SECTION 230100 - GENERAL CONDITIONS

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section.

1.1 GENERAL CONDITIONS

A. Before submitting a proposal, Bidders shall examine all related to this work and shall become fully informed as to the extent and character of the work required and its relation to the other work in the building.

B. Before commencing work, the Contractor will examine all conditions of the project upon which his work is in any way dependent for perfect workmanship according to the intent of this Specification. No "waiver of responsibility" for incomplete, inadequate or defective adjoining work will be considered unless notice has been filed by this Contractor and acceded to by the Owner's representative in writing before the Contractor begins any part of the work.

C. The Contractor will pay for all licenses, permits and inspection fees required by civil authorities having jurisdiction. Comply with all laws, ordinances, regulations, and fire underwriter’s requirements applicable to work herein specified without additional expense to the Owner.

D. Small scale drilling through walls and floors or cutting of piping insulation which may contain asbestos shall be performed by a person with a “restricted asbestos handler allied trades certificate” and shall have a copy of it in his possession at all times while working of the project. This shall also apply to removal of piping, ductwork or equipment insulation.

E. It is specifically intended that anything (whether material or labor), which is usually furnished as a part of such equipment, as is hereinafter called for (and which is necessary for the completion and proper operation) shall be furnished as part of this Contract without additional cost the Owner, whether or not shown in detail or described in the Specifications.

F. When Drawings and Specifications conflict or there is a question as to the proper intent of this Contract, the Contractor shall assume the greater quantity, the higher quality and/or the more expensive method in his pricing. All questions shall be directed to the Architect/Engineer in writing only and only up to ten (10) days prior to bidding.

G. The Drawings indicate the general runs of the piping, ductwork, etc. systems and the location of equipment and apparatus, however it shall be understood that the right is reserved by the Architect/Engineer to change the location of piping work, ductwork, equipment and apparatus to a reasonable extent as building conditions may dictate, prior to their installation without extra cost to the Owner.

H. All components supplied by this Contractor shall be UL listed and/or ETL labeled and shall conform to ASHRAE Standard 15.

I. Any changes from the Drawings and Specifications and any interpretation thereof shall have the prior approval of the Architect/Engineer. The Contractor shall submit in writing, at the time of signing the Contract, any items of necessary labor and materials, which, in his opinion, are lacking in requirements of the Drawings and Specifications to insure a complete job in all respects. No consideration will be granted to alleged misunderstanding of materials to be furnished, work to be done, or conditions to be complied with, it being understood that the tender of a proposal carries with it the agreement to all items and conditions referred to herein, or indicated on the accompanying Drawings.

END OF SECTION 230100

SECTION 230110 - SCOPE OF WORK

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section.

1.1 SCOPE OF WORK

A. The work under this section includes all labor, materials, equipment, tools, transportation, and the performance of all work necessary and required for the furnishing and installation complete of all work as shown on the Contract Documents, including but not necessarily limited to the following:

1. Hot water heating boilers with oil burners.

2. Exhaust, fans and related appurtenances.

3. Outdoor heat pumps and associated indoor units (not in scope, by owner).

4. Air handling units and related appurtenances.

5. All required piping, valves, and related specialties.

6. Inline centrifugal pumps.

7. Variable frequency drives.

8. Fin-tube radiation and cabinet and unit heaters.

9. Sheetmetal ductwork and related accessories.

10. Duct and pipe insulation.

11. Registers, diffusers, and dampers.

12. Fuel oil tank(s) with remote monitoring/alarm and fueling station/dispenser.

13. Fuel tank(s) removal per applicable codes.

14. Rigging of equipment.

15. Furnish all combination motor starter/disconnects for equipment (with the exception of starters and electric items already mounted on equipment or equipment not requiring same). Fan motor starter/disconnects shall have contacts for ATC connection and a terminal block connection for Fire Alarm fan shutdown. Starters per manufacturers recommendations. Underwriters inspection and certificate required. Coordinate with Electrical Contractor.

16. Air and Water Balancing.

17. Automatic temperature controls with complete wiring (regardless of voltage).

18. Testing, adjusting and start-up of equipment.

19. Painting and identification of all equipment and piping.

20. Firestopping per NFPA requirements (UL approved systems).

21. Operating and maintenance instructions.

22. As-Built Drawings - Refer to Division 1.

23. Cutting and Patching - Refer to Division 1.

24. Excavation and Backfill - Refer to Division 2.

B. Coordination Drawings (if applicable): Attention is directed to Division 1 for coordination drawing requirements for this project. These drawings are critical to the proper execution of the work and failure to honor these requirements may become the basis for denial of any and all claims for either or both “time” and “money”.

1.2 REMOVALS

A. Removals should be coordinated with other trades affected.

B. Removal of any piece of equipment or terminal device shall include removal of connecting ductwork and piping back to existing mains that remain. Cap each branch air/water-tight. Controls and control components shall also be removed. Do not leave components (controllers, pneumatics, etc.) that have no function. Provide control wiring, ductwork, piping, etc. as necessary to maintain continuity of service for equipment or terminal devices to remain.

C. Piping which penetrates the construction may be cut and capped provided capping is done beneath the finished surfaces so that construction over it can be achieved.

D. Soot Removal: In connection with the dismantling of boilers, Contractor shall gather together with a vacuum-cleaning machine all accumulations of soot. He shall remove all soot from the base of the chimney.

E. All removals shall be removed from the site.

1.3 ALTERATION WORK

A. All equipment, piping, control components, etc. to be removed, shall be disposed of or salvaged as directed by the Owner. They shall not be removed from the premises without the Owner’s approval.

B. All piping to be removed shall be properly plugged or capped so that upon completion of all new work, all abandoned piping shall be concealed in finished areas.

C. No dead ends shall be left on any piping upon completion of job. The existing system shall be left in perfect working order upon completion of new work.

D. Location and sizes of existing piping, ductwork, equipment, etc. are approximate. Exact sizes and locations of all existing work shall be verified on the job.

1.4 OIL TANK REMOVAL

A. Requirements of Regulator Agencies: Comply with applicable provisions of regulatory agencies below and others having jurisdiction:

1. Underwriters' Laboratories, Inc. UL-1316.

2. National Fire Protection Association.

3. United States Environmental Protection Agency.

4. Local and State Building Codes and Ordinances

a. The New York State Uniform Fire Prevention and Building Code.

b. State of New York local codes and ordinances Department of Environmental Protection Division.

c. The New York State Department of Health Requirements.

d. New York State Department of Environmental Conservation (NYDEC).

e. Westchester County Sanitary Code Article XXV.

5. Permits: Contractor shall obtain, file and pay for all required permits, fees and inspections.

A. Remove existing oil tank from site per New York State codes.

1. Tank / piping / concrete pad etc. for complete removal.

2. Test for contaminated soil per code and remove any contaminated soil. (see front end spec)

3. Remove remaining oil and transport to location within the district per owner.

4. Backfill to grade with approved material.

END OF SECTION 230110

SECTION 230120 - BOILERS / BURNERS

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

1.1 GENERAL REQUIREMENTS

A. Furnish and install (2) low pressure, wet base, cast iron sectional boiler(s) with power burner(s) that pressurize the firebox and operate under forced draft.

B. Assemble and install boiler-burner unit(s) in compliance with manufacturer's installation instructions. All work must be done in a neat and workman like manner.

C. Weil-McLain BL-11 80-W F boiler(s) with burner(s) capable of burning No. 2 fuel oil.

1. (P) Boiler-burner unit completely packaged and fire tested
2. (A) Boiler-burner unit with factory assembled sections.
3. (B) Boiler-burner unit Field assembled (standard).
4. (L) No. 2 fuel oil.
5. (W) Water.

D. Boiler(s) shall have AHRI gross output(s) at 100% firing rate – 1229 MBH per boiler.

E. Boiler(s) shall be manufactured to conform to Section IV of the ASME Boiler and Pressure Vessel Code.

1. Individual sections to be hydrostatically pressure tested at factory in accordance with ASME requirements.

2. Individual sections shall bear the ASME symbol as well as the “MAWP WATER 80 PSI” and “MAWP STEAM 15 PSI” on the outside surface of each section.

3. The boiler rating label shall read Maximum Allowable Working Pressure 80 PSI water and 15 PSI steam.

F. Regulatory Requirements

1. Boiler(s) and controls to comply with applicable regulations.
2. Provide U.L. labeled burner(s).
3. Provide add option for local code(s) ie: MASS Code, BAR

G. Submittals

1. Submit shop drawings and product data.
2. Submittal packet to include boiler (and burner) manufacturer descriptive literature, installation instructions, operating instructions, and maintenance instructions.

PART 2 - PRODUCTS

2.1 BOILER / BURNER UNITS

A. Acceptable boiler/burner manufacturer(s) include(s):

1. Weil-McLain only, as specified in Part I, Paragraph C.

2. Other manufacturer(s) or other Weil-McLain boiler(s) must comply with specifying engineer's requirements, including:

a. Full intent of these specifications, and provide complete submittal including literature, wiring diagrams, fuel piping diagrams, and a list of similar installations.
b. Submittal to be presented to specifying engineer at least seven working days for approval before bid opening. Substitutions are not permitted after contract is awarded.
c. Burner(s) and Energy Management Control System(s) must be tested and approved for installation with specified boiler by boiler manufacturer.

B. Boiler Construction

1. Cast Iron sections
2. Assembled with short, individual draw rods.
3. Cast with sealing grooves for high temperature sealing rope to assure permanent gas-tight seal.
4. Sealed watertight by elastomer sealing rings, not cast iron or steel nipples. Each port opening is machined to completely capture sealing ring between sections.
5. Must be hydro-wall design to provide completely water-cooled combustion chamber.
6. Provided with sufficient tappings to install required controls.
7. Limited 10-year warranty against workmanship and defects to be in writing by manufacturer.

C. Boiler(s)

1. Boiler(s) to be designed with a top flue outlet.
2. Provided with cast-in air elimination to separate air from circulating water.
3. Provided with expansion tank tapping to divert separated air to expansion tank.
4. Constructed to provide balanced water flow through entire section assembly using single supply and return connections for water. No external headers are necessary for water. Steam requires an external header 24" minimum from the waterline to the bottom of the header.
5. Designed with a low silhouette to provide maximum headroom.
6. Furnished with insulated burner mounting plate having necessary holes and tappings to mount burner. High temperature sealing rope is used to provide permanent gas-tight seal between front section and plate.
7. Furnished with two observation ports (one in front and one in back) to allow visual inspection of the flame.
8. Provided with steel flue damper assembly with a built-in adjustable damper capable of being locked into place after adjustment.

9. Furnished with flanged aluminized steel flue collector hood bolted to top of section assembly.
10. High temperature sealing rope used to provide permanent gas-tight seal between hood and section assembly.
11. Furnished with heavy-duty ¼" steel cleanout plates to cover cleanout openings on the side of the boiler(s).
12. Port openings must be of captured seal design – a machined groove assures uniform compression of the sealing ring and protects the seal from contaminants. Elastomer sealing rings are to be used to provide permanent watertight seal between sections. Unlike cast iron or steel push nipples, the elasticity of the seals fills any gaps caused by misalignment or expansion and contraction.
13. Provided with flexible refractory blankets to be attached to back and floor of combustion chamber.
14. Shipped with insulated heavy gauge steel jacket(s) with durable powdered paint enamel finish. Jacket designed to be installed after connecting supply and return piping.
15. Jacket design will allow easy access to top and sides of boiler for maintenance and/or inspection without use of tools.

D. Boiler foundation(s):

1. Installer to construct needed support and level concrete foundation(s) where boiler room floor is uneven or will not support the weight of the boiler(s).

E. Boiler trim:

1. All electrical components to be of high quality and third (3rd) party recognized.
2. Water boiler(s) standard controls furnished:

   a. Combination low temperature limit (operating) and high temperature limit control.

   b. Low temperature limit set according to system design. High temperature limit set at least 20°F higher than the low limit (240°F is the maximum allowable water temperature).

   c. Combination pressure-temperature gauge with dial clearly marked and easy to read.

   d. ASME certified pressure relief valve, set to relieve at 30 PSIG. Side outlet discharge type; contractor to pipe outlet to floor drain or near floor, avoiding any area where freezing could occur.

2.2 BURNER(S), CONTROL PANELS AND START-UP & SERVICE

A. Burner(s)

1. Burner fuel supply system and burner installation to conform to burner manufacturer's installation instructions and applicable codes.

2. Burner motor characteristics: 240/60/1.

3. Control characteristics 120/60/1.

4. Burner fuel – No. 2 fuel oil.

5. Code(s) - standard boiler.

6. Burner(s) to have U.L. label(s) supplied by the burner manufacturer.

7. Burner(s) designed to ensure high efficiency and good performance under forced draft conditions with 0.1" W.C. positive pressure at the flue collar.

8. Burner(s) to be adjusted to provide 12% CO2 (± ¼%) with zero smoke for oil firing.

9. Burner(s) manufactured by: Power-Flame, or approved equal.

10. Burner operating mode: Low-High-Off

B. Panel options – power on/fuel on light is standard on all burner(s) with panels.

1. Call For Heat
2. Ignition On
3. Pilot Failure
4. Low Water
5. Flame Failure
6. Silencing Switch
7. Control Fuse and Holder
8. Post Purge Timer
9. Alarm Bell

C. Start-up and Service

1. The contractor shall obtain the services of a factory-authorized agent to provide burner light off and adjustment. The start-up agent shall provide a burner light-off report as written proof that the burner was adjusted to optimum performance.

2. The authorized agent shall provide a one-year service warranty after start-up.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories, and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230120

SECTION 230130 - BOILER START-UP AND TESTING

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section.

1.1 BOILER START-UP AND TESTING

A. Before any water is added to the boiler for testing or other purposes, a sufficient amount of sodium sulphite (to provide a residual of 100 p.p.m.) shall be added to the boiler water to prevent deterioration due to dissolved oxygen in the boiler water. When ready for firing the Contractor shall clean the boiler internal surfaces in the following manner:

B. Fill the boiler with fresh water.

C. Dissolve Metro Boiling Out Compound (or mixture of equal parts of trisodium phosphate, caustic soda and soda ash) at the rate of 1 pound per 20 gallons.

D. Dosage: 50 pounds per 1000 gallons of water content of the boiler.

E. Connect 2" full size blow off line to blow off tapping located near the boilers normal water line. The discharge of this shall be piped full size to a suitable drain.

F. Heat the boiler for a period of 16-24 hours without generating steam.

G. Open the blow off valve and feed the boiler with fresh water, maintaining a "normal" water line while "skimming" all oil and grease from the top blow off line.

H. Continue this procedure until the water is clear and free of any oil or grease.

I. Drain the boiler and flush thoroughly with a hose through the manhole opening until all signs of debris, oil, grease and mill scale are removed.

J. Fill with fresh water, treated either with Chem Aqua 999 boiler treatment (hot water systems), or sufficient quantity of sodium sulphite to raise the level to 100 p.p.m. (steam systems).

K. Raise the level of the water to the steaming point to remove as much dissolved oxygen as possible.

L. Re-test the level of sodium sulphite or boiler water treatment, adding sufficient to raise protection to the proper level.

M. Note: In the event of a boiler contaminated with large quantities of oil or grease it may be required to repeat this procedure. Procedure shall be repeated until ALL traces of oil and grease are removed from the boiler.

N. Contractor shall operate the boiler for a minimum of eight hours, following the above procedure, during which time valves to system and terminal units shall be in the open position and all returning water shall be wasted to drain. The purpose to remove as much scale and dirt from the piping system. During this period of operation, the residual level of water treatment of sodium sulphite shall not be allowed to fall below 100 p.p.m.

O. Upon completion of the above, the Contractor shall close manholes and handhole mating surfaces.

P. Provide chemical pot feeder for each boiler where shown on Drawings.

Q. The By-pass Feeders shall be equal to Griswald DB-5-SB-CS-2, 5-gallon pot feeder, domed bottom, ASME rated, 600 psi @ 250 degrees F.

END OF SECTION 230130

SECTION 230140 - DOUBLE WALL INSULATED BOILER BREECHING SYSTEM AND WATER HEATER FLUE (HOT WATER FLUE NOT IN SCOPE, BY OWNER)

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

PART 2 - PRODUCTS

2.1 DOUBLE WALL INSULATED BOILER BREECHING SYSTEM

A. Factory built modular breeching shall be laboratory tested and listed by the Underwriters Laboratories, for use with building heating equipment burning gas, solid or liquid fuels as described in NFPA 211, which produce exhausted flue gases at a temperature not exceeding 1400 degrees under continuous operating conditions. UL listing shall be for both temperature and pressure. The breeching and the stack shall be sealed and pressure tight at the operating pressures of the boiler outlet.

B. The breeching and the stack shall be sealed and pressure tight at the opening pressures of the boiler outlet. Double wall vent system shall be as manufactured by Metal-Fab IPIC-2 pressurized system or approved equal.

C. The double wall breeching shall have an inner gas carrying pipe of type AL294C stainless steel. The inner wall shall be .035” minimal thickness. The outer jacket shall be aluminum coated steel .25” nominal thickness for 6” through 24” diameters. A 2” thick layer of insulation shall occupy the space between the inner and outer walls, of the entire section of the breeching and stack.

D. Inner pipe joints shall be sealed by use of V Bands and RTV Silicone Sealant.

E. Roof penetrations shall be suitable for a non-combustible roof and shall be according to the Drawings. Provide stainless steel rain cap and any required firestops and flashing.

F. The breeching shall be warranted against functional failure due to defects in material and workmanship for a period of ten (10) years from date of delivery. Functional failure is defined as any failure of the system or a component to perform its intended function without adverse leakage. During this period any defective system or component shall be repaired or replaced. Three actions are required by the Contractor to place the warranty in effect.

1. Shop drawings showing the actual layout and drawn to scale shall be provided by the manufacturer. The system shall be installed as designed by the manufacturer and in accordance with the terms of the manufacturer’s 12-year warranty.

2. The inner diameter for breeching and stack shall be verified by the manufacturer’s computer. The computer program shall be technically sound, shall follow ASHRAE calculation methods, and incorporate the specific flow characteristics of the inner pipe.

3. The Contractor shall furnish the exact boiler model and operating characteristics to the factory representative. Operating characteristics shall include flue gas flow rate, temperature, velocity and available external static pressure at boiler outlet, at maximum and minimum levels of burner turndown range.

G. Aluminized steel surfaces exposed to the elements shall be protected by a minimum of one base coat of primer and one finished coat of corrosion resistant paint such as series 4200 or 4300 as manufactured by Rust-o-leum. Paint to be supplied by the installing Contractor.

H. Technical Services

1. The factory built modular breeching system shall be furnished and coordinated by a vendor organization which specialized in the application of packaged boiler systems, to assure design, installation and service coordination and to provide in-warranty and post-warranty unified responsibility for Owner, Architect, consulting Engineer and Contractor.

2. Breeching vendor organization shall obtain boiler operating characteristic for the manufacturer as input for developing system configuration and parameters. Vendor shall transmit detailed stack/breeching design diagrams to Architect and consulting Engineer and shall provide periodic supervision of installation for the trade Contractor.

3. Vendor shall provide inspection report to consulting Engineer, after completion of installation, verifying proper condition of breeching system.

I. Gas Flue: Furnish and install where shown on the Drawings, flue/breeching vent pipe for gas burning equipment equal to Metal-Fab type “B” or approved equal, including all fittings, brackets, support plates and fittings, all as required to carry out the full intent. Install flue vent in accordance with the National Fuel Gas Code, NFPA No. 54.

J. Equipment and components shall be in compliance with all standards of Air Movement and Control Association (AMCA), which apply to the various air moving equipment types, and with requirements of AMCA Certified Rating Program.

K. Equipment shall be in compliance with ANSI/AMCA Standard 210-85 laboratory methods of testing fans.

L. Compliance with ASHRAE Standard 111-1988 practices for measurement, testing, adjusting and balancing of building heating, ventilating, air conditioning and refrigeration systems.

M. Submit shop drawings for approval that shall include dimension drawings, catalog cuts, performance and construction schedules.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230140

SECTION 230150 – ABOVEGROUND DOUBLE-WALL FUEL OIL STORAGE TANK AND ACCESSORIES

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section.

1.1 DESCRIPTION OF WORK

A. Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install double walled aboveground fuel oil storage tank(s) and accessories complete with all appurtenances including tank(s) and piping leak detection, monitoring and alarm systems.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Manufacturer shall have a minimum of five (5) years experience in producing similar equipment and shall show evidence of least five (5) installations in satisfactory operation.

B. Requirements of Regulator Agencies: Comply with applicable provisions of regulatory agencies below and others having jurisdiction:

1. Underwriters' Laboratories, Inc. UL - 142, UL - 2085 for Insulated Secondarily Contained.
2. National Fire Protection Association 30, 30A, and 31
3. United States Environmental Protection Agency
4. Local and State Building Codes and Ordinances

    a. The New York State Uniform Fire Prevention and Building Code.
    b. State of New York local codes and ordinances Department of Environmental Protection Division.
    c. The New York State Department of Health Requirements.

5. Permits: Contractor shall obtain and pay for all required permits, fees and inspections.

C. Source Quality Control - UL inspection and labeling as follows:

1. UL inspection and labeling UL-142, UL - 2085 Insulated Secondarily Contained.
2. Factory Mutual inspection and labeling.
3. Perform the following tests and inspection at factory.

    a. Primary and Secondary tank wall field pressure tested to a maximum 3 p.s.i., factory tested 25 p.s.i.
    b. UL inspection and labeling.

D. Operations and Maintenance Data - Submit complete manuals including:

1. Copies of all shop drawings, test reports, maintenance data and schedules, description of operation, and spare parts information.

1.3 SUBMITTALS

A. Shop Drawings - Submit for approval the following:

1. Manufacturer's literature, illustrations, specifications, engineering data, materials of construction, dimensions.

2. The manufacturer of the tank(s) shall submit shop drawings of the tank(s) for approval. The shop drawing shall indicate the size, construction data, tapping connections and location of the tappings, also details of anchoring and holddown straps.

3. Tank(s) gauge assembly, high level switch, high level alarms and tank(s) accessories.

4. Fuel oil tank and piping leak detection system, all components, wiring diagrams and manufacturer's literature.

5. Integral overfill and spill containment chamber details.

B. Warrantee: Vault manufacturer shall provide certificate of insurance that provides a minimum of Eleven Million Dollars ($11,000,000,00) of product liability coverage per occurrence. The vault tank manufacturer shall include a warranty for 30 years. The Vault manufacturer warranty shall cover the primary and secondary tank walls.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Delivery and Handling

1. Tank(s) shall be lifted off delivery truck and not rolled, dropped or impacted in accordance with manufacturer's recommendations.

2. Use lifting lugs with spreader bars if tank(s) has two or more lift lugs.

3. The manufacturer's price shall include the cost of all shipping permits and transportation to deliver the tank(s) to the jobsite.

B. Storage

1. Tank(s) shall be stored on smooth ground free rocks and other damaging objects.

2. Tank(s)s shall be chocked with support wedges and tied down with nylon rope to prevent being blown by wind.

3. Vent tank(s) to allow for temperature changed during storage and installation.

4. Protect openings to prevent damage to flanges and exclude foreign matter.

C. General: Comply with manufacturer's recommendations in handling and storing tank(s).

1.5 JOB CONDITIONS

A. Coordinate with other Contractors for excavation work and aboveground piping layout to avoid any conflicts with installation. Contractor to field verify exact location of tank(s) installation.

PART 2 - PRODUCTS

2.1 DESCRIPTION OF WORK

A. The Contractor shall furnish the labor, materials, equipment, appliances, services and hauling, and perform operations in connection with the removal, construction and installation of the work. Work shall be as herein specified and as denoted in the accompanying Drawings. The tank(s) manufacturer shall provide complete package spill containment, emergency vents, vent caps, leak detection and monitoring system with applicable warranties.

B. Provide one (1) 550 gallon aboveground double wall Fire Rated Vault type with integral spill and overfill containment chamber, vent caps, anchor pad, electrical conduit vent piping etc. to make a complete installation ready to use.

C. The Owner will provide fuel to fill tank(s). Contractor shall notify Owner in advance of setting date of tank(s) for Owner to fill immediately thereafter.

2.2 GOVERNING STANDARDS

A. UL Standard 2085 for insulated Secondary Containment Aboveground Tank(s) for Flammable and Combustible liquids. Tank(s) shall carry the UL 2244 listing for tank(s) and equipment. UL 142 Standard for primary and secondary steel tank(s) wall construction. Tank (s) shall have a minimum of 110% secondary containment.

B. National Fire Protection Association, NFPA 30 and 30A for "fire resistant" tank(s)s and meet the requirements of the Uniform Fire Code Articles 52 and 79, Appendix standard A-11-F-1 for "protected" aboveground tank(s). BOCA and SBCCI building Code approval, CARB Certified for Stage I and II Vapor Recovery.

C. The standard Fire Protection material shall be lightweight concrete and surrounded by the primary tank(s) UFC Appendix Standard A-II-F (formally UPC 79-7).

D. The tank(s) and piping shall be properly installed in accordance with the manufacturer's instructions and either "Petroleum Equipment Institute Recommended Practices for Installation of Aboveground Liquid Storage Systems" or "American Petroleum Institute Publication Installation of Aboveground Petroleum Storage Systems".

E. UL 971 - Non metallic pipe and UL standard 567-89 pipe connections for flammable and combustible products.

F. ASTM specification A53. Pipe and steel, black and hot dipped, zinc coated welded and seamless.

2.3 QUALITY ASSURANCE

A. Tank(s) shall be double wall steel with a fiberglass coating with an interstitial lightweight concrete filler and constructed to meet governing standards with certification plate (UL Label) affixed.

B. Shop Drawings

1. Contractor shall submit 5 copies of shop drawings for tank(s). Drawings shall include all critical dimensions, locations of fittings and accessories, i.e.: spill containment, etc.

2. All tank(s) equipment and piping materials shall be physically inspected and air tested before being installed. Any defects observed shall be immediately brought to the attention of the Owner. It shall be the sole responsibility of the Contractor to correct any deficiencies, with the manufacturer in strict accordance with manufacturer's recommendations, at no additional cost to the Owner.

3. Contractor shall submit 5 copies of manufacturer's literature including 5 copies of manufacturer's current installation instructions to the Owner.

C. The Contractor shall be a licensed AST installer in the State of New York, during the entire duration of the project. The Contractor shall have the responsibility of notifying and coordinating with all local and state officials. All inspection and registration fees shall be paid by the Owner. The Contractor shall coordinate with the Owner to provide a written site safety plan.

2.4 ACCEPTABLE MANUFACTURERS

A. Fuel Storage Tank(s): Containment Solutions, Inc. Beta Tank, Belco Tank, Highland Tank.

B. Tank(s) Leak Detection System: Pneumercator, Veeder Root, Preferred.

C. Spill Containment: Shall be integral with the tank(s) per manufacturer.

D. Overfill Prevention Assembly: Guillotine, OPW, EBW

E. Flexible Piping: APT, Environ, Total Containment.

F. Inventory Gauging System: Pneumercator, Preferred, Veeder Root.

G. Bumper Posts: Riverside, Fairfield, Universal.

H. Remote Fill Assembly: Simplex, CSI, OPW

I. Manufacturer equals must be submitted to Engineer a minimum of 14 days prior to bidding. No concrete exterior tanks are acceptable.

2.5 FUEL STORAGE TANK(S)

A. Fuel Storage Tank(s): Provide one (1) 550 gallon aboveground double wall steel vault tank(s) with two hour fire rating UL 2085 secondarily contained. Minimum 110% secondary containment.

B. Primary Storage Tank(s): The standard storage tank(s) shall be rectangular in design. It shall be constructed of UL 142 specified steel thickness with continuous welds, inside and out.

1. The primary storage tank(s) shall be constructed of ASTM A-569 or A-36 carbon steel, as required for compatibility of product being stored.

2. The primary tank(s) shall be fitted with a 2” fill port, 2” normal working vent, 4” emergency vent port, a 2” liquid gauging port, and two (2) 2” spare ports.

3. The primary tank(s) shall be pressure tested UL 142 Standard (minimum 3 to 5 p.s.i.) at the factory and shall be field tested by the Contractor.

4. The primary tank(s) shall be compatible with all petroleum regulated products.

C. Fire Protection: The standard fire protection material shall be lightweight concrete and surround the primary tank(s). The tank(s) design shall provide a minimum two (2) hour fire rating per UTC Appendix Standard A-II-F (formally UFC79-7) and UL 2085 Protected Secondary Containment Tank(s).

1. The fire protective material shall allow liquid leaking from the primary tank(s) to penetrate the material and communicate with the leak detection tube according to UL 2085 Protected Secondary Containment.

2. The fire protective material shall be of a monolithic pour, performed at the factory.

3. The fire protective material shall provide an R 10 insulating factor.

D. Bullet Resistance: The fire protected primary tank(s) shall be tested by a qualified engineering firm to be resistant to penetration of the primary tank(s) by a 150 grain, M 2 Bullet traveling at a velocity of at least 2700 feet per second, when fired from a .30 caliber rifle, located a maximum of 100 feet from the target.

1. The fire protected tank(s) must be able to be repaired in the field by a factory representative, when impacted by a bullet.

2. The factory representative must be able to certify that the primary and secondary containment do not leak, and the fire protected material regains its maximum two (2) hour protection.

3. The vault tank(s) shall include a warranty for 30 years provided by the Manufacturer.

E. Secondary Leak Containment Tank(s): The secondary leak containment tank(s) shall be rectangular in design and constructed of UL 142 specified steel thickness, with continuous welds inside and out, and listed according to UL 2085 insulated secondary aboveground tank(s) for flammable and combustible liquids.

1. The secondary tank(s) shall be tested liquid tight at the factory and shall be field tested. (minimum 3 p.s.i.) by the Contractor.

2. The secondary tank(s) shall be fitted with a 2” monitoring port, and 4” emergency vent, in addition to openings for all ports in the primary tank. Tank(s) shall have side mounted pipe brackets, and top mounted brackets for electrical conduit.

3. The secondary tank(s) shall provide true 360 degree radius pressure testable containment by the primary tank(s).

4. The port openings in the top of the secondary tank(s) shall be constructed with full welds to prevent moisture from seeping between the fire proofing material and secondary and primary tank(s).

5. The top of the tank(s) shall be sloped as that water will not accumulate on the top of the tank(s).

6. The secondary tank(s) shall have a 2” monitoring post including a tube, which provides a means to detect product leakage from the primary tank(s) into fire protection material that directly surrounds the primary tank(s). The design shall be listed under UL 2085 secondarily contained tank(s).

7. Threaded fittings on UL labeled tank(s) shall be of a material of construction consistent with the requirements of the UL label.

F. Fuel Oil Storage Tank(s) connections

1. 2” fill line through spill containment to primary tank(s).
2. 2” primary tank(s) working vent.
3. 2” mechanical level gauge.
4. 4” primary tank (2) emergency vent.
5. 2” return line.
6. 2” supply line.
7. 4” secondary containment emergency vent.
8. 2” secondary monitor port.
9. 2-2” misc. lines.

2.6 TANK(S) LEAK DETECTION SYSTEM

A. Tank(s) shall provide an interstitial space between the primary and secondary tank(s) walls to allow for free flow of monitoring liquid between tank(s)'s walls and containment of any released product from the primary tank(s). Interstitial electronic monitoring device shall be installed into the interstitial space and shall be wired directly to the product inventory gauging and leak detection panel. Contractor shall provide all electrical wire and intrinsically safe electrical conduit for safe operation of the monitoring system.

2.7 OVERFILL PREVENTION ASSEMBLY

A. Overfill prevention valve shall be 3" diameter assembly capable of restricting flow into the tank, with pressure relief valve.

2.8 ALCOHOL COMPATIBLE PRODUCT PIPING

A. Primary product piping from tank(s) to the transition sump shall be schedule 40 galvanized pipe. Pipe shall be protected from corrosion. Installing Contractor shall install a transition sump allowing for the safe transition from galvanized pipe to alcohol compatible double wall flexible pipe. Transition sump shall offer spill containment in the event a leak should occur at the transition from one pipe material to another. Transition sump shall allow for access at grade.

2.9 PRODUCT INVENTORY GAUGING SYSTEM

A. Provide an electronic monitoring panel for interstitial monitoring and inventory and alarm information.

B. Hardware: A wall mounted console with liquid crystal display for on-site viewing of all inventory and alarm information.

C. A panel keyboard with control functions for programming, operating and reporting.

D. An integral and internal remote audible warning and alarm indicator for low and high fuel, high water levels, leaks, hardware failure, and external input.

E. A report printer for hard copy documentation of inventory, leak detect and alarm information.

F. Inventory probe with built in diagnostics.

G. An internal and external remote alarm for high, low fuel, high water, leaks hardware failure.

H. No more than two wires between each probe and the control console.

I. 100% methanol compatible probes.

J. Operating Capabilities: The ability to monitor inventory in up to eight tank(s)s and produce a combination of automatic and manual reports which include the following

information:

1. Fuel Volume
2. Fuel Height
3. Water Height
4. Ullage to 90% and 95% full
5. Last inventory increase amount
6. Last alarm history
7. Time and date
8. Tank(s) identification
9. Fuel identification
10. Sensor identification

K. Programmable alarm limits to warn of:

1. Leaks
2. Overfills
3. High Level Alarm
4. High Water
5. Low Inventory
6. External Input

2.10 REMOTE FILL ASSEMBLY

A. Contractor shall install a remote fill assembly with spill containment. Remote fill shall be installed on the tank(s) by the tank(s) manufacturer and shall be mounted on the end of the tank(s). Galvanized piping shall be used to connect the “Fill Port” remote fill assembly to the primary tank(s) fill fitting. Fill port shall include a lockable access door, and a manual hand pump.

2.11 INSTALLATION OF TANK

A. The foundation of the tank(s) must be designed to support the total tank(s) weight plus 100% of the weight of the maximum amount of product the tank(s) will be storing. The foundation shall be concrete and with a minimum 3.000 p.s.i. rating. The pad thickness shall be at least 12” with two layers of rebar. First layer shall be #4 rebar, 3” off of the bottom. 12” on center both ways. Second layer shall be #3 rebar, 3” from the top, 18” on center both ways. Consult local building codes for correct frost footings that may be required to be part of the pad.

B. Stable material and must include provisions in its design to prevent tank(s) movement. The foundation design must also include provisions for draining surface water away from the tank(s) to minimize corrosion.

C. The tank(s) must be installed in accordance with all Local, State and Federal Environmental Safety Codes.

D. Tank(s) must be grounded per local codes.

E. Tank(s) shall be protected and secured from vandalism. The tank(s) shall also be protected from accidental damage, such as vehicular impacts in accordance with all

local applicable codes.

F. Do Not Drop or Drag the Tank(s).

G. Proper lifting equipment shall be supplied by the Contractor to properly lift the tank(s) into place.

H. Tank(s) shall be carefully handled to prevent damage to the exterior tank(s) coating. The use of the nylon straps is preferred to prevent damage to the tank(s) coating. When using cables/chains they shall be padded and of adequate length and size.

I. It is the responsibility of the Contractor or buyer to touch-up and repair any damage to the coating that occurs during transportation, installation or piping.

J. The inner tank(s) must be empty before the tank(s) is moved.

K. Installing Contractor shall be familiar with all the manufacturers installation and testing procedures.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230150

SECTION 230175 - FUEL OIL PIPING

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section. Submit shop drawings for checking and approval.

1.1 SUMMARY

A. Section Includes:

1. Fuel-oil pipes, tubes, and fittings.
2. Double-containment piping and fittings.
3. Piping specialties.
4. Joining materials.
5. Specialty valves.
6. Mechanical leak-detection valves.
7. Labels and identification.

1.2 DEFINITIONS

A. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

B. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

C. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

1.3 ACTION SUBMITTALS

A. Product Data - For each type of product.

1. Include construction details, material descriptions, and dimensions of individual components and profiles.

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

3. For valves, include pressure rating, capacity, settings, and electrical connection data of selected models.

B. Shop Drawings - For fuel-oil piping.

1. Include plans, elevations sections, hangers, and supports for multiple pipes.

2. Include details of location of anchors, alignment guides, and expansion joints and loops.

3. Scale: 1/4 inch per foot.

C. Delegated-Design Submittal: For fuel-oil piping indicated to comply with performance requirements and design criteria.

1. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Detail fabrication and assembly of anchors and seismic restraints.
3. Design Calculations: Calculate requirements for selecting seismic restraints.
4. Detail fabrication and assembly of pipe anchors, hangers, supports for multiple pipes, and attachments of the same to building structure.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings

1. Plans and details, drawn to scale, on which fuel-oil piping is shown and coordinated with other installations, using input from installers of the items involved.
2. Site Survey: Plans, drawn to scale, on which fuel-oil piping and tanks are shown and coordinated with other services and utilities.

B. Brazing certificates.

C. Welding certificates.

D. Field quality-control reports.

E. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel-oil equipment and accessories to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.7 QUALITY ASSURANCE

A. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code.

1.8 DELIVERY, STORAGE AND HANDLING

A. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.

B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

C. Store pipes and tubes with protective PE coating to avoid damaging the coating and to protect from direct sunlight.

D. Store PE pipes and valves protected from direct sunlight.

1.9 FIELD CONDITIONS

A. Interruption of Existing Fuel-Oil Service: Do not interrupt fuel-oil service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary fuel-oil supply according to requirements indicated:

1. Notify Architect/ Owner no fewer than two days in advance of proposed interruption of fuel-oil service.
2. Do not proceed with interruption of fuel-oil service without Architect/Owner written permission.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of flexible, double-containment piping and related equipment that fail in materials or workmanship within specified warranty period.

1. Failures due to defective materials or workmanship for materials including piping, dispenser sumps, water-tight sump entry boots, terminations, and other end fittings.
2. Warranty Period for Below Ground Installation: 30 years from date of Substantial Completion.
3. Warranty Period for Above Ground Installation: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.

C. Fuel-Oil Valves: Comply with UL 842 and have service mark initials "WOG" permanently marked on valve body.

D. Comply with requirements of the EPA and of state and local authorities having jurisdiction. Include recording of fuel-oil piping.

2.2 PERFORMANCE REQUIREMENTS

A. Maximum Operating-Pressure Ratings: 3-psig fuel-oil supply pressure at oil-fired appliances.

2.3 FUEL-OIL PIPES, TUBES AND FITTINGS

A. See "Outdoor Piping Installation" and "Indoor Piping Installation" articles for where pipes, tubes, fittings, and joining materials are applied in various services.

B. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.

   Wrought-Steel Welding Fittings: ASTM A 234/A 234M, for butt and socket welding.

2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

3. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

   a. Material Group: 1.1.
   b. End Connections: Threaded or butt welding to match pipe.
   c. Lapped Face: Not permitted underground.
   d. Gasket Materials: Asbestos free, ASME B16.20 metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
   e. Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.

4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

C. Drawn-Temper Copper Tube: Comply with ASTM B 88, Type K.

1. Copper Fittings: ASME B16.22, wrought copper, streamlined pattern.
2. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.

   a. Gasket Material: Asbestos free, ASME B16.20 metallic or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
   b. Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.

D. Annealed-Temper Copper Tube: Comply with ASTM B 88, Type K

1. Copper Fittings: ASME B16.22, wrought copper, streamlined pattern.
2. Flare Fittings: Comply with ASME B16.26 and SAE J513.
   a. Copper fittings with long nuts.
   b. Metal-to-metal compression seal without gasket.
   c. Dry-seal threads complying with ASME B1.20.3.

2.4 DOUBLE-CONTAINMENT PIPE AND FITTINGS

A. Flexible, Nonmetallic, Double-Containment Piping: Comply with UL 971.

1. Manufacturers subject to compliance with requirements, provide products by the following:
   a. OPW Fueling Components; Dover Company.

2. Pipe Materials: PVDF complying with ASTM D 3222 for carrier pipe with mechanical couplings to seal carrier, and PE pipe complying with ASTM D 4976 for containment piping.

3. Fiberglass or PE sumps.

4. Watertight sump entry boots, pipe adapters with test ports and tubes, coaxial fittings, and couplings.

5. Minimum Operating Pressure Rating: 10 psig.

6. Plastic to Steel Pipe Transition Fittings: Factory-fabricated fittings with plastic end matching or compatible with carrier piping, and steel pipe end complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

7. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.

B. Flexible, Metallic, Double-Containment Piping: Comply with UL 971A.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Omega Flex, Inc.; Double-Trac or comparable product by the following:
   a. OPW Fueling Components; Dover Company.

2. Pipe Materials: Stainless steel carrier pipe with nylon secondary containment with mechanical couplings to seal carrier.

3. Fiberglass or PE sumps.

4. Watertight sump entry boots, pipe adapters with test ports and tubes, coaxial fittings, and couplings.

5. Minimum Operating Pressure Rating: 50 psig.

C. Rigid, Double-Containment Piping: Comply with UL 971.

1. Manufacturers subject to compliance with requirements, provide products by the following:
   a. Ameron; a National Oilwell Varco brand.
   b. Conley Corporation.
   c. Perma-Pipe, Inc.
   d. Smith Fiberglass; a National Oilwell Varco brand.
   e. Tricon Piping Systems, Inc.

2. RTRP: ASTM D 2996 or ASTM D 2997 carrier and containment piping and mechanical couplings to seal carrier and containment piping or individually bonded joints.

   a. Minimum Operating-Pressure Rating for RTRP NPS 2 and NPS 3: 150 psig.

   b. Minimum Operating-Pressure Rating for RTRP NPS 4 and NPS 6: 125 psig. Compliance with UL 971 is not required for NPS 6 and larger piping.

   c. Fittings: RTRF complying with ASTM D 2996 or ASTM D 2997 and made by RTRP manufacturer; watertight sump entry boots, termination, or other end fittings.

3. Leak-Detection System: Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.

2.5 PIPING SPECIALTIES

A. Metallic Flexible Connectors

1. Manufacturers subject to compliance with requirements, provide products by the following:

   a. American Flexible Hose Co., Inc.
   b. Flexicraft Industries.
   c. FLEX-ING, Inc.
   d. Hose Master, Inc.
   e. Metraflex Company (The).
   f. Omega Flex, Inc.
   g. Proco Products, Inc.
   h. Tru-Flex Metal Hose Corp.
   i. Unaflex.

2. Listed and labeled for aboveground and underground applications by an NRTL acceptable to authorities having jurisdiction.
3. Stainless-steel bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
4. Minimum Operating Pressure: 150 psig.

5. End Connections: Socket, flanged, or threaded end to match connected piping.
6. Maximum Length: 30 inches.
7. Swivel end, 50-psig maximum operating pressure.
8. Factory-furnished anode for connection to cathodic protection.

B. Nonmetallic Flexible Connectors

1. Manufacturers subject to compliance with requirements, provide products by the following:

   a. American Flexible Hose Co., Inc.
   b. Flexicraft Industries.
   c. FLEX-ING, Inc.
   d. Tru-Flex Metal Hose Corp.

2. Listed and labeled for underground applications by an NRTL acceptable to authorities having jurisdiction.
3. PFTE bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
4. Minimum Operating Pressure: 150 psig.
5. End Connections: Socket, flanged, or threaded end to match connected piping.
6. Maximum Length: 30 inches.
7. Swivel end, 50-psig maximum operating pressure.
8. Factory-furnished anode.

C. Y-Pattern Strainers

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 60-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. Basket Strainers

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 60-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

E. T-Pattern Strainers

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.

3. Strainer Screen: 60-mesh startup strainer and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

F. Manual Air Vents

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

2.6 JOINING MATERIALS

A. Joint Compound and Tape for Threaded Joints: Suitable for fuel oil.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

D. Bonding Adhesive for RTRP and RTRF: As recommended by piping and fitting manufacturer.

2.7 SPECIALTY VALVES

A. Pressure Relief Valves

1. Manufacturers subject to compliance with requirements, provide products by the following:

   a. Anderson Greenwood; Pentair, Ltd.
   b. Fulflo Specialties, Inc.
   c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
   d. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.

2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Body: Brass, bronze, or cast steel.
4. Springs: Stainless steel, interchangeable.
5. Seat and Seal: Nitrile rubber.
6. Orifice: Stainless steel, interchangeable.
7. Factory-Applied Finish: Baked enamel.
8. Maximum Inlet Pressure: 150 psig.
9. Relief Pressure Setting: 60 psig.

B. Oil Safety Valves

1. Manufacturers subject to compliance with requirements, provide products by the following:
   a. Anderson Greenwood; Pentair, Ltd.
   b. Fulflo Specialties, Inc.
   c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
   d. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.
2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Body: Brass, bronze, or cast steel.
4. Springs: Stainless steel.
5. Seat and Diaphragm: Nitrile rubber.
6. Orifice: Stainless steel, interchangeable.
7. Factory-Applied Finish: Baked enamel.
8. Manual override port.
9. Maximum Inlet Pressure: 60 psig.
10. Maximum Outlet Pressure: 3 psig.

C. Emergency Shutoff Valves

1. Manufacturers subject to compliance with requirements, provide products by the following:
   a. EMCO Wheaton.
   b. Franklin Fueling Systems.
   c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
2. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
3. Single poppet valve.
4. Body: ASTM A 126, cast iron.
5. Disk: FPM.
6. Poppet Spring: Stainless steel.
7. Stem: Plated brass.
8. O-Ring: FPM.
9. Packing Nut: PTFE-coated brass.
10. Fusible link to close valve at 165 deg F.
11. Thermal relief to vent line pressure buildup due to fire.
12. Air test port.
13. Maximum Operating Pressure: 0.5 psig.

2.8 MECHANICAL LEAK-DETECTION VALVES

A. Manufacturers subject to compliance with requirements, provide products by the following:

1. Franklin Fueling Systems.
2. Red Jacket Pumps.

B. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.

C. Body: ASTM A 126, cast iron.

D. O-Rings: Elastomeric compatible with fuel oil.

E. Piston and Stem Seals: PTFE.

F. Stem and Spring: Stainless steel.

G. Piston Cylinder: Burnished brass.

H. Indicated Leak Rate: Maximum 3 gph at 10 psig.

I. Leak Indication: Reduced flow.

2.9 LEAK-DETECTION AND MONITORING SYSTEM

A. Cable and Sensor System: Comply with UL 1238.

1. Manufacturers subject to compliance with requirements, provide products by the following:
   a. Omntec Inc. (District/owner preferred vender)
   b. Containment Solutions, Inc.
   c. Highland Tank & Manufacturing Company, Inc.
   d. MSA Instrument Division.
   e. Pneumercator Inc.
   f. Veeder-Root Company (The).

2. Calibrated leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil piping.

3. Include fittings and devices required for testing.

2.10 LABELS AND IDENTIFICATION

A. Detectable Warning Tape: Acid and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and other conditions affecting performance of fuel-oil piping.

B. Examine installation of fuel-burning equipment and fuel-handling and storage equipment to verify actual locations of piping connections before installing fuel-oil piping.

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

3.2 EARTHWORK

A. Comply with requirements in Division 1 and 2 for excavating, trenching, and backfilling.

3.3 PREPARATION

A. Close equipment shutoff valves before turning off fuel oil to premises or piping section.

B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.4 OUTDOOR PIPING INSTALLATION

A. Install Underground Fuel-Oil Piping Buried

1. Under Compacted Backfill: 18 inches below finished grade.
2. Under Asphalt 2 Inches Thick: 8 inches below bottom of asphalt.
3. Under 4 Inches of Reinforced Concrete in Areas Subject to Vehicle Traffic: 4 inches below bottom of concrete.
4. If fuel-oil piping is installed with less than 12 inches of cover to finished grade, install in containment piping.
5. Comply with requirements in Divisions 1 and 2 for excavating, trenching, and backfilling.

B. Steel Piping with Protective Coating

1. Apply joint cover kits to pipe after joining, to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer. Review protective coating damage with Architect prior to repair.
3. Replace pipe having damaged PE coating with new pipe.

C. Install double-containment, fuel-oil pipe at a minimum slope of 1 percent downward toward fuel-oil storage tank sump.

D. Install vent pipe at a minimum slope of 2 percent downward toward fuel-oil storage tank sump.

E. Assemble and install entry boots for pipe penetrations through sump sidewalls for liquid-tight joints.

F. Install metal pipes and tubes, fittings, valves, and flexible connectors at piping connections to AST and UST.

G. Install fittings for changes in direction in rigid pipe.

H. Install system components with pressure rating equal to or greater than system operating pressure.

3.5 INDOOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction to allow for mechanical installations.

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

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings at a height that allows sufficient space for ceiling panel removal.

F. Install piping free of sags and bends.

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

H. Comply with requirements for equipment specifications for roughing-in requirements.

I. Conceal pipe installations in walls, pipe spaces, or utility spaces; above ceilings; below grade or floors; and in floor channels unless indicated to be exposed to view.

J. Prohibited Locations

1. Do not install fuel-oil piping in or through HVAC ducts and plenums, clothes or trash chutes, chimneys, or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
2. Do not install fuel-oil piping in solid walls or partitions.

K. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

L. Connect branch piping from top or side of horizontal piping.

M. Install unions in pipes NPS 2 and smaller at final connection to each piece of equipment and elsewhere as indicated. Unions are not required on flanged devices.

N. Do not use fuel-oil piping as grounding electrode.

O. Install sleeves and sleeve seals for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230420 "Supports Sleeves and Plates."

P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230420 "Supports Sleeves and Plates."

3.6 VALVE INSTALLATION

A. Install manual fuel-oil shutoff valves on branch connections to fuel-oil appliance.

B. Install valves in accessible locations.

C. Install oil safety valves at inlet of each oil-fired appliance.

D. Install pressure relief valves in distribution piping between the supply and return lines.

E. Install one-piece, bronze ball valve with hose end connection at low points in fuel-oil piping.

F. Install manual air vents at high points in fuel-oil piping.

G. Install emergency shutoff valves at dispensers.

3.7 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Bevel plain ends of steel pipe.
2. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tubing" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness for service application. Install gasket concentrically positioned.

G. Flared Joints: Comply with SAE J513. Tighten finger tight then use wrench according to fitting manufacturer's written instructions. Do not overtighten.

H. Fiberglass-Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.8 HANGER AND SUPPORT INSTALLATION

A. Pipe hanger and support and equipment support materials and installation requirements are specified in Section 230420 " Supports Sleeves and Plates."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1-1/4 and Smaller: Maximum span, 84 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
4. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 1/2 inch.
5. NPS 3: Maximum span, 12 feet; minimum rod size, 1/2 inch.
6. NPS 4: Maximum span, 13 feet; minimum rod size, 5/8 inch.

C. Support vertical steel pipe at each floor and at spacing not greater than 15 feet.

D. Install hangers for horizontal, drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 and Smaller: Maximum span, 60 inches; minimum rod size, 3/8 inch.
2. NPS 1: Maximum span, 72 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/4: Maximum span, 84 inches; minimum rod size, 3/8 inch.
4. NPS 1-1/2 and NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 1/2 inch.
6. NPS 3: Maximum span, 10 feet; minimum rod size, 1/2 inch.
7. NPS 4: Maximum span, 11 feet; minimum rod size, 5/8 inch.

E. Support vertical copper tube at each floor and at spacing not greater than 10 feet.

3.9 LEAK-DETECTION AND MONITORING SYSTEM INSTALLATION

A. Install leak-detection and monitoring system. Install alarm panel inside building where indicated.

B. Double-Containment, Fuel-Oil Piping: Install leak-detection sensor probes at low points in piping.

3.10 CONNECTIONS

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

B. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment having threaded pipe connection.

C. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.

D. Connect piping to equipment with shutoff valve and union. Install union between valve and equipment.

E. Install flexible piping connectors at final connection to burners or oil-fired appliances.

3.11 LABELING AND IDENTIFYING

A. Nameplates, pipe identification, valve tags, and signs are specified in Section 230480 "General labeling, valve charts and piping identification."

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on or near each service regulator, service meter, and earthquake valve.

1. Text: In addition to identifying unit, distinguish between multiple units; inform operator of operational requirements; indicate safety and emergency precautions; and warn of hazards and improper operations.

C. Install detectable warning tape directly above fuel-oil piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs. Terminate tracer wire in an accessible area and identify as "tracer wire" for future use with plastic-laminate sign.

1. Piping: Over underground fuel-oil distribution piping.

3.12 FIELD QUALITY CONTROL

A. Pressure Test Piping: Minimum hydrostatic or pneumatic test-pressures measured at highest point in system:

1. Fuel-Oil Distribution Piping: Minimum 5 psig for minimum 30 minutes.

2. Fuel-Oil, Double-Containment Piping:
   a. Carrier Pipe: Minimum 50 psig for minimum 30 minutes.
   b. Containment Conduit: Minimum 25 psig for minimum 60 minutes.

3. Suction Piping: Minimum 20-in. Hg for minimum 30 minutes.
4. Isolate storage tanks if test pressure in piping will cause pressure in storage tanks to exceed 10 psig.

B. Inspect and test fuel-oil piping according to NFPA 31, "Tests of Piping" Paragraph; and according to requirements of authorities having jurisdiction.

C. Test leak-detection and monitoring system for accuracy by manually operating sensors and checking against alarm panel indication.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Bleed air from fuel-oil piping using manual air vents.

F. Fuel-oil piping and equipment will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.13 OUTDOOR PIPING SCHEDULE

A. Underground Fuel-Oil Piping: Flexible or Rigid, double-containment piping. Size indicated is carrier-pipe size.

B. Underground fuel-oil-tank fill and vent piping shall be the following:

1. NPS 2 and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints. Coat pipe and fittings with protective coating for steel piping.
2. NPS 2-1/2 and Larger: Steel pipe, steel welding fittings, and welded joints. Coat pipe and fittings with protective coating for steel piping.
3. Flexible, Double-Containment Piping: Comply with UL 971.

C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

D. Aboveground fuel-oil piping shall be the following:

1. NPS 2 and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints.
2. NPS 2-1/2 and Larger: Steel pipe, steel welding fittings, and welded joints.
3. Flexible, Double-Containment Piping: Comply with UL 971.
4. Annealed-temper copper tube with wrought-copper fittings and brazed joints.

3.14 INDOOR PIPING SCHEDULE

A. Aboveground fuel-oil piping shall be the following:

1. NPS 1/2 and Smaller: Annealed-temper copper pipe, wrought copper fittings, and brazed or flared joints.
2. NPS 5/8 to NPS 2 Steel pipe, steel or malleable-iron threaded fittings, and threaded joints
3. Flexible, Double-Containment Piping: Comply with UL 971.
4. NPS 2-1/2 and Larger: Steel pipe, steel fittings, and welded or flanged joints.

3.15 SHUTOFF VALVE SCHEDULE

A. Valves for aboveground distribution piping NPS 2 and smaller shall be the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.

B. Distribution piping valves for pipe NPS 2-1/2 and larger shall be the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze, nonlubricated plug valve.

C. Valves in branch piping for single appliance shall be the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION 230175

SECTION 230190 - PUMPS

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section.

PART 2 - PRODUCTS

2.1 IN-LINE PUMPS

A. Furnish and install where indicated on Drawings, ITT Bell & Gossett pumps of model and size indicated on Drawing schedule or equal.

B. The pumps shall be of the horizontal oil lubricated type specifically designed and guaranteed for quiet operation and suitable for minimum 125-psig working pressure.

C. The pumps shall have a ground and polished steel shaft with a hardened integral thrust collar. The shaft shall be supported by two (2) horizontal sleeves bearing designed to circulate oil. The pumps are to be equipped with a watertight seal to prevent leakage. Mechanical seal faces to be carbon on ceramic. The motor shall be non-overloading at any point on pump curve.

D. The motor shall be of the drip-proof, sleeve bearing, quiet operation, and rubber mounted construction.

E. The Contractor shall furnish and install a magnetic starter for each booster pump with at least two (2) thermal overload protectors. The starter shall be equipped with manual reset buttons.

2.2 DUPLEX FUEL OIL TRANSFER PUMP SET

A. Furnish and install, where shown on the Drawings, a factory assembled “packaged type” pump set as manufactured by BFS Industries, Cleaver-Brooks or Preferred Utilities. Unit to be complete with all equipment hereinafter specified mounted, piped and wired on a steel stand ready for oil suction, discharge and electrical connections.

B. The units shall be valved and piped in accordance with Drawings and shall be complete with the following equipment:

1. Two (2) fuel oil pumps, each with a capacity of not less than 51-gph, 12 inch hg. suction capacity and 100-psig discharge pressure when operating with commercial grade no. 2 fuel oil. (35 ssu). Pumps shall be rotary type direct flexible coupling drive units similar to Viking for no. 2 oil pumping. Fuel oil pump motors shall be 1/3 HP.

2. One (1) screwed duplex strainer for the suction of pumps. Strainer shall be similar to Preferred Utilities standard cast iron or approved equal. Strainer shall have one-piece cast iron body, hydrostatically tested and suitable for 125-psig service.

3. Two (2) fuel oil pumps relief valves.

4. One (1) 2-1/2 inch dial compound gauge to be placed on discharge side of suction strainer. Gauge shall be similar to Weiss 0-30-psig and 0-30 inch vacuum or approved equal. One (1) 2-1/2 inch dial pressure gauge to be placed on discharge side of pumps. Gauge shall be similar to Weiss 0-300 psig or approved equal.

5. A steel control cabinet with hinged front door shall be mounted on the unit and shall be complete with electrical components.

C. The panel shall be complete with the following equipment mounted and wired:

1. Motor starters for each fuel oil pump.
2. H/O/A switches and “run” indicating light for each fuel oil pump.
3. A wiring diagram shall be included in the cabinet.
4. Circuit breakers for each motor starter.

D. All fuel oil piping shall be of the size noted on the Drawings and as scheduled elsewhere. All oil side gate valves, as noted, shall be similar to American or approved equal. Globe valve shall be similar to American or approved equal. Check valves for discharge side of each fuel oil pump shall be constructed of bronze with steel ball and shall be similar to American or approved equal.

E. All piping, valves and fittings shall be in accordance with the Drawings and shall be completely factory fabricated. Fuel oil piping arrangement shall have pressurized primary loop, and parallel flow secondary loops serving each boiler. Supply line to each boiler shall originate from pressurized side of primary loop and return line from each boiler shall be connected to return side of back pressure valve, located in the primary loop.

F. All underground fuel oil piping shall be perma-flex, heavy duty, smooth bore polyethylene plastic pipe with Dupont sealer barrier liner and shall be of size as noted on Drawings. Provide all adapters to connect fuel oil supply and return piping. Use Schedule 40 steel pipe for interior oil piping.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230190

SECTION 230200 - HYDRONIC SPECIALTIES

PART 1 - GENERAL

Applicable provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

PART 2 - PRODUCTS

2.1 AIR SEPARATOR

A. Furnish and install as shown on Drawings, an external low velocity air separator unit consisting of a steel tank with screwed piping connections and a tapping to connect the air separator directly to the compression tank with screwed piping connections and a tapping to connect the air separator directly to compression tank.

B. The unit is to be furnished with a steel base and constructed in accordance with ASME boiler pressure vessel code and stamped 125 psi working pressure. The air separator shall be ITT Bell & Gossett “Rolairtrol” or approved equal.

2.2 EXPANSION TANKS (S)

A. Furnish and install pre-charged bladder type expansion tank(s) of size and capacity as shown on Drawings. Tank shall have carbon steel shell and heavy-duty butyl rubber bladder.

B. Tank to be constructed for (125 psig) working pressure and to be guaranteed leakproof by manufacturer. Tank to be stamped with "U" symbol and Form U-1 furnished denoting compliance with paragraph U-69 for Construction of Unfired Pressure Vessels Section VIII ASME.

2.3 AIR VENTS

A. Install at all high points automatic air vents to eliminate air binding. All automatic air vents shall be approved heavy duty type equipped with petcocks and tubing for manual venting. All vents installed in coils, etc. shall be of manual key operated type.

B. All vents concealed from view shall be accessible through access doors. Vents shall be by Hoffman, Anderson or ITT Bell & Gossett, 125 psig rated.

2.4 PRESSURE GAUGES

A. Furnish and install pressure gauges on suction and discharge sides of each pump and as required to check operation of equipment; pressure gauges shall have 4-1/2"diameter dials, Ashton, Ashcroft or approved equal.

2.5 THERMOMETERS

A. Install thermometers at all locations in piping system as noted on Drawings and as required to check system performance. Thermometers shall be installed at the supply and return of coils and 3-way diverting valves as manufactured by Trerice, Weksler or Moeller, with 4-1/2 inch face, cast aluminum case, chrome plated steel ring, white background with black embossed markings, glass window, stainless steel pointer, brass movement, 316 stainless steel bulb. Provide separable, universal angle sockets for all thermometers.

2.6 TRIPLE DUTY VALVES

A. Furnish and install at each pump a nonslam check valve with a spring loaded disc and a calibrated adjustment feature permitting regulation of pump discharge flow and shut-off. Valves shall be designed to permit repacking under full line pressure.

B. Unit shall be installed on discharge side of pump in a horizontal or vertical position with the stem up. Allow for minimum clearance of valve stem. This unit shall be cast iron body construction suitable for maximum working pressure of 175 psig and maximum operating temperature of 300 degrees F.

C. All units shall be ITT Bell & Gossett Triple Duty Valve model or approved equal.

2.7 SUCTION DIFFUSERS

A. Furnish and install at each pump a suction diffuser. Units shall consist of angle type body with inlet vanes and combination Diffuser-Strainer-Orifice Cylinder with 3/16 inch diameter openings for pump protection. A permanent magnet shall be located within the flow stream and shall be removable for cleaning.

B. The orifice cylinder shall be equipped with a disposable fine mesh strainer, which shall be removed after system startup. Orifice cylinder shall have a free area equal to five times cross section area of pump suction opening. Vane length shall be no less than 2-1/2 times the pump connection diameter. Unit shall be provided with adjustable support foot to carry weight of suction piping. Each Suction Diffuser to be ITT Bell & Gossett model or approved equal.

2.8 COMBINATION BALANCING / SHUT-OFF VALVES (Circuit Sensors /Setters and Flow Meters)

A. Provide Circuit Sensor/Setter balance valves as manufactured by Bell & Gossett or approved equal.

B. Circuit Sensors: Furnish and install as shown on Drawings, a cast iron wafer-type flow meter designed for low pressure drop operation.

1. The flow meter will be equipped with brass readout valves (with integral check valve) for taking differential pressure readings across the orifice of the flow meter.

2. The flow meter shall be designed to operate at a maximum working pressure of 300 psig at 250 degrees F.

3. The flow meter must be furnished with a calibrated nameplate for determining an accurate system flow rate.

4. Each flow meter shall be ITT Bell & Gossett Circuit Sensor Flow Meter model no. OP.

C. Circuit Setters: (1/2”-3”) Furnish and install as shown on Drawings and with manufacturer's recommendations Bell & Gossett® Circuit Setter® Plus calibrated balance valve Model CB or Model MC as manufactured by Xylem.

1. Valves to be designed to allow installing Contractor to pre-set balance points for proportional system balance prior to system start-up.

2. Valve body shall be constructed out of lead-free brass.

3. Valve shall include a ball valve constructed in 304 Stainless Steel.

4. Valve shall be AB1953 and CSA certified and compliant with Vermont 152S, Maryland House Bill HB372, Senate Bill S.3874, and NSF/ANSI-372.

5. Valve body shall include two pressure/temperature ports.

6. Valve body shall include an optional drain valve port.

7. Valve shall utilize a calibrated nameplate with a memory stop.

8. Valve shall utilize a reduced port design that provides velocity head recovery.

9. Valve temperature range shall be from -4°F (-20°C) to 250°F (121°C).

10. Model CB: Valve shall have either NPTF thread or SWTF end connections.

11. Model CB: Valves with NPT end connections shall be rated for 400 PSIG working pressure.

12. Model CB: Valves with SWTF end connections shall be rated for a maximum of 300 PSIG working pressure.

13. Model MC: Valve shall be rated for 300 PSIG working pressure.

14. Model MC: Valve shall include a SWTF or NPTF fixed end connection on the discharge end and a union tailpiece adapter with choice of SWTF, NPTF thread, or NPTM thread tailpiece connection on the supply end. The union tailpiece end should include a union nut that can secure the tailpiece to the body of the valve to create a water-tight seal.

15. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplate to assure specific valve settings. Valves to be leak-tight at full rated working pressure. Valves 4-inch pipe size to be of cast iron body/brass vane construction with differential pressure read-out ports fitted with internal EPT insert and check valve.

16. Provide Extended Pressure/Temperature Ports and Drain Valve/Extended Drain Valve

D. Circuit Setters: (4”-12”) Furnish and install as shown on Drawings and with manufacturer's recommendations Bell & Gossett® Circuit Setter® Plus calibrated balance valve Model CB as manufactured by Xylem.

1. Valves to be designed to allow installing Contractor to pre-set balance points for proportional system balance prior to system start-up.

2. Valve body shall be constructed out of cast iron and rated for 175 PSIG working pressure (if flanged) or constructed out of ductile iron and rated for 300 PSIG working pressure (if grooved).

3. Valve shall be a multi-turn globe style valve.

4. Valve shall include a brass disc.

5. Valve disc shall have a soft seat design made of EPDM.

6. (If Flanged) Valves shall include ANSI Class 125# flanged connections.

7. (If Grooved) Valves shall include grooved end connections.

8. Valve body shall include two pressure/temperature ports.

9. Valve shall utilize a calibrated nameplate with position indicator from 0 to 100% open.

10. Valve shall include a memory button to allow for positioning the valve to the appropriate set position after closing.

11. Valve temperature range shall be from -4°F (-20°C) to 250°F (121°C).

12. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplate to assure specific valve settings. Valves to be leak-tight at full rated working pressure. Valves 4-inch pipe size to be of cast iron body/brass vane construction with differential pressure read-out ports fitted with internal EPT insert and check valve.

E. Readout Meters: Provide a portable Readout Meter with provision for hanging, capable of indicating pressure differential across a system component. Unit to be complete with all necessary hoses, shut-off and vent valves, and carrying case. Reading range to be .5' to .16'. Read Out Kits to be ITT Bell & Gossett model no. RO-3.

2.9 CHEMICAL FEEDING EQUIPMENT

A. Chemical Feed System Description:

1. Closed-Loop System: One bypass feeder on each system with isolating and drain valves with inlet piping connecting to discharge of circulating pumps, and outlet side of feeder connected to suction side of pump unless otherwise indicated.

2. Introduce chemical treatment through bypass feeder when required or indicated by test.

B. Domed Bottom Bypass Feeder: Provide the quantity and capacity of feeder as shown on the construction drawings. Griswold Water Systems Model DB-SB-Series or approved equal.

1. The feeder shall be constructed of steel (or stainless steel where indicated) in the construction drawings.
2. Capacity 5 gallon.
3. Steel feeders shall have an enameled painted powder coat finish.
4. The feeder will be rated for a minimum of 350 psig at 250 degrees F.
5. Tank shall be provided with a wide mouth of not less than 4” inside diameter so that chemicals can be introduced without the need of a funnel.
6. Four ¾” access ports for flow, vent, and drain.
7. The enclosure shall be a grooved end cap. The retaining bolts are removable by a small adjustable wrench. Rotating cap closures or closures requiring special wrenches shall not be considered equal.
8. The feeder will include heavy legs, minimum 3/16” thick, welded to the sides of the vessel, with holes in the feet to allow floor mounting with anchor bolts.
9. Accessories:
   a) Stainless steel basket with 1/8” perforations to hold solid chemicals or optional filter bag.
   b) Filter Bag (where indicated) – The bypass feeder shall be provided with a 25 micron filter bag fully supported by a stainless steel filter basket.
   c) Cartridge Filter Kit (where indicated) with 25 micron element rated for the specified maximum temperature of 100, 170 or 250 degrees F as stated on the construction drawings.
   d) Plastic filling funnel kit with valve for introduction of liquid agents without opening the lid to the feeder. Valve in kit will include an integral vent valve to bleed off air or release pressure.
   e) Isolation valve kit includes two ¾” Griswold ball valves with integral ¼” drain/vent valves, minimizing installation time and cost by eliminating separate valves and piping components.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230200

SECTION 230220 – MAKEUP AIR UNIT

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section. Submit shop drawings for checking and approval.

1.1 SYSTEM DESCRIPTION

A. Vertical, Direct Drive, 2-pipe, room fan coil unit with painted finish cabinet for exposed installation or ducting.

1.2 QUALITY ASSURANCE

A. Unit shall be tested in accordance with ARI Standard 440 and ETL listed to US and Canadian safety standards.

B. Each coil shall be factory tested for leakage at 600 psig air pressure with coil submerged in water.

C. Insulation and adhesive shall meet NFPA-90A requirements for flame spread and smoke generation.

D. All equipment wiring shall comply with NEC requirements.

1.3 DELIVERY, STORAGE AND HANDLING

A. Each unit shall be individually packaged from point of manufacture. Unit shall be handled and stored in accordance with the manufacturer's instructions.

PART 2 – PRODUCTS

2.1 EQUIPMENT

A. General:

1. Factory-assembled, vertical, draw-thru type fan coil for exposed or concealed installations, ducted or free discharge with plenum. Unit shall be complete with water heating coil, fan(s), motor(s), drain pan, and all required wiring, piping, controls, and special features.

B. Base Unit:

1. Units shall be fabricated of galvanized or galvannealed steel, 19gauge, exterior panels with 19gauge interior panels. Internal insulation is 1" fiberglass with 1.5 pound density, providing effective acoustical and thermal control and fire safety. Cabinet shall include removable buttom access panel with a ducted return air, filter rack and 2-in. pleated MERV 8 filter. Cabinet exterior has a baked on polyester powder-coated finish for corrosion and scratch resistance while providing an enhanced appearance. Painted panels shall pass 500 hour salt spray test as described in ASTM B-117. Fan access and filter doors shall be hinged and utilize ¼ - turn or ½ turn slot head larches for service convenience.

2. The drain pan shall extend the entire length and width of the coil, with primary and auxiliary connections that are ¾" FPT.

    a. Standard – double-sloped polymer with PVC male connections.

C. Fans:

1. Backward curved fans shall be welded construction, statically and dynamically balanced with motor integrated into or closely coupled with the wheel.

D. Coils:

1. Hot water heating coils shall be 2-row, slab style perpendicular to airflow, factory installed. Coil fin spacing shall be 10 or 12 fins per inch (FPI). Tube diameter shall be 3/8" OD or ½" OD.

2. All coils shall have copper tubes and aluminum fins. Coil fins are mechanically bonded to tubes. The copper tubes comply with ASTM B-75. The fin thickness is 0.0045-in. All coils are tested with air under water.

2. Water coils are tested in accordance with AHRI 410.

E. Controls and Safeties:

1. Fan Controls: Unit shall be furnished with 24V fan controls to allow control by field-provided and installed 24V thermostat.

    a. Integrated ECM motor controls: variable speed driven by unit – mounted potentiometer.

2. Factory-wired selections:

    a. Integral door disconnect switch

F. Operating Characteristics:

1. A unit with single hydronic coil installed in a 2-pipe system shall be capable of providing heating as determined by the operating mode of the central water supply system and as determined by field-provided and installed valves and controls.

2. In all arrangements, temperature controls are field-provided and installed and can interface with the unit per section "Controls and Safeties."

G. Electrical Requirements:

1. The unit power supply shall be 60 Hz, with 208/240/1-Phase.

H. Motors(s):

1. Integral ECM, electrically commutated motor (ECM), built into the plenum fan wheel assembly, up to 40% more efficient than permanent split-capacitor type induction motors, with field-adjustable fixed speed and continuously variable speed options.

END OF SECTION 230220

SECTION 230235 - ENERGY RECOVERY UNITS

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section. Submit shop drawings for checking and approval.

1.1 QUALITY ASSURANCE

A. Manufacturer's Qualification's:

1. Manufacturer regularly engaged, for past 5 years, in manufacture of air handling units of similar type to that specified.

2. ISO 9001 certified company

B. Installer's Qualifications:

1. Installer regularly engaged, for past 5 years, in installation of air handling units of similar type to that specified.

2. Employ persons trained for installation of air handling units.

1.2 DELIVERY, STORAGE, AND HANDLING

A. Delivery Requirements: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

B. Storage and Handling Requirements:

1. Store and handle materials in accordance with manufacturer's instructions.

2. Keep materials in manufacturer's original, unopened containers and packaging until installation.

3. Store materials in clean, dry area indoors.

4. Protect materials during storage, handling, and installation to prevent damage.

1.3 WARRANTY

A. Warranty period: 3 years

PART 2 - PRODUCTS

2.1 ENERGY RECOVERY VENTILATORS

A. Energy Recovery Ventilators: "Topvex TR Series".

1. Model: TR4000HW-208-3

2. Indoor, compact, commercial, air handling units.
3. Hot Water Coil
4. Airflow Control Constant Volume

B. General:

1. Each Unit or Group of Units: Capable of operating in any mode independently or dependently of other systems.
2. Capable of changing modes with no interruption to system operation.
3. Listed under CSA C22.2, No. 113/UL 1812.
4. Wiring: NFPA 70.
5. Performance: As scheduled on the Drawings.
6. Equip with control systems.
7. Perform all functions necessary for operation.
8. Ventilation to Building: Not to cease in any mode based solely on operational temperature of minus 13 to 104 degrees F (minus 25 to 40 degrees C.)
9. Surrounding Sound Power Rating: Not higher than 75 dB(A).
10. Sound Data: Measured in accordance with AMCA 300.
11. Capable of operating at normal condition with specific fan power (SFP) lower than 0.9 W/cfm (2.35 kW/m^3/s).
12. Capable of operating in winter and summer conditions without imbalance or loss of ventilation capacity greater than specified in design.

C. Unit Cabinet:

1. Cabinet Exterior: 20-gauge sheet steel, ASTM A653-G90, standard specification for steel sheet, zinc-coated (galvanized).
2. Double-Wall Cabinet Interior:
   a. 20-gauge sheet galvanized steel, G90.
   b. Seams: Sealed, requiring no caulking in field.
3. Insulation within Double Wall:
   a. 2.0-inch (50.8-mm) fiberglass.
   b. Flame Spread Index, UL 723: Not over 25.
   c. Smoke Developed Index, UL 723: Not over 50.
4. Provisions for field installed pre-heater system.

D. Fans:

1. Direct-drive, backward-inclined, motorized impellers.
2. Fan Motors:

   a. Maintenance-free, permanently lubricated, sealed ball bearings.
   b. Thermal overload protected (TOP).
   c. UL listed to UL 1004-1, 1004-2, 1004-3, 1004-7 and/or UL 2111; CSA C22.2, No. 77 and No.100.
   d. IP Protection: Class 44 or 54.
   e. Electronically commutated “EC” to maximize efficiency at different speeds.
   f. Mounted for quiet operation.
3. Separate fans for exhaust and supply blowers.

E. Energy Recovery Wheel:

1. Rotor Matrix: Corrosion-resistant aluminum alloy, composed of alternating corrugated and flat, continuously wound layers of uniform width that guarantee laminar air flow and low static pressure loss.
2. Counter-flow construction type.
3. Free cooling capacity.
4. Performance: Certified and listed by AHRI.
5. Rotor Wheel: 8-inch-thick wheel welded at hub and perimeter to prevent uneven run-out during normal operations.
6. Corrugated Surfaces: Coated with thin, non-migrating, adsorbent, Zeolite particles.
7. Effectiveness of Wheel: Documented in accordance with ASHRAE 84 and AHRI 1060.
8. Flame Spread Index, Energy Recovery Wheel, UL 723: Not over 25.
9. Smoke Developed Index, Energy Recovery Wheel, UL 723: Not over 50.

F. Air Filters:

1. Fresh air protected by MER13 pockets filter constructed to meet UL 900.
2. Exhaust air protected by MER9 pockets filter constructed to meet UL 900.
3. Individual Pockets: Assembled into galvanized steel header providing rigid support to filter.
4. Filter Element: Fully synthetic fiber, not shedding or affected by humidity.
5. Adjustable Monitoring System: Activates alarm through main controller when pressure drop increase through supply or exhaust filters.

G. Temperature Sensors: Four stainless steel temperature sensors for monitoring supply and exhaust air in and air out, maximizing units efficiency and detecting need for frost prevention.

H. Hot Water Coil:

a. Aluminum plate fins on copper tubing.
b. Heat Control: Operated by 0 to 10 V signal activated by unit's main controller
c. Frost Protection Sensor: Activates alarm if frost occurs.

I. Electrical:

1. Electrical Power: 208-230 VAC, 3 phase, 60 Hz with neutral line.
2. Internal Electrical Components: Factory wired for single-point power connection.
3. Electrical Box Components: Accessible without stopping unit or opening doors.
4. Electrical Box:
   a. Isolated from airflow paths.
   b. Protect integral wires and connections.
5. Controlled by integral microprocessor controller.

J. Serviceability:

1. Access Panel: Hinged and/or screwed access panel on bottom of unit. Specifier Notes: Sliding door system is optional. Delete if not required.

2. Sliding Door System: Minimize clearance required for doors during maintenance.
3. Energy Recovery Wheels, Filters, and Motors: Serviceable from front of unit.
4. Fan Assemblies: Mounted on removable base.
5. Energy Recovery Wheels and Filters: Mounted on slide-out rails.

2.2 ENERGY RECOVERY VENTILATOR CONTROLS

A. General:

1. All energy recovery units will be equipped with a factory installed and configured “Corrigo” controller with remote display by Regin.
2. The controller shall be pre-programmed for ventilation applications; no further programming will be required.
3. All controller settings, I/O points, configurations, functions, set-points, time schedules, and control modes shall be modifiable via remote display, PC software or network.
4. Access rights: there shall be four different program access levels: Admin, Service, Operator and Normal. Each level with have a password and grant the following level of access:
   a. Admin level: full read/write access to all settings and parameters in all menus.
   b. Service level: access to all menus except the submenus under Configuration: In- and Outputs & System.
   c. Operator level: gives access to all menus except “Configuration”.
   d. Normal level: only permits changes in "Running mode" and read-only access to a limited number of menus.
5. The controller must be capable of supporting remote controllers, schedule timers, system controllers, centralized controllers, integrated web-based interface, graphical user workstation, and system integration to Building Management Systems via BACnet, Modbus via RS 485, Exoline, built-in web, and TCP/IP.
6. Controller Communications: Via common non-polar communications bus.
7. Control Wiring: Installed in system daisy-chain configuration from unit to BAS controller and to other units, if applicable.
8. Network Wiring: CAT-5e with RJ-45 connection or two wire RS-485.

B. Sensors:

1. The following sensors shall also be installed and pre-configured with the controller by the manufacturer: temperature sensors (supply, return, exhaust, outdoor & entering), wheel rotation sensor, dirty filters sensor, defrost sensor, hydronic coil frost protection sensor and electric heating high temperature limit sensor.
2. In constant air volume applications, independent pressure sensors shall monitor both supply and exhaust fans for constant airflow.
3. In variable air volume applications, independent pressure sensors shall monitor both supply and exhaust fans to maintain constant duct pressure.

C. Temperature Control Modes:

1. When a post conditioning coil is present, the following temperature control modes permit control of the supply air temperature as specified:

a. Supply air control: the supply air temperature will be controlled using the supply air temperature and the user setpoint values as control inputs.

D. Airflow Control:

1. The controller shall be capable of constant air volume control and independently controlling both the supply and exhaust air fans to maintain the supply and exhaust air volume setpoints.

E. Additional Functions:

1. Humidity Control:
   a. Humidification: an analogue output is used to control a humidifier. The output will increase on decreasing humidity. A digital output can also be used to start a humidifier.
   b. Dehumidification: an analogue output is used to control a dehumidifier. The output will increase on increasing humidity. A digital output can also be used to start a dehumidifier.
2. Enthalpy Control: When a recirculation arrangement external to the Topvex is provided; If the enthalpy is higher outdoors than indoors, the external recirculation damper can be overridden to increase the recirculation. If the enthalpy is lower outdoors than indoors, the external recirculation damper can be overridden to decrease the recirculation in this case outdoor air is used for cooling the room instead.
3. Support Control Heating/Cooling: when the unit is off (unoccupied mode) and when the room temperature is above or below a start & stop value, the controller shall enable heating/cooling as to limit the offset in temperature when the unit is off.
4. Free Cooling (Night Overcool): during nighttime in the summer months, the unit will use cool outdoor air as to pre-condition the building space. The following conditions shall be met for free cooling:
   a. Less than four days have passed since the unit was last in running mode.
   b. The outdoor temperature during the previous running period exceeded a set limit (22°C/72°F).
   c. It is between 12:00 AM (midnight) and 07:00 AM in the day (settable).
   d. The timer outputs for "normal speed", "Extended running, Normal" and "External switch" are off.
   e. The unit was running in the last 24 hours.
5. Temperature Compensation: when running pressure control, the controller shall have the capability to outdoor compensate the pressure setpoint value. The outdoor compensation is linear and is set using two parameter pairs which give the value of the compensation at two different outdoor temperatures. The compensation can be positive or negative.

F. Alarms:

1. Alarms are indicated by the red alarm LED on the remote display or on the network.
2. All alarms can be monitored, acknowledged and blocked.

3. Three different classes of alarms: A, B & C. Each level will relate to the severity of the alarm, with class A being the most serious and class C being the least. Class A & B alarms have the potential to shut down the unit. Class C alarms will not cease operation of the unit.
4. On applicable alarms, alarm delays, setpoints and class level may be settable.

2.3 ASSEMBLY

A. Factory assemble and wire energy recovery ventilators.

2.4 ACCESSORIES

A. Hydronic Re-Heat

B. Shut-Off Damper:

C. Silencer for Circular Ducts

D. Silencer for Rectangular Ducts

E. Temperature Sensor (minus 40 to 60 degrees C/IP65):

F. Presence Detector:

G. 24 A Valve Actuator (0 to 10 V)

H. 3-Way Valve

I. Hydronic Pre-heat

2.5 SOURCE QUALITY CONTROL

A. Run test at factory.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and supporting structure to receive energy recovery ventilators.

B. Notify Architect of conditions that would adversely affect installation or subsequent use.

C. Do not begin installation until unacceptable conditions are corrected.

3.2 PREPARATION

A. Prepare surfaces where energy recovery ventilators are to be mounted.

B. Ensure surfaces are flat, level, plumb, and can support weight of energy recovery ventilators.

3.3 INSTALLATION

A. Install energy recovery ventilators in accordance with manufacturer's instructions at locations indicated on the Drawings.

B. Install energy recovery ventilators in accordance with NFPA 70.

C. Install energy recovery ventilators level, plumb, and secure.

D. Do not expose electronic components to temperatures below 32 degrees F (0 degrees C) or above 122 degrees F (50 degrees C).

3.4 ADJUSTING

A. Adjust energy recovery ventilators for proper operation in accordance with manufacturer's instructions.

3.5 DEMONSTRATION

A. Demonstration:

1. Demonstrate that the energy recovery ventilators function properly in every respect.

2. Perform demonstration at final system inspection by factory-trained and certified representative of manufacturer.

B. Instruction and Training:

1. Provide instruction and training of Owner's personnel as required for operation and maintenance of energy recovery ventilators.

2. Provide hands-on demonstrations of operation of system components and complete system, including user-level program changes and functions.

2. Provide instruction and training by factory-trained and certified representative of manufacturer.

3.6 PROTECTION

A. Protect installed energy recovery ventilators from damage during construction.

END OF SECTION 230235

SECTION 230260 – DUCTLESS SPLIT SYSTEMS (NOT IN SCOPE, BY OWNER)

PART 1 - GENERAL

Applicable provisions of the conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

1.1 SYSTEM DESCRIPTION

A. Outdoor-mounted, air-cooled split system outdoor section suitable for rooftop installation. Unit shall consist of a hermetic reciprocating, scroll, or rotary compressor, an air-cooled coil, propeller-type blow-thru outdoor fans, reversing valve, accumulator, holding refrigerant charge heating mode metering device, and control box. Unit shall discharge air horizontally as shown on the contract drawings. Units shall function as the outdoor component of an air-to-air cooling and heating system.

B. Indoor, in-the-ceiling-mounted or wall mounted direct-expansion fan coil to be matched with the commercial heat pump unit.

1.2 QUALITY ASSURANCE

A. Unit construction shall comply with ANSI/ASHRAE 15, latest revision, and with the NEC.

B. Unit shall be rated (when matched with appropriate outdoor unit) per ARI Standard 210/240. Units shall be certified by UL and CSA.

C. Units shall be constructed in accordance with UL standards.

D. Units shall be listed in the CEC directory.

E. Unit cabinet shall be capable of withstanding Federal Test Standard No. 141 (method 6061) 500-hour salt spray test.

F. Air-cooled condenser coils shall be leak tested at 350 psig air pressure with the coil submerged in water.

1.3 DELIVERY, STORAGE AND HANDLING

A. Units shall be shipped in one piece and shall be stored and handled per unit manufacturer’s recommendations.

PART 2 - PRODUCTS

2.1 OUTDOOR HEAT PUMP CONDENSING UNIT

A. Factory assembled, single piece, air-cooled outdoor unit. Contained within the unit enclosure shall be all factory wiring, piping, controls, compressor, charge of R-410A refrigerant and special features required prior to field start-up.

B. Unit Cabinet

1. Unit cabinet shall be constructed of galvanized-steel, bonderized and coated with a baked-enamel finish.

2. Unit access panels shall be removable with minimal screws and shall provide full access to the compressor, fan, and control components.

3. Outdoor compartment shall be isolated and have an acoustic lining to assure quiet operation.

C. Fans

1. Outdoor fans shall be direct-drive propeller type and shall discharge air horizontally. Fans shall blow air through the outdoor coil.

2. Outdoor fan motors shall be totally enclosed, single-phase motors with class B insulation and permanently lubricated sleeve bearings. Motor shall be protected by internal thermal overload protection.

3. Shaft shall have inherent corrosion resistance.

4. Fan blades shall be corrosion resistant and shall be statically and dynamically balanced.

5. Outdoor fan openings shall be equipped with PVC coated protection grille over fan and coil.

D. Compressor

1. Compressor shall be fully hermetic reciprocating or scroll type.

2. Compressor shall be equipped with oil system, operating oil charge, and motor. Internal overloads shall protect the compressor from over temperature and over current. Scroll compressors shall also have high discharge gas temperature protection if required.

3. Motor shall be NEMA rated class F, suitable for operation in a refrigerant atmosphere.

4. Reciprocating compressors shall be equipped with crankcase heaters to minimize liquid refrigerant accumulation in compressor during shutdown and to prevent refrigerant dilution of oil.

5. Compressor assembly shall be installed on rubber vibration isolators and shall have internal spring isolation.

6. Compressors shall be single phase or 3-phase as specified on the Contract Drawings.

E. Outdoor Coil: Coil shall be constructed of aluminum fins mechanically bonded to internally enhanced, seamless copper tubes that are cleaned, dehydrated, and sealed.

F. Refrigeration Components: Refrigerant circuit components shall include brass external liquid line service valve with service gage port connections, suction line service valve with service gage connection port, service gage port connections on compressor suction and discharge lines with Schrader-type fittings with brass caps, accumulator, bi-flow filter drier, pressure relief, reversing valve, and heating mode metering device.

G. Controls and Safeties: Operating controls and safeties shall be factory selected, assembled, and tested. The minimum control functions shall include the following:

1. Controls

   a. Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
   b. Automatic restart on power failure.
   c. Safety lockout if any outdoor unit safety is open.
   d. A time delay control sequence is also provided standard through the fan coil board, thermostat, or controller.
   e. High-pressure and liquid line low-pressure switches.
   f. Automatic outdoor-fan motor protection.
   g. Start capacitor and relay (single-phase units without scroll compressors).

2. Safeties

   a. System diagnostics.
   b. Compressor motor current and temperature overload protection.
   c. High pressure relief.
   d. Outdoor fan failure protection.

H. Electrical Requirements

1. Unit shall operate on a 208-v or 230-v, 60 Hz power supply as specified on the equipment schedule.

2. Unit shall operate on single-phase, 60 Hz power at 115 v or 208/230 v, or three-phase, 60 Hz power at 208/230 v or 460 v, as specified.
3. Unit electrical power shall be a single point connection.

4. Unit control voltage to the indoor-fan coil shall be 24 v, except 38BK009 and 012 units, which shall supply line voltage.

5. All power and control wiring must be installed per NEC and all building codes.

6. Unit shall have high- and low-voltage terminal block connections.

I. Special Features (Field Installed)

1. Low-Ambient Kit: Control shall regulate fan-motor cycles in response to saturated condensing pressure of the unit. The control shall be capable of maintaining a condensing temperature of 100 F ±10 F with outdoor temperatures to –20 F. Installation of kit shall not require changing the outdoor-fan motor.

2. Liquid Solenoid Valve: This electronically operated shutoff valve shall close and open in response to compressor operation. The valve should be used with all long-lines applications (over 100 ft).

3. Crankcase Heater (units with scroll compressors only): Unit shall be shipped with a clamp-on compressor oil sump heater.

2.2 WALL MOUNT INDOOR UNIT

A. Indoor, direct-expansion, low-profile (11-3/4 in. high) wall mount fan coil. Unit shall come complete with cooling/heating coil, electric heater, fan, fan motor, piping connectors, electrical controls, condensate pump, and hanging brackets.

B. Unit cabinet shall be constructed of zinc-coated steel. Fully insulated discharge and inlet grilles shall be attractively styled, high-impact polystyrene. Cabinet shall have filter tracks and cleanable filters which shall be accessible from below with a 1/4 -turn fastener. Adjacent room cooling to be provided by a simple knock-out in the cabinet side panel, and cabinet shall have provisions to accommodate a limited amount of ductwork, if desired.

C. Fan shall be a centrifugal, direct-drive blower type with air intake in center of the unit and discharge on the perimeter. Air louvers shall be adjustable for 2, 3, or 4-way discharge.

D. Coil: Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins will be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a factory-installed condensate pump and drain connection for hose attachment to remove condensate.

E. Motors: Motor shall be totally enclosed and permanently lubricated with inherent protection. Fan motor shall be 3-speed.

F. Controls: Controls shall be 24-v and shall be easily operated by the user from a wall-mounted control unit. Float control shall be in the condensate sump to shut unit down in case of pump malfunction. A wall-mounted electromechanical thermostat with 3 fan-speed selections and an auto/manual switch shall be supplied for field installation. Automatic changeover from cooling to heating modes and selectable 2 or 4 minute start-up delay shall be included. The R-401 refrigerant shall be controlled with a piston-type refrigerant metering device, and evaporator coil freeze protection shall be provided.

G. Filters: Unit shall have filter track with factory-supplied cleanable filters.

H. Electrical Requirements: Unit shall operate on a 208-v or 230-v, 60 Hz power supply as specified on the equipment schedule.

I. Operating Characteristics: (See Drawing Schedule)

J. Special Features (Field Installed)

1. Electronic Programmable Thermostat: Thermostat shall be commercial grade and shall provide 7-day, 4-event scheduling. Integral sub base shall be included. Thermostat shall also provide 3-speed fan switchover capability, air sweep auto changeover, and shall not require a battery to retain memory.

2.3 AIR CONDITIONING CONDENSATE PUMP
(PROVIDE IN ALL CASES WHERE CONDENSATE CANNOT DRAIN BY GRAVITY)

A. Pump shall be equal to “Little Giant” model no. VCMA-15ULS–554401. Automatic, 15 ft. shut-off, 1/2 gallon tank, safety switch check valve, 6 ft. power cord power cord with plug.

B. Provide 3/8” copper tubing discharge piping installed per manufacturer’s recommendations.

C. For roof discharge applications provide pitch pocket, rigid 3/8” copper discharge piping and gooseneck turned down 12 inches above roof. Provide splash block and remove pump check valve before installation.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230260

SECTION 230265 - VARIABLE REFRIGERANT FLOW OUTDOOR UNITS (NOT IN SCOPE, BY OWNER)

PART 1 - GENERAL

Applicable provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

1.1 SYSTEM DESCRIPTION

A. Indoor units are matched with heat pump or heat recovery VRF (variable refrigerant flow) outdoor unit.

1.2 DELIVERY, STORAGE AND HANDLING

A. Units shall be stored and handled per unit manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 MULTI V™ 5 HEAT RECOVERY AND HEAT PUMP SYSTEM(S) – (6 to 42 tons nominal)

MULTI V™ S HEAT RECOVERY AND HEAT PUMP SYSTEM(S) – (2 to 5 tons nominal)

A. Multi 5 Heat Product Design

1. LG Multi V 5 heating and cooling system shall be an air cooled system allowing user to configure in the field a heat pump or a heat recovery system consisting of one to three outdoor unit modules, conjoined to make a 6-42 ton single refrigerant circuit.

    a) Heat recovery systems, employing three pipes, shall be connected to Heat recovery (heat recovery) unit(s) and indoor unit(s). Multi-port heat recovery units shall allow simultaneous heating and cooling of individual zone(s) at various capacities as required to satisfy their zone requirements.
    b) Heat pump systems shall require two pipes, simultaneous heating and cooling shall not be supported. The heat recovery system shall consist of three pipes, liquid, suction and hot gas pipes. Heat recovery systems operating at 0°F that cannot deliver single phase superheated refrigerant vapor at a minimum of 162°F while operating in the heating mode shall not be acceptable.

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

B. Multi S Product Design

1. Variable Refrigerant Flow (VRF) HVAC outdoor unit shall be a variable capacity, direct expansion (DX), Heat Pump or Heat Recovery engineered system. The VRF system shall consist of a single frame outdoor unit, interconnecting piping, multiple indoor units (ducted, non-ducted or mixed combinations), onboard, self-contained, stand-alone communication and controls. Heat recovery systems also include intermediary heat recovery units.

2. LG Multi V S outdoor unit shall be manufactured as either a Heat Pump or a Heat Recovery model capable of heating and/or cooling. Heat pump models shall be able to heat OR cool separate thermal zones. Heat recovery models shall be able to heat AND cool separate thermal zones simultaneously.

3. Heat pump systems ARUN shall require two pipes, between the outdoor unit and indoor units. Simultaneous heating and cooling is not supported. One pipe shall support bidirectional flow single state liquid refrigerant. The other pipe shall support bidirectional flow of single state refrigerant gas. In heating mode the gas shall be super-heated high pressure. In cooling mode the gas shall be low pressure, low temperature.

4. Heat recovery system ARUB shall require three pipes between the outdoor unit and the heat recovery unit and two pipes between the heat recovery unit and each indoor unit to support simultaneous heating and cooling. Between the outdoor unit and heat recovery unit, one pipe shall support bidirectional flow single state liquid refrigerant. The second pipe shall deliver flow of low pressure, low temperature refrigerant gas from the heat recovery unit to outdoor unit. The third pipe shall deliver single state, super-heated, refrigerant hot gas during simultaneous and 100% heating operations from the outdoor unit to heat recovery unit. Heat Recovery systems using two pipes that deliver mixed state (hot gas and liquid) with separation occurring in heat recovery unit shall not be accepted.

5. Heat pump and Heat recovery outdoor units shall be designed to communicate directly with all VRF indoor units manufactured by the same supplier over a field supplied stranded, twisted and shielded pair wire. Systems requiring intermediary protocol translators, signal boosters, integration with a third party building management systems (BMS) or any other device required for communication possible shall not be accepted.

6. Indoor unit connectivity: The system shall be designed to accept connection up to 12 indoor units of various configurations and capacity.
   a)

7. Combination Ratio (CR) is defined as sum of nominal cooling capacity of proposed indoor units/nominal cooling capacity of the outdoor unit. The maximum allowable system combination ratio shall be 130%. Systems designed with combination ratio above 130% are not acceptable. The total nominal capacity of all indoor units shall be no less than 50%.

C. Multi 5 Heat Operating Conditions

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

2. Operating Ambient Air Conditions:
   a) Cooling: 5°F DB to 122°F DB With optional low ambient kit from -9.9°F DB to 122°F DB
   b) Heating: -22°F WB to 61°F WB
   c) Cooling Based (ODU reversing valve in cooling position) Synchronous: 14°F DB to 81°F DB (Heat Recovery Operation Only)
   d) Heating Based (ODU reversing valve in heating position) Synchronous: 14°F WB to 61°F WB (Heat Recovery Operation Only)

D. Multi S Operating Conditions

1. The VRF systems shall be capable of providing continuous compressor operation over the required ambient operating range. Submittal or technical performance data that indicates the required operating ambient range includes data points that do not guarantee continuous compressor operation, noted or footnoted as reference data, shall not be accepted. The required ambient operating range is defined as follows:
   a) Cooling
      i. Heat Pump & Heat recovery System: 23°F DB to 122°F DB
      ii. With optional low ambient kit from -9.9°F DB to 122°F DB
   b) Heating
      i. Heat Pump ARUN: - 4°F WB to 61°F WB
      ii. Heat Pump ARUN: -13˚F WB to 61˚F WB
      iii. Heat Recovery ARUB: -13˚F WB to 61°F WB
   c) Heat Recovery Synchronous (Simultaneous heating and cooling)
      i. Cooling based: 14°F DB to 81°F
      ii. Heating-based: 14°F WB to 61°F WB

E. Electrical

1. All air source heat pump and heat recovery frame(s) shall be designed and electrically protected to maintain stable continuous compressor operation when provided with Multi S- 208-230/60/1 power and can withstand: Multi 5 460/60/3 or 208-230/60/3 power with the following specifications:

   a) Multi 5 - 460/60/3
      i. Voltage tolerance 414V

   b) Multi 5 - 208-230/60/3 power and can withstand a voltage fluctuation of ± 10%.
      i. Multi S -Voltage tolerance between 187V to 253V

   c) Multi 5 - Voltage imbalance of up to two percent.

d) Power surge of up to 5kA RMS Symmetrical.

F. General Features

1. The air-conditioning system shall use R410A refrigerant. Multi-S - The factory shall supply the charge quantity of refrigerant R410A:
2. Multi 5 - Each system shall consist of one, two or three air source outdoor unit modules conjoined together in the field to result in the capacity specified elsewhere in these documents.
3. Dual and triple frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kits and field provided interconnecting pipe to form a common refrigerant circuit.
4. System shall have following frame configurations vs. capacity.

    a) 6 to 20 ton units shall be a single frame only.
    b) 22 to 34 ton units shall be dual frame only.
    c) 36 to 42 ton heat recovery units shall be triple frame only

5. System shall employ self-diagnostics function to identify any malfunctions and provide type and location of malfunctions via fault alarms.
6. Multi S - All outdoor units, regardless of the Heat Pump or Heat Recovery models, shall be the same generation and provide with most up to date firmware version at the time of delivery. Manufacturers commissioning agents shall assure the owner in the commissioning report that the latest software version.
7. If the specifications include both heat pump and heat recovery outdoor models, the manufacturer shall provide the most recent generation equipment only. Old stock or obsolete models will not be accepted. Products purchased over the internet and not from the manufacturer's authorized local mechanical representative or authorized distributer will not be accepted.
8. Field Provided Refrigerant Piping:
    a) Multi 5 - The refrigerant circuit shall be constructed using field provided ACR copper, de-hydrated, refrigerant rated copper pipe, piped together with manufacturer supplied Heat recovery unit(s) and Y- branches, as may be required, connected to multiple (ducted, non-ducted or mixed combination) indoor units to effectively and efficiently control the heat pump operation or simultaneous heating and cooling operation of the heat recovery VRF system. Other pipe materials, if used, shall perform, at a minimum, as well as that specified above, shall not have any adverse reactions, for example galvanic corrosion, to any other components or materials also in use in the system and shall be installed per manufacturer's instructions.
    b) The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor(s), controls, temperature sensor, humidity sensor, contacts, relay(s), fans, power and communications wiring as necessary to perform both Heat Pump and Heat recovery operations.
    c) Each outdoor unit refrigeration circuit shall include, but not limited to, the following components:
        i. Refrigerant strainer(s)
        ii. Check valve(s)

iii. Inverter driven, Multi 5 - medium pressure vapor injection, high pressure shell compressors
iv. Multi 5 - Liquid refrigerant cooled inverter PCB
v. Oil separator(s)
vi. Accumulator /controlled volume receiver(s)
vii. 4-way reversing valve(s)
viii. Multi 5 - Vapor injection valve(s)
ix. Variable path heat exchanger control valve(s)
x. Oil balancing control
xi. Oil Level sensor(s)
xii. Electronic expansion valve(s)
xiii. Double spiral tube sub-cooler (s) and EEV
xiv. Multi 5 - Vapor Injection Valve(s)
xv. High and low side Schrader valve service ports with caps
xvi. Multi S – High/low Service valves
xvii. Multi S – Threaded fusible plug
xviii. Multi S – High pressure switch

9. Multi-5 Field Insulation:

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

10. Microprocessor:

a) Multi 5 - Factory installed microprocessor controls in the outdoor unit(s), heat recovery unit(s), and indoor unit(s) shall perform functions to optimize the operation of the VRF system and communicate in a daisy chain configuration between outdoor unit and heat recovery unit(s) and indoor unit(s) via RS485 network. Controls shall also be available to control other building systems as required from the VRF control system. DIO/AIO capabilities shall be available as well as a central controller to perform operation changes, schedules and other duties as required by this specification. Addition of separate building control system shall not be required. Other control devices and sequences shall be as specified in other sections of this project specification.
b) Multi S- Factory installed microprocessor control in the outdoor unit, heat recovery unit(s), and indoor unit(s) shall communicate using the same protocol. Translators of any kind are not allowed. Communication between VRF system components shall be via field supplied stranded, shielded and twisted wire pair in a RS 485 network configuration. Integrated control system shall perform functions to optimize the operation of the VRF system.

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

d) Multi S- Main microprocessor shall include human interface capability that provides a visual code that reports systems operation status. If any malfunction occurs, or system is operating with an unstable refrigerant cycle sensor shall report the malfunction to the visual display.

e) Multi S- Main processor shall provide the commissioning agent the ability to customize the VRF systems operation based on the environment in which it is installed. Customization function to include defrost operation, modifying target superheat, sub-cooling, low pressure and high pressure values , and invoke other algorithms such as smart load control to optimize system operating efficiency. The main processor board shall include the following features:

i. Service tool connection
ii. DIP switches
iii. Auto addressing
iv. Error codes
v. Main microprocessor
vi. Inverter PCB

11. Multi S- Outdoor unit microprocessor shall have the capability of reporting malfunction and diagnostic codes to remote control devices such as the VRF manufacturer’s central controller, Zone controllers, and Building Management System (BMS).

12. Multi 5 - Inverter PCB Cooling:

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

13. Compressor Control:

    a) Multi 5 - Fuzzy control logic Multi S- The refrigerant cycle operation core logic shall establish and maintain target evaporating temperature (Te) to be constant on cooling mode and condensing temperature (Tc) constant on heating mode Multi 5 - by Fuzzy control logic to ensure the stable system performance. Multi S- heating mode and maintain system stable operation while operating compressors across the range of environmental conditions guaranteeing continuous compressor operation. VRF system core logic shall be able to dynamically modify the target evaporator and condenser temperatures to maximize energy savings when system is operating at part load conditions.

14. Initial Test Run (ITR) (Heating or Cooling) / Fault Detection Diagnosis (FDD) Code:

    a) Multi 5 - This control mode shall monitor and display positive or negative results of system initial startup and commissioning. Heating or Cooling ITR mode will be automatically selected. It shall monitor and provide performance metrics for the following, but not be limited to, refrigerant quantity charge, auto-charge, stable operations, connection ratios, indoor unit status, error status, and number of indoor units connected. This control mode shall not replace the system error monitoring control system.

15. BMS Integration:

    a) Multi 5 - The VRF system shall be able to integrate with Building Management Systems via BACnet™ IP gateway. This gateway converts between BACnet™ IP or Modbus TCP protocol, and RS-485 LGAP (LG Aircon protocol) allowing third party control and monitoring of the LG A/C system, or LonWorks™ gateways. See controls specification for points list.
    b) Multi S- The VRF system manufacturer's central controls platform shall be able to communicate with third party building management systems (BMS) via BACnet IP, Modbus TCP, or LonWorks™ protocol allowing third party BMS system control and/or monitoring of the LG air conditioning and heating system. See controls specification for more detailed description of integration and points to be controlled and monitored.
    c) The VRF system manufacturer shall have available off-the shelf devices that allows on/off binary interfaces between third party ancillary devices such as fans, door locks, photo eyes, key card switches, motion sensors, exhaust fans, dampers, and a single (or group of) VRF indoor units. Indoor units shall have the ability to start/stop the third party device, receive a contact closure signal from the third party device, or have the third party device change the operating conditions of the VRF indoor unit. Operating conditions shall include one or more of the following indoor unit functions: fan speed, fan on/off, thermal on/off cooling or heating, or indoor unit start/stop.

16. Wi-Fi Communication:

    a) The outdoor unit shall be Wi-Fi enabled and capable. Wi-Fi shall allow service or maintenance personal access to the Multi 5 - complete operating system, via LGMV mobile, without need of tools other than smart phone or tablet. Active live system review, collection of all system data for a field determined duration presented in a .csv file format or collection of all operating conditions, including all indoor units, valves, sensors, compressor speeds, refrigerant pressures, etc., by snapshot of conditions and placing that snapshot into a power point slide to be reviewed at another time. Multi S- operating system diagnostics and monitoring functions, via the manufacturer's provided maintenance and diagnostic software over a mobile device or personal computer. Communication between devices shall include: 1) Real-time system operation monitoring with the ability to capture all system operating data for a field determined period of time into a downloadable csv file format to a wireless connected device; 2) Collection of point in time (snapshot) information including all current outdoor unit operating conditions and each indoor unit, system EEV and solenoid valves, sensors, compressor speed, and refrigerant operating pressures. Systems that require computers, hard wire only connection or other devices to collect, review or record operating conditions shall not be allowed.

17. Indoor Unit Connectivity:

    a) Multi 5 - The system shall be designed to accept connection up to 64 indoor units of various configuration and capacity, depending on the capacity of the system.

18. Power and Communication Interruption:

    a) Multi 5 - The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable.

19. Connection Ratios:

    a) Multi 5 - The maximum allowable system combination ratio for all VRF systems shall be 130% and the minimum combination ratio shall be 50%.

20. Comfort Cooling Mode:

    a) Multi 5 - Comfort cooling shall be initiated via a field setting at the outdoor unit during commissioning or anytime thereafter. Comfort cooling shall allow user to select all or some of the zones on a system to adjust automatically their evaporator temperatures, independent of other zones, based on the impending total loads of that zone determined by using the zone controller temperature sensor.

21. Multi 5 - The outdoor unit refrigerant circuit shall employ for safety a threaded fusible plug.

22. Refrigerant Flow Control

    a) Multi 5 - An active refrigerant control and multi section accumulator-receiver that dynamically changes the volume of refrigerant circulating in the system based on operating mode and operating conditions to ensure maximum system performance and efficiency.
    b) Multi 5 - Subcooler: The VRF outdoor unit shall include a factory provided and mounted sub-cooler assembly consisting of a shell and tube-type sub-cooling heat exchanger and EEV providing refrigerant sub-cooling modulation control by fuzzy logic of EEV and by mode of operation to provide capacity and efficiency as required. Brazed plate heat exchangers shall not be allowed for this function. Multi S - The VRF outdoor unit shall use the sub-cooler while operating in cooling mode to sub-cool liquid refrigerant coming from the condenser coil well below saturation temperature to ensure that refrigerant remains in 100% liquid state when it reaches the farthest indoor unit's EEV valve. The amount of sub-cooling shall be modified by the microprocessor controller and minimized at all times to maximize efficiency by not overcooling the liquid.
    c) Smart Load Control: Multi 5 - The air source unit shall be provided with Smart Load Control (SLC) enhanced energy saving algorithm that reduces compressor lift during off peak operation. Multi S- Smart load control operation shall enhance energy savings and increase indoor comfort by monitoring the real time ambient temperature, real time weighted mean average building load, and the outdoor relativity humidity (if enabled).
        i. Multi 5 - The SLC algorithm shall be monitoring in real time, the rate of change of the outdoor ambient air temperature, either the outdoor ambient air relative humidity or the indoor air relative humidity [field selectable], and the rate of change of the building load.
        ii. Multi 5 - The SLC algorithm shall foresee pending changes in the building load, outdoor temperature, and humidity (or indoor humidity) and proactively reset head and/or suction pressure targets in anticipation of the reduction/increase in building load.
        iii. Multi 5 - The SLC algorithm shall provide no fewer than 3 field selection options to maximize the control of the VRF system operation during morning warm-up or cool-down following night-setback reset. The selection shall be set by the commissioning agent (or at any other time thereafter). Selectable algorithm choices include:
            1. Maximize energy savings.
            2. Balance the rate of temperature change with energy consumed.
            3. Quickly cool/heat the building.

iv. Multi S- Smart load control shall be field selectable to optimize system operation for project location and building use. Smart Load Control field setting shall select one of three operating algorithms. The commissioning agent shall select at the time of commissioning and can be changed at any other time:

v. Multi S-The Smart Load Control available settings shall:
   1. The system shall be influenced by any one of the chosen algorithm
   2. Off mode: Smart load control algorithm shall be in off mode
   3. Smooth mode: Smart Load control shall maximize energy savings. The rate of temperature change shall be insignificant.
   4. Normal Mode: Smart Load Control shall balance the rate of temperature change with energy consumed.
   5. Peak Mode: Smart Load shall quickly cool/heat the building. The energy consumption shall not be the priority in this mode.

vi. Multi S- For the first 20 minutes after the initial startup, the Smart Load Control will influence the outdoor unit operation for the chosen algorithm. This operation will be available at every start up.

vii. Multi S- After 20 minutes of compressor operation
   1. Smart Load control will maintain the chosen logic and system will operate with the same core logic.

viii. Multi S- Smart Load Control monitors two or three inputs:
   1. Weighted mean average building load
   2. Outdoor ambient dry bulb temperature
   3. Outdoor ambient relative humidity or indoor relative humidity (when enabled)

d) Multi S- Enhance energy savings

i. Multi S- Cooling Mode:
   1. Smart Load Control raises the system target low pressure during off-peak operation.
   2. Raising the operating low pressure shall reduce the compressor lift, reduce compressor's speed and power consumption.

ii. Multi S- Heating Mode
   1. Smart Load control shall lower the system target high pressure during off-peak heating operation.
   2. Lowering the operating high pressure target shall reduce compressor lift, reduce compressor speed and power consumption.
   3. Energy saved is in addition to the energy savings basic VRF load control provides.

e) Multi S- Increased indoor comfort

i. Multi S- Smart Load control shall use one (or two) sensors to measure changing outdoor weather conditions and shall prepare the VRF system to operate under the revised weather conditions. This operation shall be activated before the changed ambient conditions have an impact on indoor units.

23. Multi 5 - Refrigerant Volume Management

a) Multi 5 - Active Refrigerant Charge
   i. The VRF system shall be able to operate at any and all published conditions year-round in cooling or heating mode without the need of adding or removing refrigerant from the system.
   ii. The air source unit shall be provided with an isolated vessel to store spare refrigerant and actively pass refrigerant to (or from) the accumulator in real time as necessary to maintain stable refrigeration cycle operation.
   iii. The air source unit microprocessor shall be provided with an algorithm that monitors the VRF system head pressure, suction pressure, subcooling, superheat, compressor speed, high and low side temperatures and the load on the system to adjust the volume of refrigerant actively circulating.

b) Manual Seasonal Refrigerant Charge Adjustments
(Applicable for VRF systems without Active Refrigerant Charge)
   i. Alternates: Systems that CANNOT passively and automatically modify the active refrigerant charge using the method(s) stated to maintain stable cycle operation shall clearly state so in bold capital letters in the proposal. VRF systems that cannot perform active refrigerant control may submit a proposal as an Alternate and must include as part of the equipment price the cost of to provide bi-annual refrigerant charging services for 15 years. Service shall be performed by the factory authorized agent only. Service shall include refrigerant, parts, labor, and fees necessary to analyze the current state of the system and perform the refrigerant charge adjustment. Service must occur one month before the winter season and one month before the summer season.
   ii. If the VRF system requires a charge adjustment more frequently to maintain stable operation, the VRF manufacturer shall provide additional services at no additional charge.
   iii. The 15-year period shall begin on the date the equipment is commissioned or the date the building occupancy permit was issued for the area(s) served by the system – whichever date is later.
   iv. This service shall be underwritten, warranted, and administered by the VRF equipment manufacturer – not the local distributor or applied representative.
   v. The selected service provider shall be mutually agreeable between the building owner (or owners' agent) and must be licensed, insured, and trained to work on the VRF system. No third-party service (subcontracted service) providers will be acceptable.
   vi. If the service provider is not an employee of the VRF manufacturer, the service provider shall be reimbursed for services rendered directly from the manufacturer. Labor rate for services shall be paid at the prevailing wage rate in place at the time of service.

24. VRF Systems with Onboard Alternate Operating Mode Selection Capability

a) All VRF systems which provide field selectable Alternate Operating Modes, for example, High Heat or High Ambient Cooling, published data tables must be available to the public for all modes offered.
b) Acceptable Alternate Operating Modes must ship with all models of the VRF product offering and must be factory embedded. Custom factory or field modifications to factory provided algorithms created to meet scheduled requirements are not acceptable.
c) Provide a copy of instructions required to set the Alternate Operation Mode with the initial submittal.
d) For systems that provide field selectable Alternate Operating Modes, ALL technical data provided in the submittal data sheets showing product rated condition performance data, must also provide separate data sheets that show product performance data at each of the field selectable Alternate Operating Modes available. Capacity, power input, and acoustic performance data for each mode offered shall be reported separately. Mixing of ODU, IDU, or VRF system performance capability operating in one mode with for example the power consumption, sound power rating, or electrical requirements of the same system operating in another mode is not acceptable.

G. Field Supplied Refrigerant Piping Design Parameters

1. The outdoor unit shall be capable of operating at an elevation difference of up to Multi 5 - 360; Multi S- 164 feet above or Multi S-131 below the lowest or highest indoor unit respectively without the requirement of field installed subcooler or other forms of performance enhancing booster devices.
2. The outdoor unit shall be capable of operating with up to Multi 5 - 3280 Multi S-984 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.
3. The outdoor unit shall be capable of operating with up to Multi 5 - 656 Multi S-592 actual feet or Multi 5 - 738 Multi S- 574 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.
4. The piping system shall be designed with pipe expansion and contraction possibilities in mind. Required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. In addition to these requirements, the piping system installation must conform to the VRF equipment manufacturer’s published guidelines.
5. The installation of pipe hangers, supports, insulation, and in general the methods chosen to attach the pipe system to the structure must allow for expansion and contraction of the piping system and shall not interfere with that movement.
6. The elevation difference between indoor units on heat pump systems shall be Multi 5 - 131 Multi S- 49 feet.
7. Multi 5 - The elevation differences for heat recovery systems shall be:
   a) Heat recovery unit to connected indoor unit shall be 49 feet
   b) Heat recovery unit to heat recovery unit shall be 98 feet
   c) Indoor unit to indoor unit connected to same heat recovery unit shall be 49 feet

d) Indoor unit to indoor unit connected to separate parallel piped heat recovery units shall be 131 feet.

8. Multi 5 - The acceptable elevation difference between two series connected heat recovery units shall be 16 feet.

H. Defrost Operations

1. Multi 5 - The outdoor unit(s) shall be provided with a minimum of 4 independent field adjustable defrost cycle algorithms to maximize the effectiveness of the defrost cycle to the local weather conditions. Intelligent Defrost shall melt accumulated frost, snow and ice from the outdoor unit heat exchanger. The defrost cycle length and sequence shall be based on outdoor ambient temperatures, outdoor unit heat exchanger temperature, and various differential pressure variables. Intelligent Heating Mode, when outdoor unit humidistat is engaged, shall extend the normal heating sequences by adjusting the outdoor unit coil target temperature to be above the ambient dew point temperature delaying the need for defrost operations, so long as heating demand is being met.
2. Multi 5 - Smart Heating**:** This feature shall be capable of eliminating several defrost actions per day based on outdoor air temperature and humidity conditions. Smart heating shall extend the heating operation cycle by delaying the frost formation on the outdoor coil by adjusting the surface temperature to keep it above the current outdoor ambient dew point. The algorithm shall delay while maintaining indoor space temperature.
3. Multi 5 - Defrost Mode Selection: The outdoor unit shall be provided with a minimum of three field selectable defrost operation modes: Normal, Fast, or Forced.
   a) Multi 5 - Normal Defrost: Operation intended for use in areas of the country that experience adverse winter weather with periods of heavy winter precipitation and extremely low temperatures. This strategy shall maximize the systems heating performance and maintain operational efficiency. When the ambient temperature is either: a) above 32°F or b) below 32°F with the humidity level below 60% RH, Intelligent Defrost shall continue heating regardless of ice build-up on the coil until the quality of the heated air (i.e. discharge air temperature) decreases. At temperatures below 4°F, a defrost cycle shall occur every two hours to optimize system heating efficiency.
   b) Multi 5 - Fast Defrost: Operation intended for use in areas of the country with mild winter temperatures and light to moderate humidity levels. The strategy minimizes defrost cycle frequency allowing frozen precipitation to build longer in between cycles. Minimum time between defrost cycles shall be 20 minutes. Intelligent Defrost shall choose between split coil/frame and full system methods based on current weather conditions to minimize energy consumption and maximize heating cycle time.
   c) Multi 5 - Forced Defrost: Operation shall be available for the service provider to test defrost operations at any weather condition and to manually clear frozen water from the outdoor coil surfaces.

4. Multi 5 - Defrost Method Selection: The outdoor unit shall be provided with two field selectable defrost operation methods: Split Coil/Frame and Full System. Split Coil/Frame option provides continuous heating of the occupied space during defrost operation.
   a) Multi 5 - Split Coil/Frame method shall be available when Normal Defrost mode is selected. Split Coil method shall be available on all Heat Pump and Heat recovery single-frame VRF systems. Split Frame defrost shall be available on all Heat Pump and Heat recovery multi-frame outdoor units.
   b) Multi 5 - Split Coil method shall remove ice from the bottom half of the outdoor unit coil first for a maximum time of six minutes, then the top half for a maximum of six minutes. Next the bottom coil shall be heated again for an additional three minutes to remove any frozen water that may have dripped onto the lower coil during the top coil defrost operation.
   c) Multi 5 - When Split Coil/Frame method is selected, a Full System defrost shall occur every 1-9 (field selectable) defrost cycles to assure 100% of the frozen precipitation has been removed to maintain efficient performance.
   d) Multi 5 - Full System method shall be available as a field selectable option. All outdoor units located in areas of the country where large volumes of frozen precipitation are common, the commissioning agent shall be able to select the Full System only defrost method.
5. Multi 5 - Indoor Unit Fan Operation During Defrost
   a) Multi 5 - During partial defrost operation indoor units operating in cooling or dry mode shall continue normal operation.
   b) Multi 5 - During partial defrost operation, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the defrost cycle.
   c) Multi 5 - During full system defrost operation indoor unit fans will cycle off and remain off during the remainder of the defrost cycle.
6. Multi S- Heat Pump
   a) Multi S- The outdoor unit(s) shall be capable of auto defrost operation to melt accumulated frost off the outdoor unit heat exchanger. The defrost cycle control shall monitor the outdoor ambient temperature and outdoor unit heat exchanger surface temperature.
   b) Multi S- The frequency of operating the defrost cycle shall be determined by the system’s ability to maintain sufficient system head pressure to deliver comfortable warm air to the building.
7. Multi S- Heat Recovery
   a) Multi S- The outdoor unit(s) shall be capable of intelligent defrost operation to melt accumulated frost off the outdoor unit heat exchanger. The defrost cycle control shall monitor the outdoor ambient temperature, humidity (if enabled), building load, and outdoor unit heat exchanger surface temperature in real time.
   b) Multi S- The frequency of operating the defrost cycle shall be determined by the system’s ability to maintain sufficient system head pressure to deliver comfortable warm air to the building.

c) Multi S- The intelligent defrost algorithm shall be field selectable at the time of commissioning of the outdoor unit based on anticipated winter weather conditions. Intelligent defrost continuously calculates the dew point of the ambient air using the outdoor unit's temperature and humidity sensors (if enabled) and maintains the outdoor unit's coil surface temperature above the dew point delaying defrost operation while maintaining indoor space temperature.

d) Multi S- The intelligent defrost algorithm shall provide smart heating that will extend the system's heating operation and reduce the frequency of defrost cycles.

I. Oil Management

1. Multi 5 - The system shall utilize a high pressure oil return system to ensure a consistent film of oil on all moving compressor parts at all points of operation. Oil is returned to compressor through a separate high pressure oil injection pipe directly into the oil sump. Oil returned to the compressor via the suction port of the compressor shall not be allowed.
2. Multi 5 - Each compressor shall be provided with a high efficiency independent centrifugal cyclone type oil separator, designed to extract oil from the oil/refrigerant gas stream leaving the compressor.
3. Multi 5 - The system shall have an oil level sensor in the compressor to provide direct oil level sensing data to the main controller. The sensor shall provide data to main outdoor unit PCB to start oil return mode and balance oil levels between multiple compressors.
4. Multi 5 - The system shall only initiate an oil return cycle if the sensed oil level is below oil level target values as determined by the microprocessor. The system shall display an error if the oil sensor signals low oil level for a period of 130 minutes or longer.
5. Multi 5 - A default oil return algorithm shall automatically initiate the oil return mode if the system detects a failure of the oil sump sensor. A fault code shall be reported by the system.
6. Multi 5 - Timed oil return operations or systems that do not directly monitor compressor oil level shall not be permitted.
7. Multi 5 - Indoor Unit Fan Operation during Oil Return Cycle
   a) During oil return cycle indoor units operating in cooling or dry mode shall continue normal operation.
   b) During oil return, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the oil return cycle.
   c) During oil return cycle indoor unit fans will cycle off and remain off during oil return cycle while operating in all modes.
8. Multi S- The system shall have an oil injection mechanism to ensure a consistent film of oil on all moving compressor parts.
9. Multi S- The system shall be provided with a factory installed oil separator at the discharge port of the compressor and designed to separate, condense, and collect oil vapor from the discharge refrigerant gas and return oil to the sump of the compressor. The oil separator shall have no moving parts in the separation chamber.

10. Multi S- The system oil return control algorithm shall operate every 8 hours at a minimum, for a 3-minute period. When activated, the algorithm shall operate the system with the reversing valve in the cooling position, open all electronic expansion valves at the indoor unit(s) and raise the compressor speed to flush oil back to the compressor.

J. Fan and Motor Assembly

1. Multi 5 - 6 ton frames shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor with a vertical air discharge. Multi S- Heat Pump unit shall be equipped with one direct drive, variable speed, and axial flow fan with a horizontal air discharge. The motors shall be Brushless Digitally Controlled (BLDC), variable speed, inverter driven motors.
2. Multi 5 - 8 to 20-ton frames shall be equipped with two direct drive variable speed propeller fan(s) with BLDC motor(s) with a vertical air discharge. Multi S- Heat Pump and Heat Recovery unit shall be equipped with two direct drive variable speed axial flow fan(s) with a horizontal air discharge. Each fan shall be provided with an independent dedicated Brushless Digitally Controlled (BLDC), variable speed, inverter driven motors.
3. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material Multi 5 - and incorporate biomimetic technology to enhance fan performance and reduce fan generated noise.
4. The fan(s) motor shall be equipped with permanently lubricated bearings.
5. Multi 5 - The fan motor shall be variable speed with an operating speed range of 0-1150 RPM cooling mode and 0-1150 RPM heating mode. Multi S- The fan assembly(s) shall have a minimum operating speed range from 0 RPM to 850 RPM in cooling mode and heating mode.
6. The fan shall have a guard to help prevent contact with moving parts.
7. Multi 5 - The cabinet shall have option to redirect the discharge air direction from vertical to horizontal with the addition of optional factory provided air guides.
8. Multi 5 - The fan controller shall have a DIP switch setting to raise external static pressure of the fan up to 0.32 inch of W.C. to accommodate ducted installations.
9. The fan control shall have a function setting to remove excess snow automatically.
10. Multi 5 - The fan control shall have a function setting to remove access dust and light debris from the outdoor unit and coil.

K. Cabinet

1. Multi 5 - Outdoor unit cabinet shall be made of 20 gauge galvanized steel with a weather and corrosion resistant enamel finish. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours.
2. Multi 5 - Cabinet weights and foot prints shall vary between 430 lbs., 7.61 sq. ft. (1.27 sq. ft. per ton), for 6 ton cabinet to 666 lbs., 10.14 sq. ft. (.51 sq. ft. per ton), for 20 ton cabinet for single cabinet configurations. The front panels of the outdoor units shall be removable type for access to internal components.

3. Multi 5 - A smaller service access panel, not larger than 7” x 7” and secured by a maximum of (2) screws, shall be provided to access the following: Multi S- A removable service panel, shall be provided to access the following internal components:
   a) Service tool connection
   b) DIP switches
   c) Multi 5 - Auto addressing
   d) Multi 5 - Error codes
   e) Main microprocessor
   f) Inverter PCB
   g) Multi S- Outdoor unit coil EEV valve
   h) Multi S- Subcooling heat exchanger and EEV valve
   i) Multi S- Reversing valve
4. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.
5. The cabinet shall have a factory installed coil guard Multi S- and shall have a baked enamel finish.

L. Outdoor Unit Coil

1. Multi 5 - Outdoor unit coil shall be designed, built and provided by the VRF outdoor unit manufacturer.
2. Multi S- The outdoor unit coil shall have a minimum of 14 Fins per Inch (FPI). Multi 5 - The outdoor unit coil for each cabinet shall have lanced aluminum fins with a maximum fin spacing of no more than 17 Fins per Inch (FPI). All the outdoor unit coils shall be a 2 or 3 rows consisting of staggered tubes for efficient air flow across the heat exchanger.
3. Outdoor unit coil shall be comprised of aluminum fins mechanically bonded to copper tubing with inner surfaces having a riffling treatment to expand the total surface of the tube interior
4. Multi S- The aluminum fin heat transfer surfaces shall have factory applied corrosion resistant GoldFin™ coating. The coils coating shall be tested per ASTM B-117 standard. The test shall be performed for a minimum of 1000 hours. The outdoor unit coil shall have a minimum of 2 rows. Multi 5 - The aluminum fin heat transfer surfaces shall have factory applied corrosion resistant Black Fin coating. The copper tubes shall have inner riffling to expand the total surface of the tube interior.
   a) ISO 21207 Salt Spray Test Method B – 1500 hours
   b) ASTM B-117 Acid Salt Test – 900 hours
   c) The Black Fin coating shall be certified by Underwriters Laboratories and per ISO 21207. The above conditions shall establish the minimum allowable performance which all alternates must comply.
5. Multi 5 - Variable Path Heat Exchanger: System shall have a variable flow and path outdoor heat exchanger function to vary the refrigerant flow and volume and path. Control of the variable path circuits shall be based on system operating mode and operating conditions as targeted to manage the efficiency and minimize or maximize the circulating volume of the operating fluids of the system. This feature allows MV 5 to maintain system head pressure that delivers “gas-furnace leaving air temperature” from the indoor unit at moderate and low ambient outdoor air temperatures.

6. The outdoor unit coil, all indoor units and pipe network shall be field tested to a minimum pressure of 550 psig. Multi S- Manufacturers that do not specify and/or specify field testing pressures at less than 550 psig shall not be acceptable.

M. Multi 5 - Compressor(s)

1. Multi 5 - Compressor shall be designed and assembled by the VRF manufacturer specifically for use in the air source VRF product line. Third party manufactured, branded, or designed to the VRF system's OEM specifications by a third party manufacturer shall not be acceptable.
2. Multi 5 - Compressor shall be a hermetic, high-side shell (HSS), commercial grade, compliant scroll direct-drive design.
   a) Multi 5 - Compressor Design: The compressor design shall be of the high pressure shell scroll type where the internal pressure below the suction valves of the compressor shall be at the same high pressure and high temperature. The motor shall be cooled by high pressure gas at temperatures above saturation conditions and minimize the mixing of refrigerant liquid with oil in the sump. The system shall employ a high pressure oil return method returning recovered oil from the oil separator directly into the oil sump of the compressor; oil shall not be allowed to return via the suction line. Bearing surfaces are continually coated with oil. The compressor shall employ an Aero-bearing constructed with high lubricity materials increasing operation time in case of low sump oil level. Compressor shall have a nominal operating range from 12Hz to 150 Hz.
3. Multi 5 - The fixed and oscillating compressor scroll components shall be made of high grade (GC25) or denser steel material. All scrolls shall be heat treated and tempered.
4. Multi 5 - The oscillating scroll shall be finely machined and polished. PVE refrigerant oil shall be used as the sole liquid used to maintain a seal between the high and low sides of the compression chamber. Compressors that requires the use of any type of mechanical or wearable sealant material between the moving surfaces of the compression chamber is NOT ACCEPTABLE.
5. Multi 5 - Vapor Injection: System shall have a medium pressure gas vapor injection function employed in the heating and cooling modes to increase system capacity when the outdoor ambient temperatures are low and lower compressor lift when temperatures are high. The compressor vapor injection flow amount shall be controlled by the vapor injection sub-cooling algorithm reset by discharge gas temperatures of the compressor.
6. Multi 5 - Bearing surfaces shall be coated with Teflon® equal. Bearings shall be lubricated using a constant flow of PVE refrigerant oil to the bearing surfaces The film of oil separating the crankshaft journals and bearing surfaces shall be consistent at all times the crankshaft is in motion and shall be maintained irrelevant of crankshaft rotational speed.
7. Multi 5 - An internal, integrated, mechanically driven gear pump shall draw oil from the compressor sump reservoir, pressurize the oil and inject the oil directly to the crankshaft journals maintaining a consistent film of oil between all moving parts. Auxiliary, indirect, or electronically driven pumps are not acceptable.
8. Multi 5 - The viscosity property of the PVE oil in the compressor sump shall be maintained irrelevant or compressor operation and the surrounding ambient temperature.

a) Multi 5 - The compressor shall be equipped with an external thermally protected electric crankcase heater that is automatically activated only when the ambient temperature is below freezing and the compressor is not running to maintain the temperature of the oil in the sump above the refrigerant boiling point.
b) Multi 5 - During stable operation, irrelevant of ambient air temperature outside the water source unit, the temperature of refrigerant vapor in contact with the surface of the oil in the compressor sump shall be maintained above 140°F to prevent foaming and to eliminate refrigerant from mixing with the oil degrading the viscosity of the oil in the sump.
c) Multi 5 - Low side shell (LSS) type compressors that use suction vapor to cool the compressor motor shall not be acceptable.

9. Multi 5 - The compressor motor shall be designed to operate at high temperatures.
   a) Multi 5 - The motor winding insulation shall be designed to operate continuously at a minimum temperature of 180°F without deterioration.
   b) Multi 5 - The motor cooling system shall be designed to maintain acceptable operational temperature at all times and in all conditions using high pressure, hot refrigerant vapor as motor coolant.
   c) Multi 5 - Low side shell and compressors that use low pressure, low temperature refrigerant gas to cool the motor are not acceptable.
10. Multi 5 - Inverter Compressor Controller(s)
   a) Multi 5 - Each compressor shall be equipped with a dedicated inverter compressor drive. The control of multiple compressors using a single drive is not acceptable.
   b) Multi 5 - The inverter drive shall vary the speed of the compressor crankshaft between zero (0) Hz and 140 Hz.
   c) Multi 5 - The inverter driver controller shall be matched with the physical properties of the compressor. The drive shall be manufactured by the VRF air source unit manufacturer. The inverter drive and matching compressor shall have been thoroughly tested as a matched pair. The inverter drive shall be programmed to avoid operating the compressor at any speed that results in harmonic vibration, nuisance noise, or mechanical damage to either the driver or the compressor with power provided that is within the tolerance specification.
   d) Multi 5 - The compressor inverter drive assembly and software must be designed, manufactured, and supplied by the VRF product manufacturer. Third party branded inverter driver hardware and/or driver software or inverter driver hardware and/or software provided by a third party manufacturer to meet OEM specifications of the VRF water source manufacturer will not acceptable.
   e) Multi 5 - All inverter drive hardware or software manufactured in, is a product of, or sourced from China, or using a broker or third party provider as an intermediary that obtains the product from CHINA shall not be acceptable.
11. Multi 5 - Compressor(s)
   a) Multi 5 - Each 6, 8, 10 ton frames shall be equipped with a single hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressor.

b) Multi 5 - 12, 14, 16, 18 and 20 ton frames shall be equipped with dual hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressors.

c) Multi 5 - Each inverter driven, HSS scroll compressor shall be capable of operating from 12 Hz up to 150 Hz in any and all modes (cooling, heating or simultaneous modes).

d) Multi 5 - The compressor shall be designed for a separate port for oil to be directly returned to the compressor oil sump.

e) Multi 5 - The compressor bearing(s) shall have Teflon™ coating and shall be an aero type design using High lubricity materials.

f) Multi 5 - The compressor(s) shall be protected with:
   i. High Pressure switch
   ii. Over-current /under current protection
   iii. Oil sump sensor
   iv. Phase failure
   v. Phase reversal
   vi. Compressor shall be capable of receiving injection of medium pressure gas at a point in the compression cycle where such injection shall allow a greater mass flow of refrigerant at lower outdoor ambient and achieving a higher heating capability. The VRF outdoor unit shall have published performance data for heating mode operation down to -13°F on both heat pump and heat recovery systems.

g) Multi 5 - Standard, non-inverter driven compressors shall not be permitted nor shall a compressor without vapor injection or direct sump oil return capabilities.

12. Multi S- Heat Pump model ARUN

a) The compressor shall be a high efficiency high-side shell rotary hermetic design. Bearing shall be manufactured using high lubricity material. Compressor shall be factory charged with Polyvinyl Ether (PVE) oil. Single or dual speed compressors charged with Polyolester oil (POE) shall not be acceptable. Compressor inverter drive shall allow modulation from 20Hz to 90Hz with control in 1.0 Hz increments depending on the nominal capacity. <ARUN060GSS4> The compressor shall be a high-side shell hermetic scroll design. Oil sump area and chamber housing the motor shall be operated at the same temperature and pressure of the gas leaving the compressor chamber to ensure that the low temperature low pressure refrigerant returning to the compressor does not mix with the oil in the sump. Bearing shall be manufactured using high lubricity material. Compressor shall be factory charged with Polyvinyl Ether (PVE) oil. Single or dual speed compressors charged with Polyolester oil (POE) oil shall not be acceptable. Compressor motor shall be designed to operate at a frequency range of 0Hz to 160Hz. Compressor inverter drive shall allow modulation from 12Hz to 110Hz.

13. Multi S- Heat Recovery models ARUB

    a) The compressor design shall be of the high pressure shell scroll type where the internal pressure below the suction valves of the compressor shall be at the same high pressure and high temperature. The motor shall be cooled by high pressure gas at temperatures above saturation conditions and minimize the mixing of refrigerant liquid with oil in the sump. The system shall employ a high pressure oil return method returning recovered oil from the oil separator directly into the oil sump of the compressor; oil shall not be allowed to return via the suction line. Bearing surfaces are continually coated with oil. The compressor shall employ an Aero-bearing constructed with high lubricity materials increasing operation time in case of low sump oil level. Compressor shall have a nominal operating range from 12Hz to 110 Hz.

N. Operational Sound Levels

1. Multi 5 - Each single frame outdoor unit shall be rated with an operational sound pressure level not to exceed as listed on below chart when tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available. Such documentation shall be presented in all submittals, manufactures who elect to rate their equipment at other than tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available and the highest field selectable conditions shall not be allowed.
2. Multi 5 - A field setting shall be available to program the outdoor unit to reduce sound levels at night, when desired, to a selectable level while still able to meet building load requirement. This mode is available in both cooling and heating modes.
3. Multi S- The compressor(s) shall be wrapped with heat resistant foil faced, sound deadening blanket that covers all exposed surfaces of the compressor. Sound deadening blankets shall be secured in place by use of a Velcro™ tool-less joint sealing system with a minimum of ½" of overlap along all seams. The sound deadening compressor blanket shall be engineered to leave no direct sound path between the outer surface of the body of the compressor and the surrounding environment.
4. Multi S- The compressor(s) shall be mounted on rubber isolation grommets. Compressor shall ship with removable clamps that secure the compressor in place while transported. The installing contractor shall remove and discard (or optionally adjust the clamps to allow the isolator to properly function) the clamps prior to commissioning the water source unit.
5. Multi S- Manufacturers' published data shall include sound pressure and sound power levels.
    a) Sound pressure level shall not exceed 57 dB(A) during cooling operation for Heat Pump and Heat Recovery outdoor units when tested in an anechoic chamber under ISO3745 standard. Other testing conditions shall not be allowed.
    b) Sound power level shall not exceed 69 dB(A) when tested in an anechoic chamber under ISO3745 standard. Other testing conditions shall not be allowed.

O. Sensors

1. Each outdoor unit module shall have:
   a) Suction temperature sensor
   b) Discharge temperature sensor
   c) Multi 5 - Oil level sensor
   d) High Pressure sensor
   e) Low Pressure sensor
   f) Outdoor temperature sensor
   g) Multi 5 - Outdoor humidity sensor
   h) Outdoor unit heat exchanger temperature sensors

P. Wind Load Installations for Outdoor Units

1. LG FL Wind load Installation Drawings meet the requirements of the 2017 Florida Building Code, 6th Edition and ASCE Standard 7-2010.

Q. Seismic Installations

1. Provide OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. Provide LG supplemental installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.

R. Warranty

1. Limited Warranty Period

   a) STANDARD ONE-YEAR PARTS WARRANTY FOR A QUALIFIED SYSTEM - The Part(s) of a qualified System, including the compressor, are warranted for a period (the “Standard Parts Warranty Period”) ending on the earlier to occur of one (1) year after the date of original installation, or eighteen (18) months from the date of manufacture.
   b) ADDITIONAL SIX (6) YEAR COMPRESSOR PART WARRANTY - The Compressor is warranted for an additional six (6) year period after the end of the applicable Standard Part Warranty Period (the “Compressor Warranty Period”).

2. Extended Warranty

   a) The Standard Warranty Period and the Compressor Warranty Period are extended to a total of ten (10) years (the “Extended Warranty Period”) for qualified Systems that have been (a) commissioned by a party that has completed the current Training Requirements, (b) such commissioning is pursuant to LG’s current published instructions, and (c) the System commissioning results and supporting documents are entered correctly into LG’s online commissioning system. Commissioning of a System requires one (1) hour of LG Monitoring View (LGMV) data. Commissioning results must be entered into LG’s online commissioning system within sixty (60) days of System startup.

2.2 HEAT RECOVERY UNITS

A. General

1. Heat recovery unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).
2. Heat recovery unit casing shall be constructed with galvanized steel.
3. Heat recovery unit shall require 208-230V/1-phase/60Hz power supply.
4. Heat recovery Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems cooling and heating operation.
5. Heat recovery unit shall be engineered to work with a three pipe VRF system comprising of:
   a) High Pressure Vapor Pipe
   b) Low Pressure Vapor Pipe
   c) Liquid Pipe
6. Heat recovery units' main 3 pipe connections shall be capable of series or parallel pipe configuration.
7. The quantity of heat recovery units that can be piped in series shall be limited to 16.
8. A single string of series piped heat recovery units shall be capable of serving any combination of styles of VRF indoor units with a combined nominal capacity of up to 240 MBh.
9. Heat recovery unit shall have 2, 3, 4, 6 or 8 ports, each port supporting one or more indoor units with a maximum connected capacity of 60 MBH.
10. Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the heat recovery unit or in the system.
11. Each port shall be capable of connecting from 1 to 8 indoor units.
12. Connection to indoor units totaling greater than 60MBh nominal capacity shall be twinned to two adjacent ports of the heat recovery unit using a reverse Y-branch connector supplied by manufacture.
13. Heat recovery unit shall be internally piped, wired, assembled and run tested at the factory.
14. Heat recovery unit shall be designed for installation in a conditioned environment per specifications.
15. Heat recovery unit shall employ a liquid bypass valve.
16. Heat recovery unit shall have (2) electronic expansion refrigerant valves per port.
17. Heat recovery unit shall have a balancing valve to control the pressure between the high pressure and low pressure pipe during mode switching to minimize any change-over pressure related sounds.
18. Heat recovery unit shall employ an electronic expansion valve to ensure proper sub cooling of the refrigerant.
19. Heat recovery unit shall contain one double spiral sub-cooling heat exchanger per port.
20. Heat recovery unit shall not require a condensate drain or connection.
21. Heat recovery unit shall be internally factory insulated.

22. All field refrigerant lines between outdoor unit and heat recovery unit and from heat recovery unit to indoor unit shall be field ACR tubing, insulated per building or energy code and as instructed by the manufacture.
23. The heat recovery unit shall not exceed a net weight of 70 lbs.
24. Heat recovery units, for line length and pressure drop calculations, shall not exceed a maximum equivalent pipe length value of 8.2 feet.
25. The VRF manufacturer shall provide published documentation that specifically allows the installation of field provided isolation valves on all pipes connected to the Heat recovery unit to allow the servicing of heat recovery units, refrigerant circuit or the replacement of heat recovery unit without evacuating the balance of the piping system.

B. Controls

1. Heat recovery unit(s) shall have factory installed unit mounted control boards and integral microprocessor to communicate with other devices in the VRF system.
2. Heat recovery unit shall communicate with the indoor units via a 2-conductor stranded communications cable terminated using a daisy chain configuration.
3. The contractor is instructed to review the Electrical and ATC drawings and specifications for other items or tasks which this contractor is or may be responsible to provide materials and or labor under this contract. Failure to do so will not relieve this contractor of their responsibility to provide such materials and or labor and in no case shall this contractor be further compensated as a result.

C. Seismic Installations

1. Provide OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. Provide LG supplemental installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.

D. Warranty

1. Please refer to the respective outdoor unit for applicable warranty.

2.3 EEV KIT

A. General

1. Unit shall be manufactured by LG.
2. Unit shall be factory assembled and wired unit shall be designed to be installed indoors only, when installed outdoors provide NEMA weatherproof enclosure.
3. Unit shall be capable to be installed with heat pump or heat recovery VRF system.
4. Unit requires one communication kit to provide power and control signals.
5. Connects liquid line piping from outdoor unit to any AHU coil.

B. Electrical

1. Six conductor, 18 GA shielded and stranded field supplied wiring for 12 volt (low voltage) power and control signal from communication kit.

2.4 AHU COMMUNICATION KIT PAHCMR00 (RETURN AIR CONTROL)

A. General
1. Unit shall be manufactured by LG.
2. Unit shall be factory assembled and wired.
3. Unit shall be designed to be installed for indoor or outdoor.
4. Unit shall be capable to be installed with heat pump or heat recovery VRF system.
5. Allows communication between third party air handling unit (AHU) and LG Multi V air-source or water-source outdoor units with combination ratio between 50% to 100%.
6. Requires one EEV kit to control the flow of refrigerant from Multi V outdoor unit to AHU coil.

B. Electrical:

1. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz).

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230265

SECTION 230266 - VARIABLE REFRIGERANT FLOW INDOOR UNITS (NOT IN SCOPE, BY OWNER)

PART 1 - GENERAL

Applicable provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

1.1 SYSTEM DESCRIPTION

A. Indoor units are matched with heat pump or heat recovery VRF (Variable Refrigerant Flow) outdoor unit.

1.2 DELIVERY, STORAGE AND HANDLING

A. Units shall be stored and handled per unit manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 CEILING CASSETTE UNITS

A. General
1. Unit shall be manufactured by LG.
2. Unit shall be designed to be installed for indoor application.
3. Unit shall be designed to mount recessed in the ceiling and has a surface mounted grille with air inlet and outlet on the bottom of the unit.
4. The unit shall be available in both nominal 2’ x 2’ and 3’ x 3’ chassis.

B. Casing/Panel

1. Unit case shall be manufactured using galvanized steel plate.
2. The unit panel shall be provided with an off-white or black Acrylonitrile Butadiene Styrene (ABS) polymeric resin grille.
3. The grille shall have a tapered trim edge, and a hinged, spring clip (screw-less) return air filter-grille door.
4. Unit shall be provided with metal ears designed to support the unit weight on four corners.
5. Ears shall have pre-punched holes designed to accept field supplied all thread rod hangers.
6. Unit shall be supplied with snap off access panels to facilitate leveling of unit without removing the grille.

C. Cabinet Assembly

1. Unit shall have one, two- or four-way supply air outlets and one return air inlet.
2. The supply air outlet shall be through directional slot diffusers each equipped with independent oscillating motorized guide vanes designed to change the airflow direction.

3. The grille shall have a discharge range of motion of 40° in an up/down direction with capabilities of locking the vanes. The unit shall be provided with a factory perforated knockout for ventilation air.
4. Unit shall have factory installed motorized louver to provide flow of air in up and down direction for uniform airflow. The unit shall have a guide vane algorithm designed to sequentially change the predominant discharge airflow direction in counterclockwise pattern.
5. Guide vanes shall provide airflow in all directions.
6. Unit shall be equipped with factory installed temperature thermistors for:
   a. Return air
   b. Refrigerant entering coil
   c. Refrigerant leaving coil
7. Unit shall have a factory assembled, piped and wired electronic expansion valve (EEV) for refrigerant control.
8. Unit shall have a built-in control panel to communicate with other indoor units and to the outdoor unit.
9. The unit shall have factory designated branch duct knockouts on the unit case.
10. The unit shall have provision of fresh air ventilation through a knock-out on the cabinet.
11. The branch duct knockouts shall have the ability to duct up to 1/2 the unit airflow capacity.
12. The branch duct cannot be ducted to another room.
13. Unit shall have the following functions as standard:

    a. Self-diagnostic function
    b. Auto addressing
    c. Auto restart function
    d. Auto changeover function (Heat Recovery system only)
    e. Auto operation function
    f. Child lock function
    g. Forced operation
    h. Dual thermistor control
    i. Sleep mode
    j. Dual set point control
    k. Multiple aux heater applications
    l. Filter life timer
    m. External on/off input
    n. Wi-Fi compatible
    o. Auto fan operation
    p. Leak detection logic

D. Fan Assembly

1. The unit shall have a single, direct driven, crossflow tangential Sirocco fan made of high strength ABS GP-2305 polymeric resin. The unit shall have a single, direct-drive turbo fan made of high strength ABS HT-700 polymeric resin.
2. The fan impeller shall be statically and dynamically balanced.
3. The fan motor is Brushless Digitally commutated (BLDC) with permanently lubricated and sealed ball bearings.

4. The fan motor shall include thermal, overcurrent and low RPM protection.
5. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
6. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm that provides a minimum of four pre-programed fan speeds in the heating mode and fan only mode and five speeds in the cooling mode. The fan speed algorithm provides a field selectable fixed speed. Each setting is also adjustable by field setting to compensate for a limited amount of additional resistance to airflow by adjusting the RPM of the fan motor.
7. A field setting shall be provided to vary air throw pattern to compensate for high ceiling installations.
8. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, Super high, Power Cool, and Auto.
9. In heating mode, the indoor fan shall have the following settings: Low, Med, High, Super high and Auto.
10. Unit shall have factory installed motorized louver to provide flow of air in up and down direction for uniform airflow.

E. Filter Assembly

1. The return air inlet shall have a factory supplied removable, washable filter.
2. The unit shall have the capability to accept a field provided MERV 1 to MERV 10 filter.
3. The filter access shall be from the bottom of the unit without the need for tools.
4. The nominal 3'x3' cabinet unit shall have provision for an optional auto-elevating grille kit designed to provide motorized ascent/descent of the return air grille/pre filter assembly.
    a. The ascent/descent of the return air grille shall be up to a distance of 14-3/4 feet allowing access to remove and clean the filter.
    b. The auto-elevating grille shall have a control algorithm to accept up, down and stop control commands from the controller.
    c. The auto-elevating grille shall have a control to stop the descent automatically if a contact is made with any obstacle.

F. Coil Assembly

1. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
2. The copper tubing shall have inner grooves to expand the refrigerant contact surface for high efficiency heat exchanger operation.
3. Unit shall have a minimum one or two row coil, 18-19 fins per inch.
4. Unit shall have a factory supplied condensate drain pan below the coil constructed of EPS (expandable polystyrene resin).
5. Unit shall include an installed and wired condensate drain lift pump capable of providing minimum 27.5 inch lift from bottom surface of the unit.
6. Unit shall have a 1.0" ID factory insulated drain hose to handle condensate.
7. The drain pump shall have a safety switch to shut off the unit if condensate rises too high in the drain pan.
8. Unit shall have provision of 45° flare refrigerant pipe connections.

9. The coil shall be factory pressure tested at a minimum of 550 psig.
10. All refrigerant piping from outdoor unit to indoor unit shall be field insulated. Each pipe should be insulated separately. Thickness and heat transfer characteristics shall be determined by the design engineer and shall meet all code requirements.

G. Microprocessor Control

1. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system with or without the use of a wall mounted controller. The unit shall have a factory mounted return air thermistor for use as a space temperature control device. All operating parameters except scheduling shall be stored in non-volatile memory resident on the microprocessor. The microprocessor shall provide the following functions, self-diagnostics, auto re-start after a power failure and a test run mode.
2. The unit shall be able to communicate with other indoor units and the outdoor unit using a field supplied minimum of 18 AWG, two core, stranded, twisted and shielded communication cable.
3. The unit controls shall operate the indoor unit using one of the five operating modes:
   a. Auto changeover (Heat Recovery System only)
   b. Heating
   c. Cooling
   d. Dry
   e. Fan only
4. The unit shall be able to operate in either cooling or heating mode for testing and/or commissioning.
5. The unit shall be able to operate with the fan turned off during system cooling thermal off.
6. The unit shall have adjustable, multi-step cooling and heating mode thermal on/off temperature range settings.
7. The system shall include a product check function to access and display indoor unit type and capacity from a wired programmable thermostat controller.
8. Unit shall have a field settable method to choose auto fan speed change operation based on mode of operation, on/off fan operation based on mode of operation, or continuous minimum set fan speed operation.

H. Electrical

1. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz).
2. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.

I. Controls

1. Unit shall use controls provided by the manufacturer to perform all functions necessary to operate the system effectively and efficiently and communicate with the outdoor unit over an RS-485 daisy chain.

J. Seismic Installations

1. Provide OSHPD Special Seismic Certification Preapproval (OSP) documents for certified product list of VRF equipment to be installed in high seismic risk areas. Provide LG supplemental installation documents in conformance with CBC 2013, 2016 and 2019 California Building Code and IBC 2012, 2015 and 2018 International Building Code.

K. Warranty

1. Please refer to the respective outdoor unit for applicable warranty.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230266

SECTION 230280 - VARIABLE FREQUENCY DRIVES

PART 1 – GENERAL

Applicable provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

1.1 DESCRIPTION

A. This specification is to cover a complete Variable Frequency motor Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use with a standard NEMA Design B induction motor.

B. The drive manufacturer shall supply the drive and all necessary options as herein specified. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of twenty years. VFD's that are manufactured by a third party and "brand labeled" shall not be acceptable. All VFDs installed on this project shall be from the same manufacturer.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Institute of Electrical and Electronic Engineers (IEEE)
   a. Standard 519-1992, IEEE Guide for Harmonic Content and Control.

2. Underwriters laboratories
   a. UL508C

3. National Electrical Manufacturer's Association (NEMA)
   a. ICS 7.0, AC Adjustable Speed Drives

4. IEC 16800 Parts 1 and 2

5. National Electric Code (NEC)
   a. NEC 430.120, Adjustable-Speed Drive Systems

6. International Building Code (IBC)
   a. IBC 2006 Seismic – referencing ASC 7-05 and ICC AC-156

B. Qualifications:

1. VFDs and options shall be UL listed as a complete assembly. VFD's that require the customer to supply external fuses for the VFD to be UL listed are not acceptable. VFDs with red label UL stickers, requiring additional branch circuit protection are not acceptable. The base VFD shall be UL listed for 100 KAIC without the need for input fuses.
2. CE Mark – The VFD shall conform to the European Union ElectroMagnetic Compatibility directive, a requirement for CE marking. The VFD shall meet product standard EN 61800-3 for the First Environment restricted level.

3. The entire VFD enclosure, including the bypass shall be seismically certified and labeled as such in accordance with the 2006 International Building Code (IBC):
   a. VFD manufacturer shall provide Seismic Certification and Installation requirements at time of submittal.

   b. Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake test data as defined by ICC AC-156.

   c. Seismic ratings based upon calculations alone are not acceptable. Certification of Seismic rating must be based on testing done in all three axis of motion.

4. Acceptable Manufactures

   a. ABB ACH Series.

   b. Alternate manufacturer's requests must be submitted in writing to the Engineer for approval at least 20 working days prior to bid. Approval does not relieve the supplier of specification requirements.

5. The VFD manufacturer shall have available a comprehensive, HVAC Drive Computer Based Training (CBT) product. The CBT product shall include detailed, interactive sections covering VFD unpacking, proper mechanical and electrical installation, and programming. The CBT product shall allow the user to provide just-in-time training to new personnel or refresher training for maintenance and repair personnel on the user's site. The CBT product shall be repeatable, precise and shall include record keeping capability. The CBT product shall record answers to simulations and tests by student ID number. The CBT product must be professionally produced and have interactive sections, student tests, and include video clips of proper wiring and installation.

1.3 SUBMITTALS

A. Submittals shall include the following information:

1. Outline dimensions, conduit entry locations and weight.

2. Customer connection and power wiring diagrams.

3. Complete technical product description includes a complete list of options provided. Any portions of this specification not meet must be clearly indicated or the supplier and contractor shall be liable to provide all additional components required to meet this specification.

4. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).

   a. The VFD manufacturer shall provide calculations; specific to this installation, showing total harmonic voltage distortion is less than 5%. Input filters shall be sized and provided as required by the VFD

manufacturer to ensure compliance with IEEE standard 519. All VFD's shall include a minimum of 5% impedance reactors, no exceptions.

PART 2 – PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES

A. The VFD package as specified herein shall be enclosed in a UL Listed Type enclosure, exceeding NEMA enclosure design criteria (enclosures with only NEMA ratings are not acceptable), completely assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.

1. Environmental operating conditions: VFDs shall be capable of continuous operation at 0 to 50^0 C (32 to 122^0 F) ambient temperature as per VFD manufacturers documented/submittal data or VFD must be oversized to meet these temperature requirements. Not acceptable are VFD's that can only operate at 40° C intermittently (average during a 24 hour period) and therefore must be oversized. Altitude 0 to 3300 feet above sea level, less than 95% humidity, non-condensing. All circuit boards shall have conformal coating.

2. Enclosure shall be rated UL Type 1 and shall be UL listed as a plenum rated VFD. VFD's without these ratings are not acceptable. NEMA only type 1 enclosures are not acceptable (must be UL Type 1).

3. Provide NEMA 3R enclosures where exposed to outside weather or wet conditions.

B. All VFDs shall have the following standard features:

1. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.

2. The keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate "bumpless transfer" of speed reference when switching between "Hand" and "Auto" modes. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting.

3. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery back up with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power up. Capacitor back-up is not acceptable. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output Form-C relays. The VFD shall have a digital input that allows an override to the time clock (when in the off mode) for a programmable time frame. There shall be four (4) separate, independent timer functions that have both weekday and weekend settings.

4. The VFD's shall utilize pre-programmed application macro's specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time. The VFD shall have two user macros to allow the end-user to create and save custom settings.

5. The VFD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fans shall operate only when required. To extend the fan and bearing operating life, the VFD shall cycle the cooling fans on and off as required.

6. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to set point without tripping or component damage (flying start).

7. The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.

8. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430.250 for 4-pole motors.

9. The VFD shall have internal 5% impedance reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFD's with only one DC reactor shall add an AC line reactor.

10. The input current rating of the VFD shall be no more than 3% greater than the output current rating. VFD's with higher input current ratings require the upstream wiring, protection devices, and source transformers to be oversized per NEC 430.120. Input and output current ratings must be shown on the VFD nameplate.

11. The VFD shall include a coordinated AC transient surge protection system consisting of 4-120 joule rated MOV's (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.

12. The VFD shall provide a programmable loss-of-load (broken belt / broken coupling) Form-C relay output. The drive shall be programmable to signal the loss-of-load condition via a keypad warning, Form-C relay output, and / or over the serial communications bus. The loss-of-load condition sensing algorithm shall include a programmable time delay that will allow for motor acceleration from zero speed without signaling a false loss-of-load condition.

13. The VFD shall have user programmable underload and overload curve functions to allow user defined indications of broken belt or mechanical failure / jam condition causing motor overload.

14. The VFD shall include multiple “two zone” PID algorithms that allow the VFD to maintain PID control from two separate feedback signals (4-20mA, 0-10V, and / or serial communications). The two zone control PID algorithm will control motor speed based on a minimum, maximum, or average of the two feedback signals. All of the VFD PID controllers shall include the ability for “two zone” control.

15. If the input reference (4-20mA or 2-10V) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, Form-C relay output and / or over the serial communication bus.

16. The VFD shall have programmable “Sleep” and “Wake up” functions to allow the drive to be started and stopped from the level of a process feedback signal.

17. Provide drive with circuit breaker option and remote panel mounting kit.

C. All VFDs to have the following adjustments:

1. Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed. The lockout range must be fully adjustable, from 0 to full speed.

2. Two (2) PID Set point controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed-loop control. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID set point shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. There shall be two independent parameter sets for the PID controller and the capability to switch between the parameter sets via a digital input, serial communications or from the keypad. The independent parameter sets are typically used for night setback, switching between summer and winter set points, etc.

3. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain the set point of an independent process (ie. valves, dampers, etc.). All set points, process variables, etc. to be accessible from the serial communication network.

4. Two (2) programmable analog inputs shall accept current or voltage signals.

5. Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, Active Feedback, and other data..

6. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices. All digital inputs shall be programmable to initiate upon an application or removal of 24VDC or 24VAC.

7. Three (3) programmable, digital Form-C relay outputs. The relay outputs shall include programmable on and off delay times and adjustable hysteresis. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating of 2 amps RMS. Outputs shall be true Form-C type contacts; open collector outputs are not acceptable.

8. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control, or serial communications), the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop and the damper shall be commanded to close. The keypad shall display “start enable 1 (or 2) missing”. The safety input status shall also be transmitted over the serial communications bus.

9. The VFD control shall include a programmable time delay for VFD start and a keypad indication that this time delay is active. A Form C relay output provides a contact closure to signal the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates. The time delay shall be field programmable from 0 – 120 seconds. Start delay shall be active regardless of the start command source (keypad command, input contact closure, time-clock control, or serial communications), and when switching from drive to bypass.

10. Seven (7) programmable preset speeds.

11. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.

12. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise. The VFD shall have selectable software for optimization of motor noise, energy consumption, and motor speed control.

13. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows higher carrier frequency settings without derating the VFD.

14. The VFD shall include password protection against parameter changes.

D. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words. The keypad shall include a minimum of 14 assistants including:

1. Start-up assistant

2. Parameter assistants
   a. PID assistant
   b. Reference assistant
   c. I/O assistant
   d. Serial communications assistant
   e. Option module assistant
   f. Panel display assistant
   g. Low noise set-up assistant
3. Maintenance assistant
4. Troubleshooting assistant
5. Drive optimizer assistants

E. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

1. Output Frequency
2. Motor Speed (RPM, %, or Engineering units)
3. Motor Current
4. Motor Torque
5. Motor Power (kW)
6. DC Bus Voltage
7. Output Voltage

F. The VFD shall include a fireman's override input. Upon receipt of a contact closure from the fire / smoke control station, the VFD shall operate in one of two modes: 1) Operate at a programmed predetermined fixed speed ranging from -500Hz (reverse) to 500Hz (forward). 2) Operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override set point and feedback. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands), except customer defined safety run interlocks, and force the motor to run in one of the two modes above. "Override Mode" shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation, without the need to cycle the normal digital input run command.

G. Serial Communications

1. The VFD shall have an EIA-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet. [Optional protocols for LonWorks, Profibus, EtherNet, BACnet IP, and DeviceNet shall be available.] Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority (i.e. BTL Listing for BACnet). Use of non-certified protocols is not allowed.

2. The BACnet connection shall be an EIA-485, MS/TP interface operating at 9.6, 19.2, 38.4, or 76.8 Kbps. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC).

The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:

a. Data Sharing – Read Property – B.
b. Data Sharing – Write Property – B.
c. Device Management – Dynamic Device Binding (Who-Is; I-Am).
d. Device Management – Dynamic Object Binding (Who-Has; I-Have).
e. Device Management – Communication Control – B.

3. If additional hardware is required to obtain the BACnet interface, the VFD manufacturer shall supply one BACnet gateway per drive. Multiple VFDs sharing one gateway shall not be acceptable.

4. Serial communication capabilities shall include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The DDC shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible.

5. Serial communication in bypass shall include, but not be limited to; bypass run-stop control, the ability to force the unit to bypass, and the ability to lock and unlock the keypad. The bypass shall have the capability of allowing the DDC to monitor feedback such as, current (in amps), kilowatt hours (resettable), operating hours (resettable), and bypass logic board temperature. The DDC shall also be capable of monitoring the bypass relay output status, and all digital input status. All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote bypass fault reset shall be possible.

6. The VFD / bypass shall allow the DDC to control the drive and bypass digital and analog outputs via the serial interface. This control shall be independent of any VFD function. The analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive and bypass' digital (Form-C relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive and bypass' digital inputs shall be capable of being monitored by the DDC system. This allows for remote monitoring of which (of up to 4) safeties are open.

7. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control, chilled water value / hot water valve control, etc. Both the VFD PID control loop and the independent PID control loop shall continue functioning even if the serial communications connection is lost. As default, the VFD shall keep the last good set point command and last good DO & AO commands in memory in the event

the serial communications connection is lost and continue controlling the process.

H. EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level with up to 100 feet of motor cable. No Exceptions. Certified test reports shall be provided with the submittals confirming compliance to EN 61800-3, First Environment.

I. All VFD's through 75HP at 480 V shall be protected from input and output power mis-wiring. The VFD shall sense this condition and display an alarm on the keypad. The VFD shall not sustain damage from this power mis-wiring condition.

J. OPTIONAL FEATURES – Optional features shall be furnished and mounted by the drive manufacturer. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

1. Door interlocked, pad-lockable disconnect switch that will disconnect all input power from the drive and all internally mounted options. Disconnect option shall be available with or without systems requiring bypass.

2. Field-bus adapters - Protocols such as BACnet IP shall be a plug in modules.

K. Bypass

1. A complete factory wired and tested bypass system consisting of a door interlocked, pad-lockable circuit breaker, output contactor, bypass contactor, and fast acting VFD input fuses. UL Listed motor overload protection shall be provided in both drive and bypass modes.

2. The bypass enclosure door and VFD enclosure must be mechanically interlocked such that the disconnecting device must be in the "Off" position before either enclosure may be accessed.

3. The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 Amps and this rating shall be indicated on the UL data label.

4. The drive and bypass package shall be seismic certified and labeled to the IBC:

   a. Seismic importance factor of 1.5 rating is required and shall be based upon actual shake table test data as defined by ICC AC-156.

5. Drive Isolation Fuses - To ensure maximum possible bypass operation, fast acting fuses, exclusive to the VFD, shall be provided to allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection. This maintains bypass operation capability in the event of a VFD failure. Bypass designs which have no such fuses, or that incorporate fuses common to both the VFD and the bypass, will not be accepted. Third contactor "isolation contactors" are not an acceptable alternative to fuses, as contactors could weld closed and are not an NEC recognized disconnecting device.

6. The bypass shall maintain positive contactor control through the voltage tolerance window of nominal voltage +30%, -35%. This feature is designed to avoid contactor coil failure during brown out / low line conditions and allow for input single phase operation when in the VFD mode. Designs that will not allow input single phase operation in the VFD mode are not acceptable.

7. Motor protection from single phase power conditions - the bypass system must be able to detect a single phase input power condition while running in bypass, disengage the motor in a controlled fashion, and give a single phase input power indication. Bypass systems not incorporating single phase protection in bypass mode are not acceptable.

8. The bypass system shall be designed for stand-alone operation and shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system for repair / replacement. Serial communications shall remain functional even with the VFD removed. Bypass systems that do not maintain full functionality with the drive removed are not acceptable.

9. Serial communications – the bypass shall be capable of being monitored and / or controlled via serial communications. On-board communications protocols shall include ModBus RTU; Johnson Controls N2; Siemens Building Technologies FLN (P1); and BACnet MS/TP.

    a. Serial communication capabilities shall include, but not be limited to: bypass run-stop control, the ability to force the unit to bypass, and the ability to lock and unlock the keypad. The bypass shall have the capability of allowing the BAS to monitor feedback such as, current (in amps), kilowatt hours (resettable), operating hours (resettable), and bypass logic board temperature. The BAS shall also be capable of monitoring the bypass relay output status, and all digital input status. All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote bypass fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus and / or via a Form-C relay output – keypad “Hand” or “Auto” selected, bypass selected, and broken belt indication. The BAS system shall also be able to monitor if the motor is running in the VFD mode or bypass mode over serial communications. A minimum of 50 field serial communications points shall be capable of being monitored in the bypass mode.

    b. The bypass serial communications shall allow control of the drive/bypass (system) digital outputs via the serial interface. This control shall be independent of any bypass function or operating state. The system digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. All system analog and digital I/O shall be capable of being monitored by the BAS system.

10. There shall be an adjustable motor current sensing circuit for the bypass and VFD modes to provide proof of flow (broken belt) indication. The condition shall be indicated on the keypad display, transmitted over the BAS and / or via a Form-C relay output contact closure. The broken belt indication shall be programmable to be a system (drive and bypass) indication. The broken belt condition sensing algorithm shall be programmable to cause a warning or system shutdown.

11. The digital inputs for the system shall accept 24VAC or 24VDC. The bypass shall incorporate an internally sourced power supply and not require an external control power source. The bypass power board shall supply 250 mA of 24 VDC for use by others to power external devices.

12. There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad command, time-clock control, digital input, or serial communications) the bypass shall provide a dry contact closure that will signal the damper to open before the motor can run. When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a bypass system input and allows motor operation. Up to four separate safety interlock inputs shall be provided. When any safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. This feature will also operate in Fireman's override / smoke control mode.

13. The bypass control shall monitor the status of the VFD and bypass contactors and indicate when there is a welded contactor contact or open contactor coil. This failed contactor condition shall be indicated on the bypass LCD display, programmed to activate a Form-C relay output, and / or over the serial communications protocol.

14. The bypass control shall include a programmable time delay bypass start including keypad indication of the time delay. A Form C relay output commands the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates at full speed in the bypass mode. The time delay shall be field programmable from 0 – 120 seconds.

15. There shall be a keypad adjustment to select manual or automatic transfer to bypass. The user shall be able to select via keypad programming which drive faults will result in an automatic transfer to bypass mode and which faults require a manual transfer to bypass. The user may select whether the system shall automatically transfer from drive to bypass mode on the following drive fault conditions:

    a. Over current
    b. Over voltage
    c. Under voltage
    d. Loss of analog input

16. The following operators shall be provided:

    a. Bypass Hand-Off-Auto
    b. Drive mode selector

c. Bypass mode selector
d. Bypass fault reset

17. The bypass shall include a two line, 20 character LCD displays. The display shall allow the user to access and view:

a. Energy savings – in US dollars
b. Bypass motor amps
c. Bypass input voltage– average and individual phase voltage
d. Bypass power (kW)
e. Bypass faults and fault logs
f. Bypass warnings
g. Bypass operating time (resettable)
h. Bypass energy (kilowatt hours – resettable)
i. I/O status
j. Parameter settings / programming
k. Printed circuit board temperature

18. The following indicating lights (LED type), or keypad display indications shall be provided. A test mode or push to test feature shall be provided.

a. Power-on (Ready)
b. Run enable
c. Drive mode selected
d. Bypass mode selected
e. Drive running
f. Bypass running
g. Drive fault
h. Bypass fault
i. Bypass H-O-A mode
j. Automatic transfer to bypass selected
k. Safety open
l. Damper opening
m. Damper end-switch made

19. The Bypass controller shall have six programmable digital inputs, and five programmable Form-C relay outputs. This I/O allows for a total System (VFD and Bypass) I/O count of 24 points as standard. The bypass I/O shall be available to the BAS system even with the VFD removed.

20. The on-board Form-C relay outputs in the bypass shall be programmable for any of the following indications.

a. System started
b. System running
c. Bypass override enabled
d. Drive fault
e. Bypass fault
f. Bypass H-O-A position
g. Motor proof-of-flow (broken belt)
h. Overload

i. Bypass selected
j. Bypass run
k. System started (damper opening)
l. Bypass alarm
m. Over temperature

21. The bypass shall provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in VFD or Bypass mode. The remote start/stop contact shall operate in VFD and bypass modes. The terminal strip shall allow for independent connection of up to four (4) unique safety inputs.

22. The bypass shall include a supervisory control mode. In this bypass mode, the bypass shall monitor the value of the VFD's analog input (feedback). This feedback value is used to control the bypass contactor on and off state. The supervisory mode shall allow the user to maintain hysteresis control over applications such as cooling towers and booster pumps even with the VFD out of service.

23. The user shall be able to select the text to be displayed on the keypad when an external safety opens. Example text display indications include "FireStat", "FreezStat", "Over pressure" and "Low suction". The user shall also be able to determine which of the four (4) safety contacts is open over the serial communications connection.

24. Smoke Control Override Mode (Override 1) – The bypass shall include a dedicated digital input that will transfer the motor from VFD mode to Bypass mode upon receipt of a dry contact closure from the Fire / Smoke Control System. The Smoke Control Override Mode action is not programmable and will always function as described in the bypass User's Manual documentation. In this mode, the system will ignore low priority safeties and acknowledge high priority safeties. All keypad control, serial communications control, and normal customer start / stop control inputs will be disregarded. This Smoke Control Mode shall be designed to meet the intent of UL864/UUKL.

25. Fireman's Override Mode (Override 2) – the bypass shall include a second, programmable override input which will allow the user to configure the unit to acknowledge some digital inputs, all digital inputs, ignore digital inputs or any combination of the above. This programmability allows the user to program the bypass unit to react in whatever manner the local Authority Having Jurisdiction (AHJ) requires. The Override 2 action may be programmed for "Run-to-Destruction". The user may also force the unit into Override 2 via the serial communications link.

26. Class 10, 20, or 30 (programmable) electronic motor overload protections shall be included.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the VFD installation manual.

B. Power wiring shall be completed by the electrical contractor, to NEC code 430.122 wiring requirements based on the VFD input current. Caution: VFDs supplied without internal reactors have substantially higher input current ratings, which may require larger input power wiring and branch circuit protection. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

3.2 START-UP

A. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

3.3 PRODUCT SUPPORT

A. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A toll free 24/365 technical support line shall be available.

B. A computer based training CD or 8-hour professionally generated video (VCR format) shall be provided to the owner at the time of project closeout. The training shall include installation, programming and operation of the VFD, bypass and serial communication.

3.4 WARRANTY

A. The VFD Product Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor, travel time and expenses. A toll free 24/365 technical support line shall be available.

END OF SECTION 230280

SECTION 230300 - FANS

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

PART 2 - PRODUCTS

2.1 FANS

A. Furnish and install fans of the type, models, size and capacity indicated on the Drawings. Models indicated are as manufactured by Carnes Company. ACME or Greenheck, with equivalent characteristics will be considered.

B. Refer to Drawing schedule for required accessories and related appurtenances.

2.2 ROOF EXHAUST FANS

A. All roof exhaust fans shall be centrifugal roof exhausters of aluminum rustproof construction.

B. Units shall be direct connected with full ball-bearing motor. Power unit shall be isolated against vibration by means of oil resistant rubber or spring steel mounting.

C. Provide square insulated curb cap of aluminum with aluminum liner as an integral part of the unit. Each unit shall be equipped with a back draft or automatic damper, disconnect switch for the motor and birdscreens.

2.3 CEILING MOUNTED EXHAUST FANS

A. Ceiling mounted exhaust fans shall be of the centrifugal direct driven type. The wheel shall be of the forward curved design, balanced for extremely low sound levels. The motor shall be a low r.p.m. and permanently lubricated for continuous operation. The motor shall be resilient mount to help reduce vibration.

B. Duct connectors shall be provided and will include built-in automatic backdraft dampers. Grilles shall be of a durable, low profile design with a white finish. 8-way adjustable mounting brackets will be provided to permit a variety of mounting options. Cabinets shall be constructed of heavy gauge galvanized steel and shall include an acoustic lining.

2.5 KITCHEN HOOD EXHAUST FANS

A. Sidewall exhaust ventilators shall be of the centrifugal belt driven type. The motor compartments shall be construed of aluminum mounted on an independent support structure. The outer shroud shall have a rolled bead for added strength. The wheel and spun inlet venturi shall be a centrifugal design of non-sparking construction. For maximum performance and quiet, efficient operation, the wheel shall overlap the inlet venturi and have backward inclined blades. The wheel shall be dynamically balanced to assure smooth and vibration-free rotation under maximum loading. The complete drive assembly, including the motor and the wheel, shall be mounted on vibration isolators.

Motors and drives shall be factory mounted. All fans shall be test run prior to shipment.

B. Motor and drives shall be isolated from the exhaust airstream. Air for cooling the motor shall be supplied to the internal motor compartments through a vent tube from a location free from discharge contaminants. Motors shall be of the heavy duty type with permanently lubricated, sealed ball bearings. Motors shall be readily accessible for maintenance. The wheel shaft shall be ground, polished, coated with a rust inhibitive finish and mounted in heavy duty, permanently sealed pillow block ball bearings which are capable of 200,000 hours of life, average operation. The drives shall be sized at a minimum of 165% of driven horsepower. Drive belts shall be oil-resistant, non-static and be capable of 25,000 hours of life, average operation. Sheaves shall be fully machined cast iron or pressed steel, keyed and securely attached to the shafts. Variable pitch motor sheaves shall be standard.

C. The motor shall be factory wired to the disconnect switch which shall be mounted in a junction box located on the fan plate inside the motor compartment. Wiring connected to the switch will travel through rigid conduit to a weatherproof junction box mounted on the exterior of the unit. Wiring shall not pass through the motor compartment vent tube. Horsepower and noise levels shall not exceed the published values and oversized motors will not be acceptable. Performance ratings shall be AMCA licensed for air and sound. Centrifugal power upblast ventilators for commercial kitchen applications shall be Carnes Company model VRBK, belt driven, sizes 06 through 48, as manufactured by Carnes Company or Verona, Wisconsin or approved equal.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230300

SECTION 230310 - HOT WATER CABINET HEATERS

PART 1 - GENERAL

Applicable provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

PART 2 - PRODUCTS

2.1 HOT WATER CABINET HEATERS

A. Furnish and install where indicated on the Drawings hot water cabinet heaters as manufactured by Sterling Co. of model, capacity and performance noted on the Drawing schedule.

B. The cabinet shall be 16 gauge steel, four side overlap front panels, with M-shaped stiffener running entire panel length as standard. Integral, stamped, inlet and outlet insulated over entire coil section.

C. Front panel removed with two tamperproof screws, and shall be of finish as selected by Architect. Unit to be equipped with factory mounted fan cycling thermostat. Fans are forwardly curved double-inlet centrifugal of aluminum construction and are modular in design.

D. The water coil is constructed of copper tubing mechanically expanded into aluminum fins. All joints are brazed with high temperature silver alloy. Water coils have a plugged drain tube and vent tube extended into the unit end compartment. Automatic air vent fittings shall be provided. Coils are field reversible.

E. Filters are removable by removing front panel. 1" woven glass filters standard to be used.

F. Provide factory finished trim flange for all semi-recessed applications.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230310

SECTION 230320 - HOT WATER UNIT HEATERS

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section. Submit shop drawings for checking and approval.

PART 2 - PRODUCTS

2.1 HOT WATER UNIT HEATERS

A. Furnish and install where shown on the Drawings model as manufactured by Sterling Co. or approved equal and shall be of sizes noted on the Drawing.

B. Casing shall be 20 gauge die-formed steel. Casing substrates shall be prepared for finishing with a hot wash, iron phosphatizing clear rinse, chromic acid rinse and oven drying. Paint finish shall be of lead-free, chromate-free, alkyd melamine resin base and applied with an electrostatic two-pass system.

C. Coil elements and headers shall be of heavy wall drawn seamless copper tubing. Element tubes shall be brazed into extruded header junctions. Pipe connection saddles shall be of cast bronze. Aluminum fins shall have drawn collars to assure permanent bond with expanded element tubes and exact spacing.

D. Motors shall be totally enclosed, resilient mounted with class B windings. All motors shall be designed for horizontal mounting.

E. Fans shall be of the aluminum blade, steel hub type designed and balanced to assure maximum air delivery, low motor horsepower requirements and quiet operation. Blades are spark proof. Fan guards shall be welded steel, zinc plated or painted.

F. Units shall be equipped with horizontal, individually adjustable louvers. Vertical louvers for 4-way air control shall be available as an optional extra.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230320

SECTION 230340 – FIN-TUBE RADIATION

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

PART 2 - PRODUCTS

2.1 FIN TUBE RADIATION

A. Furnish and install fin-tube heating elements and enclosures, indicated on Drawings, together with required mounting components and accessories.

B. Materials shall be as manufactured by Sterling Radiator Co., Vulcan Radiator Co. or Standard Fin-Pipe Radiator Corp.

C. Heating Elements

1. Various lengths and assemblies are indicated on the plan together with their pipe sizes, fin sizes, and spacing. Elements shall be completely independent of and shall not touch enclosures to assure low surface temperature.

2. Heating elements shall consist of full-hard aluminum plate fins not less than .20" thick, permanently bonded to copper seamless drawn tube and guaranteed for working pressure at 300 degrees F not less than 200 psi for 1-1/4" tube. Fins shall be actually embedded in the copper tube.

D. Enclosure and Accessories

1. Enclosures and accessories shall be of style and dimensions indicated on our Drawings and shall be fabricated from zinc-coated steel. Enclosures shall be 16 gauge. On wall-to-wall applications, enclosures shall be furnished in one piece up to a maximum of 10' - 10" enclosure length for rooms or spaces measuring a maximum of 10' - 10" wall length, using a 6" end trim each end. Enclosures shall be furnished in two or more lengths for wall lengths exceeding 10' - 10".

2. Left end of all enclosures shall have spot-welded back-up angles. The mating right end shall be fastened securely with screws. End enclosures shall have same method of joining.

3. End trims, furnished with roll-flanged edges, shall be used between ends of enclosures and walls on wall-to-wall applications. End trims to be 6" maximum length and shall be attached without visible fasteners. End enclosures shall be furnished where indicated, shall be same gauge as enclosures, and be factory-welded to enclosures.

4. Enclosures shall be supported at top and bottom by means of heavy gauge mounting channel and allow installation and removal of enclosures without scraping walls or disturbing paint lines. Enclosures are securely fastened to the bottom support.

5. Access doors shall be provided where noted on Drawings. Doors shall be 8" x 8" and shall be located directly in the enclosures. Doors shall be hinged. Where radiation is located behind casework coordinate access door locations with casework vendor.

6. Provide vertical and horizontal enclosure for pipe risers and runouts which are exposed above/below/adjacent to radiation enclosure. Riser enclosure shall be of same gauge and finish as radiation enclosure. Provide wall plate which enclosure shall snap onto without exposed fasteners. Sterling model PCH (V).

7. Enclosure finish shall be as selected by Architect (and shall match unit ventilator finish when unit ventilators are also specified for the project).

E. Enclosure Brackets and Element Hangers

1. Enclosure bracket and element hangers shall be installed not farther than 4' apart. Brackets shall be die-formed from 3/16" thick stock, 1-1/2" wide, and shall be lanced to support and position lower flange of enclosure. Enclosures shall be firmly attached to brackets by set screws, operated form under the enclosure. Devices, which do not provide positive fastening of enclosures, are not acceptable. Brackets shall be inserted in pre-punched slots in mounted channel to insure correct alignment and shall be fastened securely to wall at bottom.

2. Sliding saddles shall support heating elements and provide positive positioning of element in enclosure to insure maximum heating efficiency while preventing any possibility of fin impingement on brackets or enclosure joints during expansion or contraction. Element supports shall be a double saddle design fabrication from 16 gauge zinc-coated steel.

3. Saddle shall slide freely on saddle support arm bolted to support bracket. Support arm shall allow 1-1/2" height adjustment for pinch. The element support saddle shall allow 1-5/8" lateral movement for expansion and contraction of heating element. Rod or wire hangers not acceptable.

4. Submit shop drawings of all heating elements and enclosures. Enclosure measurements and accessories are not to be fabricated until after verified measurements have been taken at the site.

F. Piping Enclosures: Where concealed piping in ceilings and wall of finished spaces is not possible, provide vertical or horizontal metal piping enclosures equal to “Sterling” model PCH (horizontal) or PCHV (vertical). Provide all required hangers, supports, corners, brackets, etc. color per Architect.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230340

SECTION 230400 - SHEETMETAL WORK AND RELATED ACCESSORIES

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements shall govern work in this section. Submit shop drawings for checking and approval.

PART 2 - PRODUCTS

2.1 SHEETMETAL DUCTWORK

A. Contractor shall furnish and install all sheetmetal ducts as shown on the Drawings. While the Drawings shall be adhered to as closely as possible, the Engineer reserves the right to vary the run and size to meet the field conditions. Any duct size not shown shall be sized in proportion to the air carried at the same resistance in similar ductwork, or of size as directed.

B. All ductwork shall be constructed of galvanized steel gauges in accordance with the latest edition of the ASHRAE/SMACNA Guide. Bracing angles for ductwork shall be hot dipped galvanized for steel ductwork and appropriate gauge for aluminum ductwork. All ducts 18" and over in width shall be cross broken to prevent flutter.

C. Round ductwork shall be galvanized steel, spiral lock seam construction of gauges in accordance with the latest edition of ASHRAE/SMACNA guide. Fittings shall be constructed in standing seam manner. All seams, joints and collars shall be sealed in accordance with SMACNA guidelines for medium pressure ductwork to minimize noise and streaking. Ductwork and fittings shall be connected with sheetmetal couplings and sealed as to allow no leakage.

D. Ducts shall be braced as follows:

1. All ducts not exceeding 24" on one side shall be assembled with airtight slip joints.

2. 25" to 40" larger dimension 1" x 1" x 1/8" angles.

3. 41" to 60" larger dimension 1-1/2" x 1-1/2" x 1/8" angles.

4. All bracing angles shall be a minimum of 4' apart along the length of the duct.

5. Furnish and install all angles and frames for all registers, diffusers, grilles, and louvers.

6. Support horizontal ducts with hangers spaced not more than 8' apart. Place hangers at all changes in direction. Use strap hangers for cuts up to 30" wide.

E. Comply with all State and Local regulations regarding fire stopping and fireproofing. Provide fusible link fire dampers as required by State, local and Underwriter authorities and where indicated on the Drawings. Each fire damper shall be installed in such a manner as to permit ready access for inspection and maintenance purposes.

F. Provide splitter and butterfly dampers, deflecting vanes for control of air volume and direction and for balancing systems, where indicated, specified, directed and as required for the proper operation of the systems. Dampers shall be of the same material as the duct, at least one gauge heavier that the duct, reinforced where indicating quadrant and locking device for adjusting damper and locking in position.

G. Where ducts fewer than 100 square inches penetrate a rated wall, steel ductwork system of a minimum 0.0127 inch thickness shall be used.

H. All elbows shall have a minimum center line radius of 150% of duct width. If the radius is smaller, turning vanes shall be used: Turning vanes shall be double thickness, fitted into slide strips and screwed or riveted to duct below.

I. Contractor shall furnish and install all access doors in ducts as required. Access doors shall be of the pan type 1" thick and shall be provided with two galvanized hinges and suitable latched. Access doors insulated with same thickness material as duct and shall be double casing construction.

2.2 REGISTERS AND DIFFUSERS

A. Registers and diffusers shall be installed where shown on the Drawings and shall be of the sizes specified and the type indicated on the drawing schedule.

B. All registers and diffusers shall be installed in accordance with manufacturer's recommendations.

C. Registers and diffusers shall be as manufactured by Price, Carnes, Hart and Cooley or Anemostat Co.

2.3 KITCHEN EXHAUST DUCT WORK

A. Duct work or plenums for kitchen exhaust ventilators shall be constructed of not less than 16 gauge black steel or 18 gauge stainless steel with all joints and seams made with a continuous great tight weld on the external surface.

B. Duct system shall be so constructed that grease cannot become pocketed and shall slope not less than 1/4“ per lineal foot toward the ventilator hood. Duct systems shall be equipped with cleanout openings that have tight fitting doors. Doors shall be constructed of same material and gauge as duct and shall be equipped with a latching mechanism to hold the door tightly closed.

C. Kitchen exhaust system shall conform in all respects with NFPA 96

D. Insulate duct per NFPA requirements (minimum 2” calcium silicate insulation with all service jacket) and all other agencies having jurisdiction.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230400

SECTION 230410 - PIPING, FITTINGS, VALVES AND NOTES (HOT WATER)

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements shall govern work in this section. Submit shop drawings for checking and approval.

1.1 PIPING NOTES

A. The Contractor shall erect all pipe, fittings, valves, hangers, anchors, expansion joints and all accessories specified, indicated on the Drawings or required to assure proper operation of all piping systems installed under this Contract. All piping shall be maintained at a proper level to assure satisfactory operation, venting and drainage. Piping and valves in any locality where possible shall be grouped neatly and shall be run so as to avoid reducing headroom or passage clearance.

B. All piping shall be new and of the material and weight specified under various services. Steel and wrought iron pipe 2" and larger shall be seamless or lap welded. All piping shall have the maker's name and brand rolled on each length of pipe.

C. All piping, fittings, valves and strainers shall be cleaned of grease, dirt and scale before installation. All temporary pipe openings shall be kept closed during the performance of the work. The ends of all piping shall be reamed smooth and all burrs removed before installation.

D. All piping shall be cut accurately to measurements taken on the job. Offset connections shall be installed alignment of vertical to horizontal piping and where required to make a true connection and to provide for expansion. Bent or sprung pipe shall not be installed where shown on Drawings and where necessary to provide for expansion of piping. Cold spring hot lines one-half estimated distance of maximum expansion. Suitable pipe anchors shall be installed where shown or required.

E. Piping connections shall have unions where necessary for replacement and repair of equipment. Gate valves and controls valves shall be installed where shown and where necessary for proper operation and service.

F. Vertical piping shall be plumb and horizontal piping shall be parallel to walls and partitions. Piping shall be supported as required to prevent the transmission of noise and vibration.

G. Work shall include all pipe, fittings, offsets and requirements for the installation of piping of other work including ducts and conduit. Reducing fittings shall be used where pipe changes size. All piping shall be installed with ample clearance to center accurately in sleeves through floors, and walls and partitions.

H. Piping shall be downgraded to drain connections at low points and upgraded to vent connections at high points unless otherwise noted. Drain connections shall be valved and piped to a floor drain. Vent connections on mains shall be equipped with air vent valves fitted with a copper tube drip line extended to a drain outlet. Vent connections on branches and equipment shall be fitted with key type manual vent cocks.

I. Drain piping shall be installed from all equipment as required. The Contractor shall extend drain piping and turn down over floor drains.

PART 2 - PRODUCTS

2.1 PIPING (ABOVEGROUND)

A. All piping installed under this Section of the Specifications shall be in accordance with the following schedule.

1. All piping, except where indicated differently, (i.e. underground piping) shall be standard weight black steel pipe Schedule 40, Grade A53, black steel. Pipe 2” and smaller, cast iron screwed fittings. Pipe 2-1/2” and larger, steel welding fittings. Pipe and fittings as manufactured by National, Wheeling, Bethlehem or equal, manufactured in accordance with ASTM current edition. All pipes must be reamed before installation.

2. Where the Contractor elects to use copper piping, it shall be rigid Type "L" copper, Chase, Anaconda or approved equal. Fittings shall be wrot copper, Nibco, Anaconda, Mueller or approved equal. Where copper piping is used, make all additional provisions for expansion. All condensate piping shall be Type "M" copper, rigid, full size of unit drain tapping, or larger as shown on Drawings.

3. All drainage pipe lines, 2" larger except where galvanized screw pipe is shown on the Drawings or specified hereafter, shall be extra heavy cast iron soil pipe and fittings.

B. Piping installation shall be arranged for draining through accessible valves at low points.

C. Threaded short and close nipples shall be Schedule 80, extra heavy weight of the same material as pipe in system in which they are installed.

D. All bare copper pipe, tubing and fittings shall be cleaned with steel wool and all excess solder shall be removed.

2.2 UNDERGROUND PRE-INSULATED PIPING SYSTEM

A. General: All underground piping shall be the Poly-Therm type, as manufactured by Perma-Pipe or approved equal. All straight sections, fittings, anchors and other accessories shall be factory fabricated to job dimensions and designed to minimize the number of field welds. Each system layout shall be computer analyzed by the piping system manufacturer to determine stress on the carrier pipe, and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ANSI B31.3, latest edition. Factory trained field supervision shall be provided for critical periods of installation; unloading, field joint instruction and testing.

B. Service Piping: Internal piping shall be standard weight carbon steel. All joints shall be butt-welded for 2-1/2 inch and greater, and socket or butt-welded for 2 inch and below. Where possible, straight sections shall be supplied in 40 foot random lengths with piping exposed at each end of field joint fabrication.

C. Accessories: End seals, gland seals and anchors shall be designed and factory fabricated to prevent the ingress of moisture into the system.

D. Insulation: Service pipe insulation shall be spray applied nominal 2 pound per cubic foot density, polyurethane foam for straight sections and preformed polyurethane foam for all fittings. To ensure no voids are present, all insulation shall be inspected by visually checking prior to application of the jacket. The insulation shall be applied to the minimum thickness specified below. The insulation thickness shall not be less than indicated in these Specifications.

Pipe Size (in.)	Insulation Thickness (in.)
1-3	1
4-6	1.5
8-14	2

E. Protective Jacket: All straight sections of the insulated piping systems shall be filament wound, polyester resin/fiberglass reinforcement composite directly applied on the insulating foam. Thermoplastic casing material, e.g., PVC or PE, shall not be allowed. The minimum thickness for FRP jacket shall be .055 inches. All fittings of the insulated piping system shall be prefabricated to minimize field joints and jacketed in a chopped spray up, polyester resin/fiberglass reinforcement composite, directly applied onto the insulating foam to a thickness related to the filament wound jacket thickness.

F. Field Joints: After the internal pipe has been hydrostatically hammer tested to 150 psig of 1-1/2 times the operating pressure, which ever is greater. Insulation shall then be poured in place into the field weld area. All field applied insulation shall be placed only in straight sections. Field insulation of fittings shall not be acceptable. The mold for the polyurethane shall be made of clear adhesive backed polyester film. The installer shall seal the field joint area with a heat shrinkable adhesive backed wrap or with wrappings of glass reinforcement full saturated with a catalyzed resin identical in properties to the factory applied resin. Backfilling shall no begin unit the heat shrink wrap has cooled or until the FRP lay-up has cured. All insulation and coating materials for making the field joint shall be furnished by the piping manufacturer.

G. Backfilling: A 4 inch layer of sand of fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the pipe. The entire trench width shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum of 6 inches above the top of the insulated piping system. The remaining trench shall be evenly and continuously backfilled in uniform layers with suitable excavated soil. Coordinate these requirements with the excavating and backfilling Contractor.

2.3 VALVES

A. All valves, unless specified or noted otherwise, shall be designed for a working pressure of not less than 200 p.s.i. water or 125 p.s.i. steam with name and pressure rating of valve cast in body. All valves shall be of the same manufacturer, unless specified otherwise. Valves for cut-off shall be gate valves, unless otherwise specified.

B. All valves of same manufacturer: similar to Jenkins Bros., Walworth, Kennedy or approved equal.

C. Four inch and larger, flanged; smaller sizes, screwed.

D. All Gate and Globe valves shall be installed with handle in an upright position.

E. The Contractor shall furnish and install all valves shown on Drawings and all valves that are necessary for proper operation and maintenance of systems and equipment. All piping connections to each piece of equipment and all branch connections to mains shall have cut-off valves.

F. The following schedule of valves for steam condensate, hot water, etc. is based on Jenkins Brothers, Inc. catalog numbers (except as noted); equivalent Lukenheimer, Walworth, O-I-C, Crane Fairbanks Company valves will be acceptable.

G. Ball Valves

1. 1/4" to 2-1/2” rated for 600 p.s.i wog, with brass body, chrome plated brass ball, virgin PTFE seats, and full port with threaded or solder connections.

2. 2-1/2” and larger rated for 200 p.s.i with carbon steel body, stainless steel full port ball, RTFE seats, lever operated to 4” gear operated 6” and above, with flanged end connections.

H. Gate Valves

1. Up to 2" : Bronze gate solid wedge, inside screw traveling stem union bonnet, -Fig. 47U

2. 2-1/2" and 3" : Iron body, bronze-mounted gate, solid wedge, OS&Y rising stem, -Fig. 650-A

3. 4" and larger: Iron body, bronze-mounted gate, solid wedge, OS&Y rising stem, -Fig. 651-A

I. Globe Valves

1. Up to 2" : Bronze body, regrinding seat ring and plug, union bonnet, -Fig. 546P

2. 2-1/2" and 3" : Iron body, bronze-mounted globe and angle, regrinding disc and seat ring, OS&Y -Fig. 613

3. All gate valves 6" and larger: Fitted 3/4" by-pass globe valve.

J. Plug Valves

1. Up to 2" : Lubricated, semi-steel short pattern wrench operated, -Fig. 142

2. 2-1/2" and larger: Lubricated, semi-steel short pattern wrench operated, -Fig. 143

3. Similar to Rockwell Mgd. Co., Jenkins, Kennedy or approved equal.

K. Butterfly Valves used for chilled water, condenser water and hot water shall be the following:
1. 2-1/2" to 12” rated for 175 p.s.i bubble tight close off, 14” and larger for 150 p.s.i close-off.

2. Full lug cast iron body, aluminum bronze disc, stainless steel stem EPDM peroxide cured seat.

3. 2-14” to 6” valves to be equipped with 10 position notch plate and lever lock handle. 8” and larger with handwheel gear operator.

4. On installation, valves to be in full open position when flange bolts are tightened and stem in a horizontal position except when equipped with a chainwheel gear operator.

5. Provide chain wheel gear operator on all valves installed 7 feet or higher.

6. Valves to be designed with replaceable seat and parts kits.

7. Valve to be Bray series 31, Dezurik 637 or Demco.

L. Check Valves
1. 150 p.s.i. WSP class.

2. Up to 2" : Bronze, regrinding bronze disc, screw-in cap, -Fig. 762A

3. 2-1/2" and 3" : Iron body, bronze mounted regrinding bronze seat ring and disc, -Fig. 623

4. 4" and larger: Iron body, bronze mounted regrinding bronze seat ring and disc, -Fig. 624

M. Drain Valves: All low points shall have drain valves, with hose ends. Where 1/2" and 3/4" sizes are indicated, "Standard" hose end drain valves shall be used. Provide brass hose end drain caps at each drain valve. Where larger than 3/4" drains are shown, gate valve shall be used. Provide brass nipples and reducer from drain valve size to 3/4" terminating with 3/4" hose end drain valve and cap.

2.4 FITTINGS

A. Nipples

1. All nipples shall have clean cut threads and shall be made from new pipe, standard weight for all lengths, except that close and shoulder nipples shall be extra heavy.

2. Fittings - 2-1/2 and Smaller: All fittings shall be standard weight steam pattern gray cast iron, Grinnell, Stockholm or equal approved.

3. Fitting - 3" and Larger: The Contractor has the option to use screwed, flanged or welded fittings so long as all ASME requirements are met.

B. Joints and Unions

1. Threaded joints shall be full and clean cut. The ends of pipe shall be reamed to the full inside diameter, all burrs shall be removed and no more than three threads shall be exposed beyond fittings when made up. Joints shall be made up tight with graphite base pipe joint compound. Exposed threads of ferrous pipe shall be painted with acid-resisting paint after caulking, lampwick or other material will be allowed for correction of defective joints.

2. Flange joints shall be made up perfectly square and tight. Screwed flanges and loose flanges shall be cast iron and welding flanges shall be steel. Flanges shall be faced true and bolted up tight with 1/16" Carlock ring type gasket.

3. Bolts shall be high quality steel with hexagon nuts and heads. The Contractor shall apply grease to threads of bolt.

4. Welded joints in piping shall be by the electric or oxyacetylene process using welding rods if the characteristics similar to pipe material and as recommended by the pipe manufacturer and shall be done in accordance with the ASME Code for pressure piping. Welding shall be done by qualified welders under the requirements of the ASME Boiler and Pressure Vessel Code.

5. The pipe lengths shall be aligned with welding rings and the abutting pipe ends shall be concentric. Prior to welding, the groove and adjacent surfaces shall be thoroughly cleaned of all grease, scale, or rust. During welding, all slag, or flux remaining on the bead shall be removed before laying down the next bead. The welding metal shall be thoroughly fused with the base metal at all sections of the weld. Short lengths of pipe may be beveled on the job with oxyacetylene torch, provided all scale and oxides are removed.

6. Joints shall be butt-welded, single V-type. All fittings shall be steel welding fittings. Elbows and fittings formed with coupling or welded cut pipe sections shall not be acceptable.

7. Bonney Weldolets or welding saddles may be used for branch connections, which are less than one-half the size of the main to which they connect.

8. Ground Joint Unions, Flange Connections, Reaming & Filling Ground joint unions shall be 200 lb. s.w.p. for brass. Flanges shall be 150 lb. s.w.p. for brass, 125 lb. s.w.p. for cast iron.

9. Ground joint unions of flanges shall be used only on exposed accessible piping. Where concealed, right and left nipples and couplings must be used. Where flanged connections are used, full size gaskets must be inserted.

C. Threads: Shall be standard, clean cut and tapered. All piping shall be reamed free from burrs. All piping shall be kept free of scale and dirt. Caulking of threads will not be permitted. All piping shall be threaded and made up in accordance with the current edition of the ASA Standard Specifications for pipe threads.

D. Unions

1. Unions for use on ferrous pipe 2" and smaller shall be malleable iron with brass to iron ground joint spherical seat and threaded connections. Unions 2 1/2" and over shall be flanged type with gasket.

2. Unions for copper tubing shall be cast bronze conforming to ASA B16. The Contractor shall furnish adapters where required for copper pipe.

3. Where copper pipe connects to ferrous pipe or metals, the Contractor shall furnish EPCO isolating type dielectric unions. Plastic type isolating bushings are not acceptable.

4. Unions shall be installed wherever necessary for repair or replacement of equipment, valves, strainers, etc. Final connections to equipment shall be made in a manner that will permit removal without cutting of pipelines.

E. Solder

1. All sweat joints shall be made up with 95/5 solder.
2. Solder shall be National Lead or approved equal. Flux shall be non-toxic and non-corrosive.
3. All copper tubing ends shall be reamed, filed and cleared of burrs and rough edges. All pipes shall be reamed after cutting and threading.

F. Expansion

1. The entire piping installation shall be installed with adequate provision for expansion. No rigid connections will be permitted.

2. Branches shall be of sufficient length and have 3 elbow swings to allow for pipe expansion.

3. Provide expansion joints, guides and anchors equal to “Metra-Flex MetraLoops” where indicated on Drawings or where necessary for proper expansion compensation. Submit shop drawing.

4. Any breaks in the piping within the guarantee period due to improper provision for expansion must be replaced at the expense of this Contractor, and the conditions corrected to prevent future recurrence.

5. Any damages to surrounding areas and equipment due to this failure shall also be repaired and paid for at the expense of the Contractor.

6. Joints to have 150 psi rating, ANSI-B16.5 with liner and cover.

2.5 PIPING SLEEVES

A. Furnish sleeves built into place for all piping passing through walls, floors or building construction. Sleeves, not less than 1/2” larger in diameter than piping and its covering, if any, and extending full depth of construction pierced. Pack sleeves through walls/floors in accordance with Underwriters' Requirements.

B. Sleeves piercing exterior walls, integral waterproofed walls shall be standard weight steel piping. Furnish welded center flange buried in construction for sleeves through exterior walls below grade. At exterior walls, make pipes watertight in sleeves with oakum packing and caulked lead joints on both sides of wall. All other sleeves: Galvanized sheet steel with lockseam joints, #22 USSG for 3" or under. Sleeves for piping 4" and larger, #18 USSG.

C. Pipes passing through interior membrane waterproofed floors, cast iron flashing sleeve, with integral flashing flange and clamping ring, similar to Josam Series #1880. Adjust sleeves to floor construction with steel or wrought iron pipe nipples top and bottom, extending 3" above finished floor. Burn & J.R. Smith are equal.

D. Pipes passing through membrane waterproofed walls, cast iron flashing sleeve with internal flashing flange and clamping ring similar to Josam Series #1870. Make pipes watertight in sleeves with oakum packing and caulked lead joints. Burn & J.R. Smith are equal.

E. For flashing sleeves specified in Pars. C and D, lead flashing extended at least 10" around flashing sleeves, securely held in place by clamping device.

2.6 PIPING ENCLOSURES

A. Where concealed piping in ceilings and wall of finished spaces is not possible vertical or horizontal metal piping enclosures equal to "Sterling" model PCH (horizontal) or PCHV (vertical). Provide all required hangers, supports, corners, brackets, etc. color per Architect.

PART 3 - EXECUTION

3.1 GENERAL NOTES - PIPING NOTES, DRAINING, VENTING AND MISCELLANEOUS WATER SPECIALTIES

A. Piping shall be installed as indicated on Drawings. Elevations and dimensions are indicated as a guide only and are subject to change with actual job conditions.

B. Except for drainage piping, which shall pitch down with flow, mains shall pitch upward or be installed dead level as indicated. Horizontal runs shall be parallel to walls.

C. In general, all branch connections shall be top of bottom 45 degree or 90 degree, pitching up or down from mains.

D. Where indicated, flexible connectors shall be installed. All final connections to equipment, pumps, units, etc. shall have companion flanged, flange unions or ground joint unions. (125 lbs.)

E. All piping shall be adequately supported with approved type hangers so as to prevent absolutely any sagging of lines, or any undue strain on pipes or fittings. All pipe lines shall be capped during construction to prevent entry of dirt or other foreign material. All piping lines after erection shall be blown or flushed out to render the piping system as clean as possible before system water is added for operation.

F. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

G. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

H. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.2 DRAINING

A. All low points shall have drain valves with hose ends. Where 1/2" and 3/4" sizes are indicated, "Standard" hose end drain valves shall be used. Provide brass hose end drain caps at each drain valve. Where larger than 3/4" drains are shown, gate valve shall be used. Provide brass nipple and reducer from drain valve size to 3/4" terminating with 3/4" hose end drain valve and cap.

3.3 VENTING (For Hot Water)

A. All high points in piping shall be vented automatically with float vents. At all high points of piping, whether specifically indicated or not, provide Maid-o-Mist or B&G No. 7 or 27 Air Eliminators with shut off cock, auxiliary key vent and copper tubing overflow carried to floor along wall as indicated or directed.

3.4 WATER SPECIALTIES

A. Air Vents: Install at all high points automatic air vents to eliminate air binding. All automatic air vents shall be approved heavy duty type equipped with petcocks and tubing for manual venting. All vents installed in coils, etc. shall be of manual key operated type. All vents concealed from view shall be accessible through access doors. Vents shall be by Hoffman, Anderson or Bell & Gossett, 125 p.s.i.g. rated.

B. Pressure Gauge: Furnish and install pressure gauges on suction and discharge sides of each pump and as required to check operation of equipment; pressure gauges shall have 4-1/2"diameter dials, Ashton, Ashcroft or approved equal.

C. Install thermometers at all locations in piping system as noted on Drawings and as required to check system performance. Thermometers shall be installed at the supply and return of coils and 3-way diverting valves as manufactured by Trerice, Weksler or Moeller, with 4-1/2 inch face, cast aluminum case, chrome plated steel ring, white background with black embossed markings, glass window, stainless steel pointer, brass movement, 316 stainless steel bulb. Provide separable, universal angle sockets for all thermometers.

END OF SECTION 230410

SECTION 230420 - SUPPORTS, SLEEVES AND PLATES

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section. Submit shop drawings for checking and approval.

1.1 DESCRIPTION OF WORK

A. This Contractor shall furnish and install all plates, hangers and supports for his equipment including piping, headers, fans expansion tank, ductwork, etc.

B. All ductwork, piping and equipment shall be hung or supported from structural members only.

PART 2 - PRODUCTS

2.1 PIPING, DUCTWORK AND EQUIPMENT

A. All piping shall be supported from building structure in a neat and workmanlike manner wherever possible, parallel runs of horizontal piping shall be grouped together on trapeze hangers. Vertical risers shall be supported at each floor line with steel pipe clamps. Use of wire perforated metal to support pipes will not be permitted. Hanging pipes from other pipes will not be permitted.

B. Necessary structural members, hangers and supports of approved design to keep piping in proper alignment and prevent transmission of injurious thrusts and vibrations shall be furnished and installed. In all cases where hangers, brackets, etc., are supported from concrete construction, care shall be taken not to weaken concrete or penetrate waterproofing.

C. All hangers and supports shall be capable of screw adjustment after piping is erected. Hangers supporting piping expanding into loops, bends and offsets shall be secured to the building structure in such a manner that horizontal adjustment perpendicular to the run of piping supported may be made to accommodate displacement due to expansion. All such hangers shall be finally adjusted, both in the vertical and horizontal direction, when the supported piping is hot.

D. Pipe hangers shall be as manufactured by Grinnell, whose catalog numbers are given herein, or equivalent Carpenter and Paterson, or F&S Mfg. Co.

E. Piping shall be supported as follows unless otherwise indicated on the Drawings:

1. Heating piping shall be 1-1/2 " and smaller Fig. #260 adjustable clevis hanger. 2" and larger Fig. #174 one-rod swivel roll hanger.

2. Two-rod hangers shall be used for piping close to the ceiling slab or where conditions prohibit use of other hanger types.

3. Anchors for hanger rods shall be Phillips "Red Head" self-drilling type. Anchors shall be placed only in vertical surfaces.

4. Spacing of pipe supports shall not exceed 8 feet for pipes up to 1-1/2" and 10 feet on all other piping.

5. Hangers shall pass around insulation and a 16 gauge steel protective cradle; 12" long shall be inserted between hangers and insulation. Insulation under cradle shall be high density calcium silicate or approved equal to prevent crushing.

6. All piping shall be supported to allow free movement where expanding or contracting. Pipe shall be anchored as required or directed.

7. All lateral runs of piping shall be securely supported on hangers, rolls, brackets, etc. and in manner to allow for proper expansion and elimination of vibration.

8. 2" and smaller pipe, where run on walls, shall be supported on wrought iron "J" hook brackets with anchor bolts.

9. All horizontal pipes, where run overhead or on walls, shall be supported as follows unless otherwise indicated:

   a. On adjustable steel clevis type hangers suspended on hanger rods, pipe sizes up to and including 4".

F. Space limitations in hung ceilings spaces and conditions in other locations may require use of other type of hangers than those specified above. Suitable and approved pipe hangers shall be provided for such job conditions.

G. All supports shall be fastened to structural members or additional steel supports furnished by this Contractor.

H. Hanger rods shall be steel, threaded with nuts and lock nuts sizes in accordance with the following schedule:

Pipe Size	Rod Size
3/4" to 2" inclusive	3/8"
2-1/2" and 3' inclusive	1/2"
4" and 5" inclusive	5/8"
6"	3/4"
8" to 12" inclusive	7/8"

I. Hangers for copper tubing shall be tacked up with formed lead sheet on which tubing or pipe shall be placed.

J. Where pipes pass through masonry, concrete walls, foundations, or floors, this Contractor shall set sleeves as are necessary for passage of pipes. These sleeves shall be of sufficient size to permit insulation where required to be provided around pipe passing through. This Contractor shall be responsible for exact location of these sleeves.

K. Sleeves shall not be used in any portion of building where use of same would impair strength of construction features of the building. Inserts for supporting lateral pipes and equipment shall be placed and secured to form work, and all sleeves inserts locations shall be thoroughly checked with Architect so as not to conflict with other trades.

L. Where pipes pass through floor or walls, they shall be provided with chromium plated escutcheons.

M. Anchor horizontal piping where indicated and wherever necessary to localize expansion or prevent undue strain on branches. Anchors: Heavy forged construction entirely separate from supports.

N. Anchor vertical piping wherever indicated and wherever necessary to prevent undue strain on offsets and branches. Anchors, unless otherwise noted: Heavy steel clamps securely bolted and welded to pipes. Extension ends shall bear on building construction.

O. Ducts shall be hung with 1" x 1/8" metal straps. When width of duct is less than 48", hangers shall be fastened to side of ducts. Auxiliary steel supports that may be required for all mechanical equipment shall be furnished and installed by this Contractor. All operating equipment including fans, piping, etc. shall be supported so as to produce minimum amount of noise transmission.

P. Refer to "General Conditions" as well.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230420

SECTION 230430 - INSULATION AND COVERINGS

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section. Submit shop drawings for checking and approval.

1.1 DESCRIPTION OF WORK

A. Furnish insulation for all piping, equipment and sheetmetal work as noted.

B. Insulate no piping, ducts or equipment until tested and approved for tightness. All piping and ducts shall be dry when covered. Where existing insulation has been damaged, altered of removed during the course of the work, it shall be replaced with new insulation in a neat manner to match the adjacent insulation.

C. All insulation must be done by an approved Sub-Contractor or by mechanics skilled in this line of work.

D. Fire hazard classification shall be 2550 per ASTM E-84, NFPA 255 and UL 723. Insulation shall be rated non-combustible type classified flame spread - 25, smoke developed - 50.

PART 2 - PRODUCTS

2.1 DUCTWORK (INDOOR)

A. All supply, outside air intake and exhaust (on discharge side of fan) and return (in unconditioned spaces) ductwork shall be covered with fiberglass with aluminum foil vapor barrier. All joints shall be lapped so maximum coverage is achieved.

B. All insulated ductwork shall be insulated with thick fiberglass board insulation with canvas finish in areas where ductwork is exposed.

C. Insulation thickness shall be in accordance with the latest edition of the New York State Energy Conservation Construction Code C403.11.

D. Thermal acoustic lining of ductwork where indicated shall be 1” thickness fiberglass unless otherwise noted. The lining shall have a mat facing and shall meet the Life Safety Standards as established by NFPA 90A and 9B and conform to the requirements of ASTMC 1071.

E. Insulate Kitchen exhaust ductwork per NFPA requirements (minimum 2” calcium silicate insulation) and all other agencies having jurisdiction.

2.2 PIPING / EQUIPMENT (INDOOR)

A. All new or altered heating and chilled water system supply and return piping shall be covered with Manville Micro-Lok or equal approved fiberglass insulation with all service (factory applied) vapor retardant jacket. Seal with type H mastic.

B. Fittings shall be insulated with same material and thickness as adjoining pipe insulation and shall be pre-molded fittings or mitre cut segmental insulation wired on. Over the insulation, apply a wrapper of OCF glass cloth sealed with type H mastic. Apply aluminum bands on pipe covering in addition to self-sealing feature.

C. Insulation Material: Molded fibrous glass insulation, density not less than 4 lbs. per cubic foot.

D. Insulation Thickness: Shall be in accordance with the latest edition of the New York State Energy Conservation Construction Code C403.11.

E. Jacket and Finish: White flame retardant type, meeting all requirements of "Fire Hazard Classification" of NFPA, similar to "Fiberglass" Type FRJ, Insul-Coustic, Johns-Manville or approved equal.

F. Insulation and Finishes for Fittings, Valves and Flanges

1. Valves, fittings and flanges other than vapor seal insulation: Insulated in same manner and same thickness as piping in which installed.

2. Use pre-molded sectional covering where available; otherwise use mitered segments of pipe covering.

3. Obtain written approval prior to using other than molded sectional covering.

G. Vapor seal Insulation for Valves, Fittings and Flanges: Same as above, except joints sealed with vapor barrier adhesive and wrapped with glass mesh tape. Each fitting shall be finished with two coats of vapor seal mastic adhesive.

H. Jacket and Finishes: Exposed fittings - 6 oz. canvas jacket adhered with lagging adhesive.

I. Concealed fittings: Standard weight canvas jacket adhered with lagging adhesive and with bands of 18 gauge copper coated steel - 2 bands at elbows, 3 at tee.

J. Insulation at Pipe Hangers

1. Where shields are specified at hangers on piping with fibrous glass covering, provide load bearing calcium silicate between shields and piping as follows:

a. For pipe covering without vapor barrier jacket, furnish at each shield 12" - long calcium silicate section with canvas section with canvas jacket continuous between shield and insulation.
b. For pipe covering with vapor barrier jacket, furnish at each shield 12" - long vapor barrier jacket section with section of fibrous glass replaced with section of calcium silicate. Vapor barrier jacket, continuous between shield and insulation for continuous vapor barrier.

K. Condensate drain piping shall be insulated with 1/2” Armacell or approved equal closed cell insulation.

L. Refrigerant piping shall be insulated with Armacell or approved equal closed cell insulation. Thickness shall be in accordance with the latest edition of the New York State Energy Conservation Code C403.11.

M. Equipment

1. Secure fibrous glass block or board insulation in place with wire or galvanized steel bands.

a. Small Areas: Secure insulation with 16 gauge wire on maximum 6" centers.

b. Large Areas: Secure insulation with 14 gauge wire or .015" thick by 1/2" wide galvanized steel bands on maximum 10" centers. Stagger insulation joints.

c. Irregular Surfaces: Where application of block or board insulation is not practical insulate with insulating cement built-up to same thickness as adjoining insulation.

2. Fill joints, voids and irregular surfaces with insulating cement to a uniform thickness.

3. Stretch wire mesh over entire insulated surface and secure to anchors with wire edges laced together.

4. Apply finishing cement, total of 1/2" thick, in 1/4" thick coats. Trowel second coat to a smooth hard finish.

5. Neatly bevel insulation around handholes, cleanouts, ASME stamp, manufacturer's nametag and catalog number.

N. Insulated Covers for Pumps

1. Do not extend pump insulation beyond or interfere with stuffing boxes or interfere with adjustment and servicing of parts regular maintenance or operating attention.

2.3 PIPING (OUTDOOR)

A. All supply and return piping shall be or approved equal covered with insulation in accordance with the latest edition of the New York Energy Conservation code C403.11.

B. Insulation shall be complete elastomeric insulation system coupled with a multi-layered covering, resistant to ultraviolet rays and atmospheric agents. The plastic / aluminum cladding provides a secondary moisture vapor barrier to the inherently moisture-resistant closed cell foam core. The insulation cladding shall be a minimum of .016" thick. Provide 2" wide tape for seams and 8" wide tape for edges and corner with matching cladding covering. All seams and joints shall be weatherproof.

C. Insulation shall conform with ASTM C 534 Type 1, Grade 1 and shall be manufactured by K-Flex USA Model K-FLEX CLAD AL, (K-FLEX CLAD IN for extreme environmental conditions), Armacell Model ARMATUFF SA or approved equal.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230430

SECTION 230440 - DAMPERS AND MISCELLANEOUS

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section. Submit shop drawings for checking and approval.

PART 2 - PRODUCTS

2.1 DAMPERS AND MISCELLANEOUS

A. Furnish and install where shown on Drawings ARROW PIN-LOCK Dampers No. OBDPL-507 (Opposed) as manufactured by the Arrow Louver & Damper Corp. of Maspeth, NY 11378, or approved equal. Frames and blades to 1/8" extruded aluminum.

B. Blades to be single unit PIN-LOCK design 6" wide, with the PIN-LOCK an integral section within the blade center axis. Frames to be a combination of 4" extruded aluminum channel and angle, with reinforcing bosses and groove inserts for vinyl seals.

C. Pivot rods to be 1/2" diameter extruded aluminum, PIN-LOCK design interlocking into blade section. Bearings to be "Double-Sealed" type with Celcon inner bearing on rod riding in Merlon Polycarbonate outer bearing inserted in frame so that outer bearing cannot rotate.

D. Blade linkage hardware is to be installed in angle or channel frame section out of air stream. All hardware to be of non-corrosive reinforced material or to be cadmium plated.

E. Rod bearing to be designed for minimum air leakage by means of overlapping design and by extruded vinyl seals to fit into integral ribbed groove inserts in both frames and blades. All dampers in excess of 10 sq. ft. free area to have reinforced corners by means of gusset plates.

F. Dampers shall be sized by the Control Manufacturer to properly control the flow of air and ensure minimum air stratification in mixing applications. Sizing shall be submitted for approval with information similar to that submitted on valve when sizing valve.

2.2 FIRE DAMPERS

A. Dampers shall be multi blade construction UL labeled and be installed in accordance with UL 555, with breakaway connections. The units shall have stainless steel actuator springs with locking devices for horizontally mounted type.

2.3 COMBINATION FIRE / SMOKE DAMPERS

A. Furnish and install at locations shown on Drawings, or as described in schedules, combination fire smoke dampers.

B. Frame shall be a minimum of 16 gauge galvanized steel formed into a structural hat channel reinforced at corners for added strength. The blades shall be airfoil shaped single-piece hollow construction with 14 gauge equivalent thicknesses. Blade action shall be opposed. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame for long life. Galvanized bearing shall not be acceptable.

C. Blade edge seals shall be silicone rubber and galvanized steel mechanically locked into blade edge (adhesive or clip fastened seals shall be acceptable) and shall withstand a minimum of 450 degrees F. (232 degrees C.) Jamb seals shall be non-corrosive stainless steel flexible metal compression type to further ensure smoke management.

D. Each combination fire/smoke damper shall be classified for use for fire resistance ratings of less than 3 hours in accordance with UL Standard 555, and shall further be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems in accordance with the latest version of UL555S, and bear a UL label attesting to same. Damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers, required by this Specification. Testing and UL qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be leakage Class I (4 c.f.m./sq. ft. at 1" w.g. and 8 c.f.m./ft. at 4" w.g.).

E. As part of UL qualification, dampers shall have demonstrated a capacity to operate (to open and close) under HVAC system operating conditions, with pressures of at least 4" w.g. in the closed position, and 4000 f.p.m. air velocity in the open position.

F. In addition to the leakage rating already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. (177 degrees C.). Appropriate electric actuators (equal to Ruskin model MA) shall be installed by the damper manufacturer at time of damper fabrication. Damper and actuator shall be supplied as a single entity, which meets all applicable UL555S qualifications for both dampers and actuators. Damper and actuator assembly shall be factory cycled 10 times to assure operation.

G. Manufacturer shall provide factory assembled sleeve of 17" minimum length (Contractor to verify requirement). Factory supplied caulked sleeve shall be 20 gauge for dampers through 84" wide and 18 gauge above 84" wide.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect equipment space locations before beginning installation. Verify that the space is correct for entry and access. Do not proceed with installation of the equipment until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Comply with manufacturer's instructions and recommendations for installation of equipment, accessories and components.

B. All heating, ventilating and air conditioning equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces. The Contractor shall be required to rectify or replace at his own expense, any equipment not complying with the foregoing requirements.

3.3 CLEANING

A. Clean interior and exterior surfaces promptly after installation of equipment and components. Take care to avoid damage to protective coatings and finishes. Remove excess sealants, lubrication, dirt and other foreign substances.

END OF SECTION 230440

SECTION 230460 - AUTOMATIC TEMPERATURE CONTROLS

PART 1 - GENERAL

Applicable provisions of the conditions of the Contract and Division 1 General Requirements govern the work in this section. Submit shop drawings for checking and approval.

1.1 AUTOMATIC TEMPERATURE CONTROLS

A. The information for Bidders, General Clauses and Special Clauses apply to all Contractors for the project, shall apply to all work under this Section and will be adhered to by this Contractor and Sub-Contractors providing work included under this Section.

B. This Contractor shall furnish a complete Electric/Electronic system of temperature controls as manufactured by Honeywell, Barber Coleman or approved equal. All temperature control wiring regardless of voltage shall be done by this Contractor. The abbreviation "ATCS" used hereinafter signifies "Automatic Temperature Control System."

C. Provide all wiring (regardless of voltage), panels, transformers, devices, relays, switches, sensors, etc., to accomplish the sequences described hereinafter. The signal voltage for relays, etc., shall be 24 volt.

D. The ATCS system shall be complete in all respects and will be installed by competent mechanics regularly employed by the ATCS Sub-Contractor/Vendor. The ATCS Vendor shall be an authorized representative of the controls manufacturer. All major control components shall be the products of one manufacturer.

E. Complete control drawings shall be submitted and approved before field installation is started. The drawings shall give a complete description of all control elements and show all schematic piping and wiring. In addition, the submittal shall include manufacturer's data sheets on each control component and a sequence of operation, detailing the software logic of the system, and a complete hardware and software point list.

F. All temperature sensing wells, pressure switch lappings and any other devices installed in hydronic pipe will be furnished by the ATCS Contractor.

G. All electrical wiring, including but not limited to power, control and misc. conduit, connections, etc., required for the installation and operation of the ATCS, will be furnished and installed by the ATCS Contractor. All wiring shall be in rigid conduit where exposed and EMT conduit where concealed. All wiring must comply with national, state and local codes.

H. The ATCS is intended to be completely electronic sensing with electrical actuation, employing stand-alone proportional, integral and derivative control action.

I. Contractor shall furnish all necessary electrical controls, motor starters, switches, etc. for proper operation of equipment furnished by him under his Contract, and as herein noted.

J. Motor starters shall have a spare set of dry contacts for connection to the fire alarm system by the Electrical Contractor for smoke control override.

PART 2 - PRODUCTS

2.1 COMPONENTS

A. Immersion Temperature Sensors: The immersion temperature sensors shall be moisture/water proof, 4 7/8" 304 stainless tube and brass fitting. The 1/2" NPT female threaded brass fitting shall be equipped with a greenfield connector. The sensor shall also have 1/8" NPT male threads for installing into a brass thermowell. The thermowell shall be capable of screwing into a 1/2" NPT theodolet fitting and withstand a maximum temperature of 250 degrees F., and a maximum static pressure of 250 p.s.i.g. The operating range of the sensor shall be 10 degrees F. to 230 degrees F. The active sensing element shall be highly stable, precision thermistor material (Type III), accurate to within plus or minus 36 degrees F., with a stability of 24 degrees F over five years. The sensors shall produce 10,000 Ohms at 77 degrees F. An appropriation amount of thermal compound shall be supplied with each immersion temperature sensor.

B. Duct Temperature Sensor: The duct temperature sensors shall have a sensing element sealed in a conductive compound within a 7" long stainless steel tube, attached to a 4" electrical strap - by an insulating nylon fitting. The nylon fitting will be equipped with 1/2" NPT female conduit fitting and a 1/8" NPS male fitting. The sensors shall be waterproof and can withstand operating temperatures from 32 degrees F. to 160 degrees F. Sensor accuracy must be within +/- .36 degrees F.

C. Outside Air Temperature Sensor: The outside air temperature sensor shall be constructed of type III thermistor material, sheathed in a stainless steel tube and mounted inside a ventilated, treated white PVC sunshield. The sunshield and sensor assembly shall be mounted on a weatherproof outlet box. The operating range of the outside air temperature sensor shall be from minus 30 degrees F to 140 degrees F, accurate to within plus or minus 36 degrees F., with a stability of 24 degrees F over five years. The sensor shall produce a reading of 10,000 Ohms at 77 degrees F.

D. Relays: The 24 VAC coil relays shall have 10 amp rated silver DPDT contacts, pin type terminals and be UL recognized. The contact mechanism shall be capable of operating between 80% consumption shall not exceed 2.5 VA. The life expectancy shall be over 500,000 electrical operations and 10,000 mechanical operations. Pin type socket brass with screw terminals and 24 VAC varistors shall be supplied with each relay.

E. Damper Actuators: The 24 VAC actuators shall be spring return type and shall be sized for torque required at load conditions. Temperature rating -22 degrees F. to +122 degrees F.

F. Transformers: The 120 to 24 VAC transformers shall be sized to match the load of the field components, plus 10%. The transformers shall be equipped with spade connectors and inline fuses, as well as 24 VAC varistors across the secondary terminals.

G. Control Valves

1. Valves shall be fully proportioning unless otherwise specified, quiet in operation, and shall be arranged to fail safe, in either a normally open or normally closed position, in the event of power failure. The open or closed position shall be as specified or as required to suit job conditions. All valves shall be capable of operating at varying rates of speed to correspond to the exact dictates of the controller and variable load requirements.

2. Where valves operate in sequence with other valves or damper operators, provide on each valve a pilot positioner to provide adjustable operating ranges and starting points and positive close off at the required control signal. Positioners must be directly connected to the valve stem. Ratio relays are not acceptable.

3. Valves shall be sized by the Temperature Control Manufacturer and guaranteed to meet the heating requirements as specified and indicated on the drawings. Unless otherwise specified, all shall conform to the requirements herein specified for the piping system in which they are installed.

2.2 BOILER MANAGEMENT CONTROL SYSTEM

A. Boiler shall be factory equipped with a boiler management control system consisting of an on- board computerized control system capable of status annunciation, operation control and remote management (see boiler specification). The entire control system shall comply with IRI and FM insurance requirements. Control system shall be provided by boiler manufacturer for single source responsibility.

B. The unit control panel shall be mounted on the front of the boiler and shall be conveniently located for the operator. It shall have a NEMA-1 enclosure and it shall have a cabinet key lock. Terminals shall be provided in panel for remote emergency shutdown switch and for remote fresh air damper circuitry.

C. A master programming control shall be supplied to sequence fire the boilers in accordance with changing load conditions (second boiler shall be provided in the future). An operating control light will indicate when the individual boilers are called for operation.

D. Load demand shall be detected by temperature controls mounted in the common header, and the return headers going to the boilers. All modulating, operating and high limit controls will be mounted on and protect their respective boilers in a location recommended by boiler manufacturer. The temperature sensor shall be located in the main hot water header, downstream of, and common to, all boilers. If firing boilers exceed demand at low fire input, boilers will automatically shut down in reverse sequence. Should any burner fail, or be manually turned off, the next boiler will automatically be programmed on when required.

2.3 ENCLOSURES

A. All control components shall be mounted in NEMA-1, lockable, hinged enclosures.

PART 3 - EXECUTION

3.1 CONTRACTOR RESPONSIBILITIES

A. General: The Contractor or a Sub-Contractor shall perform installation of the building automation system. However, all installations shall be under the personal supervision of the Contractor. The Contractor shall certify all work as proper and complete. Under no circumstances shall the design, scheduling, coordination, programming, training, and warranty requirements for the project is delegated to a Sub-Contractor.

B. Demolition: Remove controls, which do not remain as part of the building automation system, all associated abandoned wiring and conduit and all associated pneumatic tubing. The Owner will inform the Contractor of any equipment which is to be removed, that will remain the property of the Owner. The Contractor will dispose of all other equipment that is removed.

C. Access to Site: Unless notified otherwise, entrance to building is restricted. No one will be permitted to enter the building unless their names have been cleared with the Owner or the Owner's representative.

D. Code Compliance: All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations. Should any discrepancy be found between wiring Specifications in Division 17 and Division 16, wiring requirements of Division 17 will prevail for work specified in Division 17.

E. Cleanup: At the completion of the work, all equipment pertinent to this Contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this Contract. Clean the exposed surfaces of tubing, hangers and other exposed metal of grease, plaster or other foreign materials.

3.2 WIRING, CONDUIT, TUBING AND CABLE

A. All wire will be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	18 Gauge Std.	300 volt
Communications	Per Mfr.	Per Mfr.

B. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.

C. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

D. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2 inch galvanized EMT. Setscrew fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit seal off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.

E. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.

F. Junction boxes shall be provided at all cable splices, equipment termination and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasket covers.

G. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.

H. Coaxial cable shall conform to RG62 or RG59 rating. Provide plenum rated coaxial cable when running in return air plenums.

I. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140. Only glass fiber is acceptable, no plastic.

J. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

3.3 HARDWARE INSTALLATION

A. Installation Practices for Wiring and Tubing

1. All controllers are to be mounted vertically and per the manufacturer's installation documentation.

2. The 120VAC power wiring to each Remote Site controller shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device.

3. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.

4. Wires are to be attached to the building proper at regular intervals such that wiring does not drop. Wires are not to be affixed to or supported by pipes, conduit, etc.

5. Conduit in finished areas will be concealed in ceiling cavity spaces, plenums, and furred spaces and wall construction. Exception; metallic surface raceway will be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.

6. Conduit, in non-finished areas where possible, will be concealed in ceiling cavity spaces, plenums, furred spaces and wall construction. Exposed conduit raceway will run parallel to or at right angles to the building structure.

7. Wires are to be kept a minimum of three (3) inches from hot water or condense piping.

8. Where sensor wires leave the conduit system, they are to be protected by a plastic insert.

9. Wire will not be allowed to run across telephone equipment areas.

B. Installation Practices for Field Devices

1. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.

2. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.

3. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.

4. Water line mounted sensors shall be removable without shutting down the system in which they are installed.

5. For duct static pressure sensors, the high-pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low-pressure port shall be left open to the plenum area at the point that the high-pressure port is tapped into the ductwork.

6. For building static pressure sensors, the high-pressure port shall be inserted into the space via a metal tube. Pipe the low-pressure port to the outside of the building.

C. Enclosures

1. For all I/O requiring field interface devices, these devices, where practical, will be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure, which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.

2. FIP's shall contain power supplies for sensors, interface relays and Contractors, safety circuits, and I/P transducers.

3. The FIP enclosure shall be of steel construction with baked enamel finish; NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for 20% spare mounting space. All locks will be keyed identically.

4. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.

5. All outside mounted enclosures shall meet the NEMA-4 rating.

6. The tubing and wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

D. Identification

1. Identify all control wires with labeling tape or sleeves using either words, letters, or numbers that can be exactly cross-referenced with As-Built Drawings.

2. Identify all pneumatic tubing with labeling tape or sleeves using either words, letters, or numbers that can be exactly cross-referenced with As-Built Drawings.

3. All field enclosures, other than controllers, shall be identified with a Bakelite nameplate. The lettering shall be in white against a black or blue background.

4. Junction box covers will be marked to indicate that they are a part of the BAS system.

5. All I/O field devices (except space sensors) that are not mounted within FIP's shall be identified with nameplates.

6. All I/O field devices inside FIP's shall be labeled.

E. Location

1. The location of sensors is per Mechanical and Architectural Drawings.

2. Space humidity or temperature sensors will be mounted away from machinery generating heat, direct light and diffuser air streams.

3. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.

4. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

3.4 COMMISSIONING AND SYSTEM STARTUP

A. Point-to-Point Checkout: Each I/O device (both field mounted as well as those located in FIP’s) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager for submission to the Owner or Owner’s representative.

B. Controller and Workstation Checkout: A field checkout of all controllers and front-end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the Owner or Owner’s representative by the completion of the project.

C. System Acceptance Testing

1. All application software will be verified and compared against the sequences of operation. Control loops will be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.

2. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the Owner.

3. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the Owner.

4. Perform an operational test of each third party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

3.5 SEQUENCES OF OPERATION

A. VRF Heat Recovery System

1. Point List
   a. Space Temperature
   b. Occupied/Unoccupied
   c. VRF Space Temperature Setpoint
   d. VRF Indoor Mode (Heating/Cooling)
   e. VRF Indoor Unit fan speed
   f. Energy Recovery Unit Status
   g. Fin-Tube Radiation Control Valve Status (if applicable)
   h. VRF Outdoor Mode/status

2. Sequence of Operation

   a. Unoccupied Mode: Cooling shall not operate. Fin-Tube radiation (if applicable) shall operate as Stage 1 heating. Room VRF heat pump heating shall operate as stage 2 as required to satisfy space temperature setback setpoint.

   b. Occupied Mode: Heating or cooling shall operate as required based upon its own packaged controls to maintain thermostat setpoint. Fin-Tube radiation shall operate as Stage 1 heating. Room VRF heat pump heating shall operate as Stage 2 as required to maintain space thermostat setpoint. Heat pump mode shall operate, providing heating or cooling as required. Unoccupied/Occupied scheduling will be via programmable thermostat.

B. Fin-Tube Radiation

1. Point List

a. Space Temperature
b. Valve Modulation

2. Sequence of Operation

a. Unoccupied Mode (Heating Season): Modulate control valve to maintain night setback temperature set-point (adjustable).

b. Occupied Mode (Heating Season): Modulate control valve to maintain daytime temperature set-point (adjustable). Interface with second stage heating.

E. Cabinet Heaters, Unit Heaters

1. Point List

a. Space Temperature
b. Valve Modulation
c. Fan Start/Stop

2. Sequence of Operation

a. Unoccupied Mode (Heating Season): Modulate heating control valve to maintain night setback temperature set-point (adjustable). Fan shall not run if hot water is not enabled and available.

a. Occupied Mode (Heating Season): Modulate heating control valve to maintain occupied temperature set-point (adjustable). Fan shall not run if hot water is not enabled and available.

F. Exhaust Fans

1. Point List

a. Fan Start/Stop
b. Fan Status

2. Sequence of Operation

a. Unoccupied Mode: Fans Off, Dampers Closed.
b. Occupied Mode: Fans On, Dampers Open.

G. Exhaust Fans (Addition Bays EF-1, EF-2)

1. Point List

a. Fan Start/Stop
b. Fan Status

2. Sequence of Operation

a. Unoccupied Mode: Fans Off, Dampers Closed. (Except as noted)

b. Occupied Mode: Fans On, Dampers Open.

c. Exhaust fans shall operate through diesel/carbon monoxide fume detector system and be energized when the system is in detection mode. Whenever the exhaust fan operates when the system is in detection mode, the respective outdoor air damper shall move to full open position.

H. Indoor Energy Recovery Ventilation Units

1. Point List

a. Supply Fan Status
b. Exhaust Fan Status
c. OA, EA, Air Temperatures
d. OA, EA, Damper
e. Discharge Air Temperature
f. Heating Coil Status
g. Energy Recovery Wheel VFD Speed Status
h. Dirty Filter Status
i. Freeze Stat

2. Sequence of Operation

a. Unoccupied - In this mode:
Supply and Exhaust fans off, OA and EA dampers closed, unit heaters and radiant floor heat (if applicable) shall be Stage 1.

b. Occupied - In this mode:

i. The OA and EA dampers will open and thru a hard wired interlock the Supply and Exhaust fans will start.
ii. Energy transfer will be both sensible and latent energy between air streams. Latent energy transfer media transfer will be accomplished by direct water vapor transfer from one air stream to the other, without exposing transfer media in succeeding cycles directly to the exhaust air and then to the fresh air.
iii. The heating coil shall operate as required to maintain occupied heating discharge setpoint (72˚F adjustable) as sensed by the duct discharge temperature sensor. If unit heaters and radiant floor heat (if applicable) shall be Stage 1.
iv. An adjustable dead band offset will prevent short cycling.

c. Economizer - In this mode:

i. An enthalpy calculation shall be used to determine if the system shall run in this mode. Unit shall operate according to its own packaged controls to control the wheel operation and speed when outdoor conditions are favorable.

ii. When in this mode, the heat transfer wheel shall stop, and the economizer system shall be enabled. The ERU heat transfer wheel rotation shall stop in economizer mode.

I. Hot Water Circulator Pumps

1. Point List

a. Pump Start/Stop
b. Pump Status
c. VFD Speed/Status
d. System Differential Pressure
e. Three-way Mixing Valve Status

2. Sequence of Operation

a. Occupied Mode: Pump shall start when the outdoor air temperature drops below 60 ° F. (adjustable) or average space temperature drops 70°F (adjustable).
b. Unoccupied Mode: Pump shall start when the outdoor air temperature drops below 40 ° F. (adjustable) or when a space drops below its unoccupied set point temperature.
c. Lead / Lag: When the system calls for heat, the lead pump shall start, if the pump current sensor does not sense proper current within 4 minutes, the lead pump shall shutdown and the lag pump shall become lead and an alarm shall be generated. Pumps shall alternate once each seven days to provide equal run time.
d. Pump speed shall modulate through the respective VFD as required to satisfy the system differential pressure control sensor.
e. Three-way mixing valve shall allow minimum supply water temperature to 135 degrees F. Scheduled water temperature in secondary loop shall be based upon outdoor temperature as follows:

Outside Air Temperature	System Temperature
60	135
40	145
30	160
20	175
10	180
0	180

J. Space Temperature Setpoints

1. Heating mode

a. Occupied: Temperature setpoints are adjustable. Temperature setpoint shall be maximum 72 degrees F.

b. Unoccupied: Temperature setpoints are adjustable. Temperature setpoint shall be minimum 55 degrees F.

2. Cooling mode

   a. Occupied: Temperature setpoints are adjustable. Temperature setpoint shall be minimum 78 degrees F.

   b. Unoccupied: Temperature setpoints are adjustable. Temperature setpoint shall be maximum 85 degrees F.

K. Hot Water Heating System

1. Point List

   a. Outdoor Air Temperature
   b. Outdoor Relative Humidity
   c. HW Supply Temperature (Primary Loop)
   d. HW Return Temperature (Primary Loop)
   e. HW Supply Temperature (Secondary Loop)
   f. HW Return Temperature (Secondary Loop)
   g. HW Pump HWP-1 Start/Stop
   h. HW Pump HWP-2 Start/Stop
   i. HW Pump HWP-3 Start/Stop
   j. HW Pump HWP-4 Start/Stop
   k. HW Pump EHWP-1 Start/Stop
   l. HW Pump EHWP-2 Start/Stop
   m. HW Pump EHWP-3 Start/Stop
   n. HW Pump EHWP-4 Start/Stop
   o. HW Pump EHWP-8 Start/Stop
   p. HW Pump EHWP-9 Start/Stop
   q. HW Pump EHWP-10 Start/Stop
   r. HW Pump EHWP-11 Start/Stop
   s. HW Flow Status (16)
   t. Boiler Start/Stop (B-1,2)
   u. Boiler Auto Signal
   v. Boiler Trouble Signal
   w. Boiler Flame Modulation

2. Sequence of Operation

   a. Boilers will be optimized on for occupied schedule when outside air temperature is below 60 degrees (adjustable) and average room temperature is below 70 degrees (adjustable). Boilers will be off during unoccupied schedule unless outside air temperature drops below 38 degrees (adjustable) or when a space drops below its unoccupied set point temperature. Whenever outside air is below 60 degrees, Primary boilers will sequence and stage to maintain desired water temperature (adjustable) where supply water temperature is a maximum of 180 degrees Fahrenheit.

b. The boiler start/stop and firing rate will be controlled by the stand-alone direct digital controller mounted in the new hot water system programmable local control panel. Boiler monitoring and alarming will be done at the unit control panel. The three-way control valves will modulate through DDC system to schedule the hot water supply through outside air sensor. Three-way valves shall be sized for proper flow control without hunting. Three-way valve modulation shall be arranged to limit cold water return to the boiler during warm-up mode to prevent thermal shock to the boilers.

c. Hot water circulating pump shall be energized when outside air temperature is below 60 degrees (adjustable). Should a pump fail to start its standby pump shall be energized and an alarm sent to the central control panel. Boiler water blend pump shall be hardwired interlocked with hot water circulating pump operation.

L. Data/Electrical Room Ductless Split Systems

1. Point List

a. Condensing Unit Status
b. Heating/cooling Mode
c. Room Temperature

2. Sequence of Operation

a. System shall operate in accordance with its own packaged controls.
b. Should the respective Data or Electrical room temperature (high/low) fall outside of preset limits, an alarm shall be generated at the operator's workstation.

3.6 CONTROL DIAGRAMS

A. Complete new control diagrams showing type of apparatus, cycles of operation and details of all equipment must be submitted for checking and be approved before installation is started.

B. Submit three (3) preliminary copies of the control diagrams, sequence descriptions, and equipment shop drawings for checking and submit six (6) copies, complete for final approval.

C. At the completion of installation, control manufacturer shall furnish non-fading original; plastic laminated copies of all control diagrams as they apply to the particular instruments thereon. One complete set of non-fading plastic laminated diagrams shall be mounted on wall as directed.

3.7 CERTIFICATION

A. After completion of installation and after equipment has been placed on operation, the temperature control manufacturer shall submit in writing, a complete and detailed report and certification that the entire installation is operating exactly as specified and shall be guaranteed for one year. Report shall state temperature and throttling range readings and settings of all control instruments. Submit to the Engineer preliminary for checking and approval.

3.8 INSTALLATION

A. All work under the automatic temperature control Sub-Contract shall be done by competent skilled mechanics regularly in the employ of the temperature control manufacturer.

B. Bidder must be a control manufacturer currently involved in the production of commercial pneumatic/electric temperature controls. Franchises and associations are not considered control manufacturers.

3.9 TRAINING

A. Provide start-up supervision, complete with all programming and instructions for use to the Owners/operators of the system.

B. Instructions to Owner's Staff

1. The Contractor shall include in his bid price the cost of providing appropriate training in the operation, adjustment and maintenance, including safety requirements, of the specified Automatic Temperature Control System (ATCS) as outlined below. Training shall be provided by knowledgeable instructors and shall be tailored towards the specific needs and installed system of the site. It shall not be a generic (canned) course. All instructors shall be thoroughly familiar with all aspects of the subject matter to be taught. All equipment and material required for classroom training, including printed matter, shall be provided by the Contractor.

C. Training Program

1. The training program shall be accomplished in three (3) phases for the time interval specified for each phase. A training day is defined as eight (8) hours of instruction including two 15-minute breaks and excluding lunchtime.

2. Training room should be clean, well-lit, well-ventilated and isolated from noise and other distractions (including HVAC noise). Ideally, the lights should be controllable to permit adequate contrast on any projection screen yet provide students with enough lighting to take notes.

3. Instructor should use a LCD screen or other device to project large images of software or other training images. Students should have their own computers on which to work; no computer should be used by more than two students.

4. Printed training materials should be tailored to the task at hand and should be well illustrated. Materials should take students through the steps of learning the ATCS and its software and should provide sample exercises students to perform on their classroom computers. All printed materials shall be presented to Owner for prior review and approval at least two weeks before the training begins. A full set of printed materials shall be made available for each student, plus two extra sets for the Owner.

5. If the ATCS or its software requires knowledge about HVAC, the use of a computer (or a mouse, Windows, etc.) or other technical information, these requirements should be spelled out to the Owner far enough in advance for students to take pre-training in these areas.

6. Training should steer clear of jargon and other confusing terminology and focus instead on learning how to use the system. Specific jargon can be addressed after the students have gained reasonable facility with the system.

7. All ATCS training should include a “hands-on” component that permits the students to see the hardware in place and watch the software in action.

8. Training should include quizzes and test that compel students to demonstrate understanding of the training’s most important concepts. Students who “fail” these tests should be assisted, by the instructor and other students, in trying again until they achieve a basic level of understanding.

9. Training should involve actual equipment using a training demonstration package that simulates real-time temperatures, settings and alarms.

10. The overall training approach should be interactive, encouraging students to discuss concepts and issues and share experiences.

11. Phase I

    a. This phase will be for a period of two (2) days prior to the acceptance test period at a time mutually agreeable the Contractor and the Owner. Operating personnel will be trained in the basic functions of the installed system, the procedures for system operation and the maintenance of ATCS hardware.

    b. The first day shall include:

        i. Overall structure of the system.
        ii. Logging on and off the system.
        iii. Developing point legs.
        iv. Executing commands.
        v. Generating reports.
        vi. Using trending capabilities.
        vii. Using alarm capabilities.
        viii. Working with graphics.
        ix. Hardware function and identification.
        x. Input function and identification.

c. The second day of training shall include:

i. Review of first day.
ii. Hardware access and software manipulation.
iii. ATCS troubleshooting.
iv. ATCS preventative maintenance.
v. Sensor maintenance and calibration.

12. Phase II

a. This phase of training shall be conducted approximately four (4) weeks after system acceptance testing for a period of two (2) days. The first day of training will be condensed review of the entire first phase subject material. The second day will be based upon subject matter proposed by Owner personnel. One week prior to the date of the first Phase II training session, the Owner shall submit to the Contractor a detailed list of subject matter, which shall determine the content of the program (e.g. system software operational problems, software utilization, capability and usage, etc.).

13. Phase III

a. Provide a third phase of training after the completion of one heating and cooling season. The particulars of this phase of training will be similar to that of Phase II.

b. Three (3) neatly bound vinyl notebooks shall be provided by the Contractor containing a summary of each topic discussed during the three phase of training. Each training session shall be video-taped by a professional videographic representative.

14. A factory representative shall witness the final system test and then certify with an affidavit that the system is installed in accordance with the Contract Documents and is operating properly.

END OF SECTION 230460

SECTION 230470 - TESTING, START-UP AND ADJUSTMENTS

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section.

1.1 TESTING, START-UP AND ADJUSTMENTS

A. Furnish all materials, supplies, labor and power required for testing. Make preliminary tests and prove work satisfactory. Notify Architect and all authorities having jurisdiction in ample time to be present for final testing of all piping. Test before insulating or concealing any piping. Repair defects disclosed by tests, or if required by Architect, replace defective work with new work without additional cost to Owner. Make tests in stages if so ordered by Architect to facilitate work of others. Use of wicking in tightening leaking joints not permitted.

B. HVAC Contractor is responsible for work of other trades disturbed or damaged by tests and/or repair and replacement of his work, and shall cause work so disturbed or damaged to be restored to its original condition at his own expense.

C. Unless otherwise specified, all piping systems shall be hydrostatically tested to 150 p.s.i.g. Tests shall be of four (4) hour duration during which time piping shall show no leaks and during time no sealing of leaks will be permitted.

D. HVAC Contractor shall balance out system and submit test reports showing operating data to include the following:

1. C.F.M. of all air handling equipment.
2. C.F.M. at each air outlet.
3. G.P.M. for equipment.
4. R.P.M. for each fan and fan motor.
5. Motor power consumption.
6. Air temperature readings before and after coils.
7. Water temperature readings in and out of coils and through equipment.
8. Pressure gauge readings before and out of all pertinent equipment.

E. If the performance of the systems does not conform to the design parameters the Contractor shall return to the site until the systems perform as designed.

F. HVAC Contractor shall furnish services of qualified personnel, thoroughly familiar with job, to operate and make all adjustments so that system and control equipment shall operate as intended. This shall include adjustment/replacement of sheaves/impellers to achieve design performance. Adjustments shall be made including balancing of water and air systems in cooperation with qualified representatives of mechanical equipment manufacturers and temperature control manufacturer. This shall include any required adjustment/replacement of sheaves, belts, impellers, etc. to achieve design performance. Architect/Engineer is to be notified when this balancing is to be performed.

G. When all work is in an acceptable operating condition, furnish operating and maintenance manuals as specified in General Requirements.

H. All HVAC equipment shall be carefully designed, constructed and installed so as to prevent any objectionable noise or vibration reaching any part of the building outside of the mechanical equipment room. Care shall also be taken to prevent transmission of noise or odor through ductwork into other spaces.

I. Contractor shall include in his Bid, adjustment of air quantity below scheduled C.F.M. for air systems deemed “noisy” by Owner subsequent to initial balancing.

J. The Contractor shall be required to rectify of replace at his own expense, any equipment not complying with the foregoing requirements.

K. Final inspection and approval shall be made only after proper completion of all of above requirements.

END OF SECTION 230470

SECTION 230480 - GENERAL LABELING, VALVE CHARTS AND PIPING IDENTIFICATION

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section. Submit shop drawings for checking and approval.

1.1 GENERAL LABELING AND VALVE CHARTS

A. This Contractor shall have appropriate descriptive labels, identification tags and nameplates of equipment, valves, etc. furnished and installed under this Contract and shall be properly placed and permanently secured to (or adjacent to) the item being installed. All such labels, identifications, tags, nameplates, etc. shall be selected by the Architect/Engineer.

B. In general, labels shall be the lamacoid type of sufficient size to permit easy identification, black coated, white edged, with letters 3/16" high. Major equipment, apparatus, control panels, etc. shall have 8" x 4" lamacoid plates with lettering of appropriate size.

C. Provide tags for all valves, automatic and manual dampers. Tags shall be Type #2020 anodized aluminum of #1420 lamacoid engraved. Tags may not necessarily be standard. Fasten tags to valve or damper with brass chain.

D. All nameplates, labels, identifications and tags shall be as manufactured by the Seton Name Plate Co., of New Haven, CT or approved equal. Submit complete schedules, listings and descriptive data together with samples for checking and approval before purchasing. Labeling shall include the "number" of the equipment, valve, dampers, switch, etc. and service of the valve.

E. Mount on laminated plastic boards with transparent surface all valves, wiring diagrams, control diagrams, instruction charts, permits, etc. Valve chart shall be non-fading with original copies laminated.

1.2 IDENTIFICATION OF PIPING

A. This Contractor shall provide on all piping, semi-rigid, wrap around plastic identification markers equal to Seton Snap-Around and/or Seton Strap-On pipe markers.

B. Each marker background is to be appropriately color coded with a clearly printed legend to identify the contents of the pipe. Directions of flow arrows are to be included on each marker.

C. Identification of all piping shall be adjacent to each valve, at each pipe passage through wall, floor and ceiling construction and at each branch and riser take-off.

D. Identification shall be on all horizontal pipe runs, marked every 15 ft. as well as at each inlet outlet of equipment.

END OF SECTION 230480

SECTION 230490 - GUARANTEE

PART 1 - GENERAL

Applicable Provisions of the Conditions of the Contract and Division 1 General Requirements govern work in this section.

1.1 GUARANTEE

A. The Contractor shall remove, replace and/or repair at his own expense and at the convenience of the Owner, any defects in workmanship, materials, ratings, capacities and/or characteristics occurring in the work within one (1) year or within such longer period as may be provided in the Drawings and/or Section of the Specifications, which guarantee period shall commence with the final acceptance of the entire Contract in accordance with the guarantee provisions stated in the General Conditions, and the Contractor shall pay for all damage to the system resulting from defects in the work and all expenses necessary to remove, replace, and/or repair any other work which may be damaged in removing, replacing and/or repairing the work.

END OF SECTION 230490