound rating no higher than 52 dB(A) individually or 55 dB(A) twinned while in night mode operation. Units shall have 5 levels sound adjustment via dip switch selectable fan speed settings. If an alternate manufacturer is selected, any additional material, cost, and labor to meet published sound levels shall be incurred by the contractor.
4. Refrigerant lines from the outdoor unit to the indoor units shall be insulated in accordance with the installation manual.

5. The outdoor unit shall have the capability of installing the main refrigerant piping through the bottom of the unit.
6. The outdoor unit shall have an accumulator with refrigerant level sensors and controls. Units shall actively control liquid level in the accumulator via Linear Expansion Valves (LEV) from the heat exchanger.
7. The outdoor unit shall have a high pressure safety switch, over-current protection, crankcase heater and DC bus protection.
8. VRF system shall meet performance requirements per schedule and be within piping limitations & acceptable ambient temperature ranges as described in respective manufacturers' published product catalogs. Non-published product capabilities or performance data are not acceptable.
9. The outdoor unit shall be capable of operating in heating mode down to -18°F ambient temperatures or cooling mode down to 23°F ambient temperatures, without additional low ambient controls. If an alternate manufacturer is selected, any additional material, cost, and labor to meet low ambient operating condition and performance shall be incurred by the contractor.
10. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained. Oil return sequences must be enabled only during extended periods of reduced refrigerant flow to ensure no disruption to correct refrigerant flow to individual zones during peak loads. Systems which might engage oil return sequence based on hours of operation risk oil return during inopportune periods are not allowed. Systems which rely on sensors (which may fail) to engage oil return sequence are not allowed.
11. Unit must defrost all circuits simultaneously in order to resume full heating more quickly during extreme low ambient temperatures (below 23F). Partial defrost, also known as hot gas defrost which allows reduced heating output during defrost, is permissible only when ambient temperature is above 23F.
12. While in hot gas defrost the system shall slow the indoor unit fan speed down to maintain a high discharge air temperature. Systems that keep fans running in same state shall not be allowed as they provide an uncomfortable draft to the indoor zone due to lower discharge air temperatures.
13. In reverse defrost all refrigerant shall be bypassed in the main branch controller and shall not be sent out to the indoor units, systems that flow refrigerant through indoor units during reverse defrost shall not be allowed.

B. UNIT CABINET

1. The casing(s) shall be fabricated of galvanized steel, bonderized and finished.
2. Panels on the outdoor unit shall be scratch free at system startup. If a scratch occurs the salt spray protection is compromised and the panel should be replaced immediately.

C. FAN

1. Each outdoor unit module shall be furnished with direct drive, variable speed propeller type fan(s) only. Fans shall be factory set for operation at 0 in. WG. external static pressure, but capable of normal operation with a maximum of 0.32 in. WG. external static

pressure via dipswitch.

2. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
3. All fans shall be provided with a raised guard to prevent contact with moving parts.

D. REFRIGERANT AND REFRIGERANT PIPING

1. R410A refrigerant shall be required for systems.
2. Polyolester (POE) oil—widely available and used in conventional domestic systems—shall be required. Prior to bidding, manufacturers using alternate oil types shall submit material safety data sheets (MSDS) and comparison of hygroscopic properties for alternate oil with list of local suppliers stocking alternate oil for approval at least two weeks prior to bidding.
3. Refrigerant piping shall be phosphorus deoxidized copper (copper and copper alloy seamless pipes) of sufficient radial thickness as defined by the VRF equipment manufacturer and installed in accordance with manufacturer recommendations.
4. All refrigerant piping must be insulated with ½” closed cell, CFC-free foam insulation with flame-Spread Index of less than 25 and a smoke-development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102. R value of insulation must be at least 3.
5. Refrigerant line sizing shall be in accordance with manufacturer specifications. Future changes to indoor unit styles or sizes must be possible without resizing/replacing refrigerant piping to any other branch devices or indoor units.

E. COIL

1. Outdoor Coil shall be constructed to provide equal airflow to all coil face surface are by means of a 4-sided coil.
2. Outdoor Coil shall be elevated at least 12” from the base on the unit to protect coil from freezing and snow build up in cold climates. Manufacturer’s in which their coil extends to within a few inches from the bottom of their cabinet frame shall provide an additional 12” of height to their stand or support structure to provide equal protection from elements as Mitsubishi Electric basis of design. Any additional support costs, equipment fencing, and tie downs required to meet this additional height shall be responsibility of Mechanical Contractor to provide.
3. The outdoor coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.
4. The coil fins shall have a factory applied corrosion resistant blue-fin finish. Uncoated aluminum coils/fins are not allowed.
5. The coil shall be protected with an integral metal guard.
6. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.
7. Unit shall have prewired plugs for optional panel heaters in order to prevent any residual ice buildup from defrost. Panel heaters are recommended for operating environments where the ambient temperature is expected to stay below -1F for 72 hours.

8. Condenser coil shall have active hot gas circuit direct from compressor discharge on lowest coil face area to shed defrost condensate away from coil and protect from Ice formation after returning to standard heat pump operation. While in Heat Pump operation this lower section of the Outdoor Evaporator coil shall continually run hot gas from the compressor discharge to protect the coil from ice buildup and coil rupture. Manufacturers who do not have an active hot gas circuit in the lower section of the Outdoor coil to protect coil from freezing shall not be allowed in markets where the outdoor unit will see temperatures below freezing.

F. COMPRESSOR

1. Each outdoor unit module shall be equipped with only inverter driven scroll hermetic compressors. Non inverter-driven compressors, which may cause inrush current (demand charges) and require larger generators for temporary power shall not be allowed.
2. Each compressor shall be equipped with a multi-port discharge mechanism to eliminate over compression at part load. Manufacturer's that rely on a single compressor discharge port and provide no means of eliminating over compression and energy waste at part load shall not be allowed.
3. Crankcase heat shall be provided via induction-type heater utilizing eddy currents from motor windings. Energy-wasting "belly-band" type crankcase heaters are not allowed. Manufacturer's that utilize belly-band crankcase heaters will be considered as alternate only.
4. Compressor shall have an inverter to modulate capacity. The capacity for each compressor shall be variable with a minimum turndown not greater than 15%.
5. The compressor shall be equipped with an internal thermal overload.
6. Field-installed oil equalization lines between modules are not allowed. Prior to bidding, manufacturers requiring equalization must submit oil line sizing calculations specific to each system and module placement for this project.
7. Manufacturers that utilize a compressor sump oil sensor to equalize compressor oil volume within a single module shall not be allowed unless they actively shut down the system to protect from compressor failure.

G. CONTROLS

1. The unit shall be an integral part of the system & control network described in Part 5 (Controls) and react to heating/cooling demand as communicated from connected indoor units over the control circuit. Required field-installed control voltage transformers and/or signal boosters shall be provided by the manufacturer.
2. Each outdoor unit module shall have the capability of 4 levels of demand control based on external input.

H. ELECTRICAL

1. The outdoor unit electrical power shall be 208/230 volts, 3-phase, 60 hertz or 460 volts, 3-phase, 60 hertz per equipment schedule.
2. The outdoor unit shall be controlled by integral microprocessors.

3. The control circuit between the indoor units, BC Controller and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.
4. BRANCH CIRCUIT (BC) CONTROLLERS AS REQUIRED FOR SIMULTANEOUS HEAT/COOL SYSTEMS
 - A. GENERAL
 1. BC (Branch Circuit) Controllers (or comparable branch devices) shall include multiple branches to allow simultaneous heating and cooling by allowing either hot gas refrigerant to flow to indoor unit(s) for heating or subcooled liquid refrigerant to flow to indoor unit(s) for cooling. Refrigerant used for cooling must always be subcooled for optimal indoor unit LEV performance; alternate branch devices which do not include controlled refrigerant subcooling risk bubbles in liquid supplied to indoor unit LEVs and are not allowed.
 2. BC Controllers (or comparable branch devices) shall be equipped with a circuit board that interfaces to the controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish and be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors, with access and service clearance provided for each controller. BC Controllers (or comparable branch devices) shall be suitable for use in plenums in accordance with UL1995 ed 4.
 - B. BC UNIT CABINET
 1. The casing shall be fabricated of galvanized steel.
 2. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
 3. The unit shall house two tube-in-tube heat exchangers.
 - C. REFRIGERANT PIPING (SPECIFICATIONS IN ADDITION TO THOSE FOR OUTDOOR UNIT)
 1. All refrigerant pipe connections shall be brazed.
 2. Future changes to indoor unit quantities or sizes served by BC Controller or comparable branch device must be possible with no piping changes except between the branch device and indoor unit(s) changing. Systems which might require future piping changes between branch device and outdoor unit—if changes to indoor unit quantities or sizes are made—are not considered equal and are not allowed.
 - D. REFRIGERANT VALVES
 1. Service shut-off valves shall be field-provided/installed for each branch to allow service to any indoor unit without field interruption to overall system operation.
 2. Service shut-off valves shall be pre-installed by the equipment vendor and leak tested to the applicable factory specifications for each branch to allow service to any indoor unit without field interruption to overall system operation.
 - E. FUTURE USE BRANCH
 1. Each VRF system shall include at least one (1) unused branch or branch device for future use. Future-use branches or branch devices shall be fully installed & wired in central location with capped service shutoff valve & service port.

F. CONDENSATE MANAGEMENT

1. BC Controller (or comparable branch device) must have integral resin drain pan or insulate refrigeration components with removable insulation that allows easy access for future service needs. Cabinets filled with solid foam insulation do not allow for future service and are not allowed.

G. ELECTRICAL

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 Hertz. The unit shall be capable of satisfactory operation within voltage limits of 187-228 (208V/60Hz) or 207-253 (230/60Hz).
2. The BC Controller shall be controlled by integral microprocessors
3. The control circuit between the indoor units and outdoor units shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

5. INDOOR UNITS - MEDIUM STATIC CEILING-CONCEALED DUCTED INDOOR UNIT

A. GENERAL

1. The ceiling-concealed ducted indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory. The unit shall be suitable for use in plenums in accordance with UL1995 ed 4.

B. UNIT CABINET

1. The unit shall be ceiling-concealed, ducted—with a 2-position, field adjustable return and a fixed horizontal discharge supply.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.

C. FAN

1. Indoor unit shall feature multiple external static pressure settings ranging from 0.14 to 0.60 in. WG.
2. The indoor unit fan shall be an assembly with statically and dynamically balanced Sirocco fan(s) direct driven by a single motor with permanently lubricated bearings.
3. The indoor fan shall consist of three (3) speeds, High, Mid, and Low plus the Auto-Fan function

D. FILTER

1. Return air shall be filtered by means of a standard factory installed return air filter.
2. Optional return filter box (rear or bottom placement) with high-efficiency filter as noted on equipment schedule.

E. OPTIONAL FILTER FRAME AND FILTER

1. Filter frame shall be constructed of 20 gauge G-60 galvanized steel. Knurled thumb screws on access door allow filter replacement. Foam gasket provides air-tight connection to indoor unit and access door. Filter frame shall be configurable for rear or bottom return.
2. Filter shall be rated MERV 13 when tested in accordance with ANSI/ASHRAE 52.2 Standard Rated Class 2 under U.L. Standard 900.

F. COIL

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phos-copper or silver alloy.
2. The coils shall be pressure tested at the factory.
3. Coil shall be provided with a sloped drain pan. Units without sloped drain pans which must be installed cockeyed to ensure proper drainage are not allowed.
4. The unit shall be provided with an integral condensate lift mechanism able to raise drain water 27 inches above the condensate pan.

G. ELECTRICAL

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

H. CONTROLS

1. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
2. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
3. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
4. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.
5. Control board shall include contacts for control of no less than two stages of external heat. The first stage of external heat may be energized when the space temperature is 2.7°F from set point for between 10-25 minutes (user adjustable). The second stage of external heat may be energized when the first stage has been active for no less than 5 minutes and the space temperature has not risen by more than 0.9°F.
6. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
7. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

6. CONTROLS

A. OVERVIEW

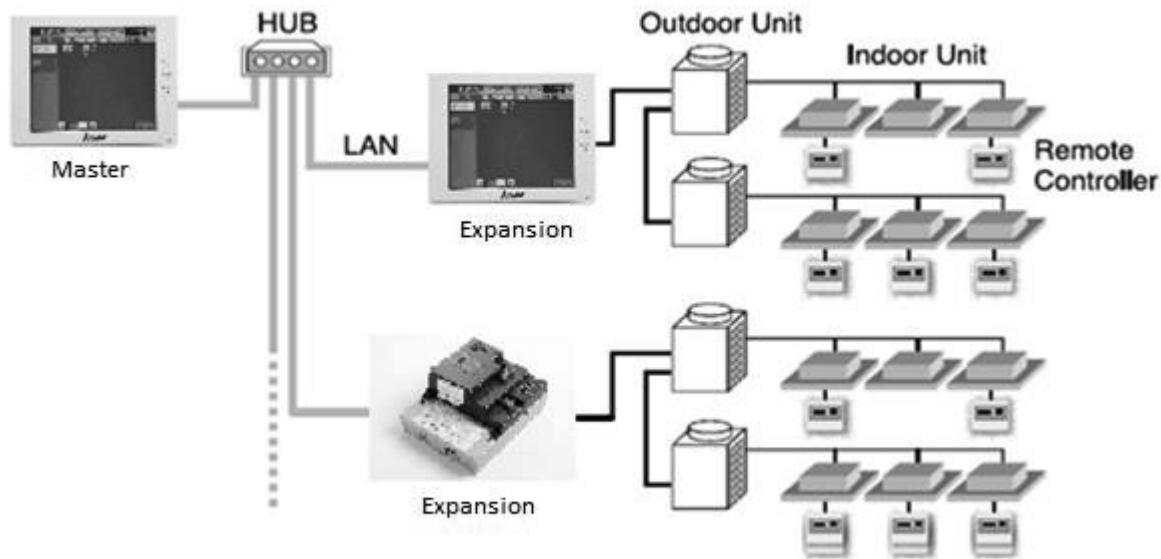
1. The control system shall consist of a low voltage communication network and a web-based interface. The controls system shall gather data and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.
2. Furnish energy conservation features such as optimal start, request-based logic, and demand level adjustment of overall system capacity as specified in the sequence.
3. System shall be capable of email generation for remote alarm annunciation.

B. ELECTRICAL CHARACTERISTICS

1. Controller power and communications shall be via a common non-polar communications bus and shall operate at 30VDC.
2. Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit, to the BC controller (main and subs, if applicable) and to the outdoor unit. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.
3. Control wiring for centralized controllers shall be installed in a daisy chain configuration from outdoor unit to outdoor unit, to the system controllers (centralized controllers and/or integrated web based interface), to the power supply.
4. Wiring shall be 2-conductor (16 AWG), twisted, stranded, shielded wire as defined by the Diamond System Builder output.
5. Network wiring shall be CAT-5 with RJ-45 connection.

C. CITY MULTI CONTROLS NETWORK

1. The CITY MULTI Controls Network (CMCN) consists of remote controllers, centralized controllers, and/or integrated web based interface communicating over a high-speed communication bus. The CITY MULTI Controls Network shall support operation monitoring, scheduling, occupancy, error email distribution, personal web browsers, tenant billing, online maintenance support, and integration with Building Management Systems (BMS) using either LonWorks® or BACnet® interfaces. The below figure illustrates a sample CMCN System Configuration.



CMCN System Configuration

D. CMCN: REMOTE CONTROLLERS - SIMPLE MA REMOTE CONTROLLER

1. The Backlit Simple MA Remote Controller shall be capable of controlling up to 16 indoor units (defined as 1 group).
2. The Backlit Simple MA Remote Controller shall only be used in same group with Wireless MA Remote Controllers or with other Backlit Simple MA Remote Controllers, with up to two remote controllers per group.

Simple MA Remote Controller			
Item	Description	Operation	Display
ON/OFF	Run and stop operation for a single group	Each Group	Each Group
Operation Mode	Switches between Cool/Drying/Auto/Fan/Heat/Setback. Operation modes vary depending on the air conditioner unit. Auto and Setback mode are available for the R2/WR2-Series only.	Each Group	Each Group
Temperature Setting	Sets the temperature from 40°F – 95°F depending on operation mode and indoor unit.	Each Group	Each Group

Simple MA Remote Controller			
Item	Description	Operation	Display
	Separate COOL and HEAT mode set points available depending on central controller and connected mechanical equipment.		
Fan Speed Setting	Available fan speed settings depending on indoor unit.	Each Group	Each Group
Air Flow Direction Setting	Air flow direction settings vary depending on the indoor unit model.	Each Group	Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter). *1: Centrally Controlled is displayed on the remote controller for prohibited functions.	N/A	Each Group *1
Display Indoor Unit Intake Temp	Measures and displays the intake temperature of the indoor unit when the indoor unit is operating.	N/A	Each Group
Display Backlight	Pressing the button lights up a backlight. The light automatically turns off after a certain period of time. (The brightness settings can be selected from Bright, Dark, and Light off.)	N/A	Each Unit
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed	N/A	Each Unit
Test Run	Operates air conditioner units in test run mode. *2 The display for test run mode will be the same as for normal start/stop (does not display "test run").	Each Group	Each Group *2
Ventilation Equipment	Up to 16 indoor units can be connected to an interlocked system that has one LOSSNAY unit.	Each Group	N/A
Set Temperature Range Limit	Set temperature range limit for cooling, heating, or auto mode.	Each Group	Each Group

E. CENTRALIZED CONTROLLER (WEB-ENABLED)

1. Master Centralized Controller:

The Master Centralized Controller shall be capable of controlling a maximum of two hundred (200) indoor units across multiple CITY MULTI outdoor units with the use of three expansion controllers. The Master Centralized Controller shall be approximately 11-5/32" x 7-55/64" x 2-17/32" in size and shall be powered with an integrated 100-240 VAC power supply. The Master Centralized Controller shall support system configuration, daily/weekly scheduling, monitoring of operation status, night setback settings, free contact interlock configuration and malfunction monitoring. When being used alone without the expansion controllers, the Master Centralized Controller shall have five basic operation controls which can be applied to an individual indoor unit, a collection of indoor units (up to 50 indoor units), or all indoor units (collective batch operation). This basic set of operation controls for the Master Centralized Controller shall include on/off, operation mode selection (cool, heat, auto (R2/WR2-Series only), dry, setback (R2/WR2-Series only) and fan), temperature setting, fan speed setting, and airflow direction setting. Since the master provides centralized control, it shall be able to enable or disable operation of local remote controllers. In terms of scheduling, the Master Centralized Controller shall allow the user to define both daily and weekly schedules (up to 24 scheduled events per day) with operations consisting of ON/OFF, mode selection, temperature setting, air flow (vane) direction, fan speed, and permit/prohibit of remote controllers.

Master Centralized Controller			
Item	Description	Operation	Display
ON/OFF	Run and stop operation.	Each Block, Group or Collective	Each Group or Collective
Operation Mode	Switches between Cool/Dry/Auto/Fan/Heat. (Group of Lossnay unit: automatic ventilation/vent-heat/interchange/normal ventilation) Operation modes vary depending on the air conditioner unit. Auto mode is available for the R2/WR2-Series only.	Each Block, Group or Collective	Each Group
Temperature Setting	Sets the temperature from 57°F – 87°F depending on operation mode and indoor unit.	Each Block, Group or Collective	Each Group

Master Centralized Controller			
Item	Description	Operation	Display
Fan Speed Setting	Available fan speed settings depending on indoor unit.	Each Block, Group or Collective	Each Group
Air Flow Direction Setting	Air flow direction settings vary depending on the indoor unit model. *1. Louver cannot be set.	*1 Each Block, Group or Collective	Each Group
Schedule Operation	Annual/weekly/today schedule can be set for each group of air conditioning units. Optimized start setting is also available. The system follows either the current day, annual schedule, or weekly, which are in the descending order of overriding priority. Twenty-four events can be scheduled per day, including ON/OFF, Mode, Temperature Setting, Air Direction, Fan Speed and Operation Prohibition. Five types of weekly schedule (seasonal) can be set. Settable items depend on the functions that a given air conditioning unit supports.	*2 Each Block, Group or Collective	Each Group
Optimized Start	Unit starts 5 - 60 minutes before the scheduled time based on the operation data history in order to reach the scheduled temperature at the scheduled time.	Each Block, Group or Collective	Each Block, Group or Collective
Night Setback Setting	The function helps keep the indoor temperature in the temperature range while the units are stopped and during the time this function is effective.	Each Group	Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter).	Each Block, Group or Collective	*3 Each Group

Master Centralized Controller			
Item	Description	Operation	Display
	Centrally Controlled is displayed on the remote controller for prohibited functions.		
Room Temp	Displays the room temperature of the group. Space temperature displayed on the indoor unit icon on the touch screen interface.	N/A	Each Group
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed When an error occurs, the LED flashes. The operation monitor screen shows the abnormal unit by flashing it. The error monitor screen shows the abnormal unit address, error code and source of detection. The error log monitor screen shows the time and date, the abnormal unit address, error code and source of detection	N/A	*4 Each Unit or Collective
Outdoor Unit Status	Compressor capacity percentage and system pressure (high and low) pressure (excludes S-Series)	Each ODU	Each ODU
Connected Unit Information	MNET addresses of all connected systems	Each IDU, ODU and BC	Each IDU, ODU and BC
Ventilation Equipment	This interlocked system settings can be performed by the master system controller. When setting the interlocked system, use the ventilation switch the free plan LOSSNAY settings between “Hi”, “Low” and “Stop”. When setting a group of only free plan LOSSNAY units, you can switch between “Normal ventilation”, “Interchange ventilation” and “Automatic ventilation”.	Each Group	Each Group
Multiple Language	Other than English, the following languages can be selected: Spanish, French, Japanese, Dutch, Italian, Russian, Chinese, and Portuguese.	N/A	Collective

Master Centralized Controller			
Item	Description	Operation	Display
External Input / Output	<p>By using accessory cables you can set and monitor the following.</p> <p>Input</p> <p>By level: "Batch start/stop", "Batch emergency stop"</p> <p>By pulse: "batch start/stop", "Enable/disable remote controller"</p> <p>Output: "start/stop", "error/Normal"</p> <p>Requires the external I/O cables (PAC-YG10HA-E) sold separately.</p>	*5 Collective	*5 Collective

2. All Master Centralized Controllers shall be equipped with two RJ-45 Ethernet ports to support interconnection with a network PC via a closed/direct Local Area Network (LAN) or to a network switch for IP communication to up to three expansion controllers for display of up to two hundred (200) indoor units on the main master centralized controller interface.
3. The Master Centralized Controller shall be capable of performing initial settings via the high-resolution, backlit, color touch panel on the controller or via a PC browser using the initial settings.
4. Standard software functions shall be available so that the building manager can securely log into each master centralized controller via the PC's web browser to support operation monitoring, scheduling, error email, interlocking and online maintenance diagnostics. Additional optional software functions of personal browser for PCs and MACs and Energy shall be available but are not included. The Energy Apportionment function shall require a LIC-Charge software license

F. GRAPHICAL USER INTERFACE

The Graphical User Interface (Integrated Centralized Control Web) shall require a field supplied PC or Tablet.

1. ICCW

The Integrated Centralized Control Web System (ICCW) interface shall enable the user to control multiple networked central controllers and shall provide additional functions such as energy apportionment from a single network PC configured with the Charge Calculation Tool. The ICCW shall be capable of controlling up to forty networked Centralized Controllers with a maximum of 2,000 indoor units across multiple CITY MULTI outdoor units. The ICCW shall be required if the user wants to simultaneously control

more than 1 Centralized Controllers from a single PC or tablet using a single web browser session. Licensing per function, per Centralized Controller shall be required for the ICCW. Optional software features shall be available through the ICCW including energy apportionment and personalized web. These optional software features shall require the ICCW, advance purchase from the customer, and licensing from ICCW.

ICCW (Integrated System Software)	
Item	Details
ON/OFF	The units can turn ON and OFF for all floors or in a block, floor, or group of units.
Operation Modes	The operation mode can be switched between COOL, DRY, FAN, AUTO, and HEAT for all floors or in a block, floor, or group of units
Temperature Setting	Sets the temperature for a single group. Range of Temperature setting from 57°F – 87°F depending on operation mode and indoor unit model. Separate COOL and HEAT mode set points available depending on remote controller and connected mechanical equipment.
Fan Speed	The fan speed can be set to four stages for all floors or in a block, floor, or group of units
Air Direction	The air direction can be set in four vertical directions or to swing for all floors or in block, floor, or group of units. (The selectable air direction differs according to the model.)
Interlocked Unit ON/OFF LOSSNAY	If there is an interlocked unit (LOSSNAY), then the unit can be turned ON (strong/weak) or OFF for all floors or in a block, floor, or group of units. (Note that the ventilation mode cannot be selected for interlocked units.)
Local Operation Prohibit	The items for which operation with the local remote controller are to be prohibited can be selected for all floors or in a block, floor, or group of units. (The items that can be prohibited are ON/OFF, operation mode, set temperature and filter sign reset.)
Annual / Weekly Schedule	The annual/weekly schedule function can be used by registering the license. Two settings, such as seasonal settings for summer and winter, can be saved.
Power Rate Apportionment Charging	A watt-hour meter (WHM) with kWH pulse output is connected to calculate the air conditioning charges based on the amount each tenant's air-conditioner has operated. Five charging rates can be applied per day.

ICCW (Integrated System Software)	
Item	Details
	***OPTIONAL ENERGY APPORTIONMENT SOFTWARE (LIC-CHARGE) and PI Controller (PAC-Y60MCA) REQUIRED
History	Up to 3,000 items for the error history and up to 10,000 items for operation history can be saved. Each history file can be output as a daily report or monthly report in CSV format. (The operation history consists only of the operations carried out with the ICCW and is limited to some limited operation items.)
Operation Time Monitor	The cumulative operation time of each indoor unit can be viewed or output as a CSV format file. (This function is valid only when the charging function license is registered.)
Filter Sign Display Mask	The filter sign display at the remote controllers can be disabled.
Set Temperature Limit	The set temperature lower limit can be set for cooling and the upper limit for heating. (ME remote controller required)