SECTION 230500

MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 GENERAL

A. Applicable provisions of this section apply to all sections of Division 23 - HVAC.

B. Provide complete functioning HVAC systems.

C. Contract drawings are diagrammatic only and do not give fully dimensioned locations of various elements of work. Determine exact locations from field measurements.

D. Where the word “concealed” is used in connection with insulating, painting, piping, ducts and the like, the word is understood to mean hidden from sight as in chases, furred spaces or above suspended ceilings. “Exposed” is understood to mean open to view.

E. It is important that the contractor be aware that the construction schedule is very short and therefore every effort should be made to expedite submittals for review and acceptance as soon as the contract is awarded.

1.2 REGULATIONS AND PERMITS

A. Perform work in accordance with applicable statutes, ordinances, codes, and regulations of governmental authorities having jurisdiction.

B. Resolve any code violation discovered in contract documents with the Engineer prior to award of the contract. After award of the contract, make any correction or addition necessary for compliance with applicable codes at no additional cost to Owner.

C. Obtain and pay for all permits and inspections.

1.3 REFERENCE SPECIFICATIONS AND STANDARDS

A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, or AWWA Specifications; Federal Standards; or other standard specifications must comply with latest editions (except where specified otherwise in individual sections), revisions, amendments or supplements in effect 60 days before date documents are issued for bidding. Requirements in reference specifications and standards are minimum for all equipment, material and work. In instances where capacities, size or other feature of equipment, devices or materials exceed these minimums, meet listed or shown capacities.

1.4 SUBMITTALS

A. Asbestos Notification. Prior to beginning any work in existing buildings, Contractor shall provide a letter to the Owner stating that he has examined the remodeling areas of the building for asbestos materials and giving results of his findings. If at any time during construction asbestos is encountered, stop work immediately and contact Architect/Engineer.

B. Material and Equipment List. Within 10 days after award of the contract and before orders are placed or shop drawings are submitted, submit a list of equipment and principal materials specified. Give names of manufacturers, catalog and model numbers, and such other supplementary information as necessary for identification.

C. Material and Equipment Shop Drawings. Submit all detailed shop drawings, descriptive literature, physical data, and performance data at one time for review for items of equipment and for principal materials proposed for installation. Include identifying symbols and equipment numbers used in plans and specifications, with reference to specification paragraphs, and drawing numbers of all equipment and material submitted. Piping shop drawings are required to be submitted for all major piping.

D. Final Submittal. In addition to number of copies of shop drawings and other data required for review submittals, maintain a separate file of final approved copies of such material. Deliver approved copies in a hard-back binder for the Owner's use. Incorporate changes and revisions made throughout construction period. Delivery of approved copies is a condition of final acceptance for the project.

E. Contractor's Check. Shop drawings will be submitted only by the Contractor. Indicate by signed stamp that the drawings have been checked, that the work shown on the drawings is in accordance with contract requirements and that dimensions and relationship with work of other trades have been checked. If drawings are submitted for approval that have not been checked and signed by the Contractor, they will be returned for checking before being considered by the Engineer.

F. Operating and Maintenance Instructions. Furnish five copies of commercially available standard operation and maintenance data, including operating instructions, maintenance instructions and parts listings. Detailed requirements for these items are as follows:

1. Information required for the preparation of O&M manuals may be furnished in the form of manufacturers' standard brochures, schematics, and other printed instructions. Clearly distinguish between information which applies to the equipment and information which does not apply. Data shall include as a minimum the following items:
    a. Recommended procedures and frequencies for preventive maintenance; inspection, adjustment, lubrication, cleaning, etc.
    b. Special tools and equipment required for testing and maintenance.
    c. Parts lists reflecting the true manufacturer's name, part number and nomenclature.
    d. Recommended spares by part number and nomenclature and spare stocking levels.
    e. Integrated mechanical and electrical system schematics and diagrams to permit operation and troubleshooting after acceptance of the system.
    f. Troubleshooting, checkout, repair and replacement procurement procedures.
    g. Operating instructions including start-up and shutdown procedures.
    h. Safety considerations including load limits, speed, temperature and pressure.
2. Provide O&M manuals for all HVAC equipment.

1.5 TRAINING

A. Upon completion of work, and at time designated by the Engineer, provide services of a competent representative of the Contractor for a period of at least 40 hours to instruct the Owner's personnel in the operation and maintenance of mechanical systems.

1.6 PROJECT RECORD DOCUMENTS

A. Preparation. Maintain at the job site a separate set of white prints of the contract drawings for the sole purpose of recording the "as-built" changes and diagrams of those portions of work in which actual construction is significantly at variance with the contract drawings. Mark the drawings with a colored pencil. Prepare, as the work progresses and upon completion of work, drawings clearly indicating locations of various lines, valves, ductwork, traps, equipment, and other pertinent items, as installed. Record underground and underslab piping installed, dimensioning exact location and elevation of such piping.

B. Deliver. At conclusion of project, obtain without cost to Owner, reproducibles of original mechanical drawings and transfer as-built changes to these. Delivery of as-built prints and reproducibles is a condition of final acceptance.

1.7 GUARANTEE

A. Guarantee work for 1 year from the date of substantial completion of the project, and during that period make good any faults or imperfections that may arise due to defects or omissions in materials or workmanship.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The acceptable manufacturers are listed in individual sections of Division 23. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer. Manufacturers' names and catalog numbers specified under sections of Division 23 are used to establish standards of design, performance, quality and serviceability and not to limit competition. Equipment of similar design, equal to that specified, from one of the named manufacturers will be acceptable on approval of the Engineer.

B. Substitution.
   1. If the Contractor desires to substitute a material or method as an equal to the specified item, he shall request permission from the Engineer, in writing, and shall include such literature, samples, etc., deemed necessary to establish the equal quality of his proposal. If the Engineer deems it necessary in order to establish the equality between two or more products, he may require laboratory testing at the Proposer's expense in order to obtain information upon which to base a decision. The Engineer will not give approval to material salesmen or subcontractors, and only in writing to the Contractor.
   2. For each proposed substitution product, clearly show how the proposed product meets the requirements of the specifications, including performance and space requirements.
   3. No substitution will be considered unless it is presented in writing within 10 days before or 10 days after Notice to Proceed.

4. Proposers of substitute products shall present samples, literature, test and performance data, record of other installations, names of owners, architects, engineers, contractors and subcontractors as references, statement of current financial condition, and other technical information applicable to their products, to aid in determining the worth of the substitute product offered in relation to the material and work specified from the standpoint of the Owner's best interest. Substitute materials and products shall be used only if approved in writing by the Engineer in advance.
5. Approval of substitute materials offered shall not be a basis for contingent extra charges because of changes in other work or related work, such as roughing-in, electrical, structural or architectural, which may result from the substitution.

2.2 MATERIALS AND EQUIPMENT

A. Furnish new and unused materials and equipment of domestic manufacture. Where two or more units of same type or class of equipment are required, provide units of a single manufacturer.

B. Consider space limitations imposed by contiguous work, including clearances required for service, in selection and location of equipment and material. Do not provide equipment or material which is not suitable in this respect.

2.3 NOISE AND VIBRATION

A. Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions without cost to the Owner. If the item of equipment is judged to produce objectionable noise or vibration, demonstrate (without cost to the Owner) that equipment performs within designated limits on the vibration chart included at the end of this section.

2.4 VARIABLE SPEED DUTY MOTORS

A. Provide premium efficiency, severe duty, Class F temperature rise (Class F insulated), 1.0 service factor motors for all equipment to operate with variable frequency drives.

2.5 AIR FILTERS AND PIPE STRAINERS

A. Immediately prior to final acceptance of project, inspect, clean and service air filters and strainers. Replace disposable type air filters if dirty.

2.6 ACCESS DOORS

A. Locate access doors for all walls or ceiling locations, as required or shown, to valves, controls, regulating devices, water arresters, fire dampers, air distribution boxes and other concealed equipment requiring maintenance adjustment or operation.

PART 3 - EXECUTION

3.1 OBSTRUCTIONS

A. Notify the School Personnel of any crane activity as soon as the contractor knows when the crane will be used and for the duration it will be used.

B. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.

C. Prior to any utility shutdown be it chilled water or electrical shutdown Notification to the Owner is required by this process:
   1. First the contractor will notify the Owner 2 weeks in advance of possible shut down dates, time, utilities being shut down and duration of shutdown in writing, by email or hand delivery to the School Administrative offices.
   2. 24 hours prior to shut down again written notification of the utility to be shut down, the time, date and duration of the shutdown by email and hand delivery to the School Administrative offices.
      a. Confirm verbally that the school knows about the shutdown and understands what will be taken out of service for the correct duration. If this verbal confirmation cannot be confirmed prior to shut down time the contractor shall reschedule shutdown for the next 24 hour period or until School Personnel can acknowledge they are prepared for the shutdown of that utility.

D. Before any cutting or trenching operations are begun, verify with Owner's representative, utility companies, municipalities, and other interested parties that all available information has been provided. Verify locations given.

E. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.

F. Assume total responsibility for and repair any damage to existing utilities or construction, whether or not such existing facilities are shown.

3.2 OPENINGS

A. Framed, cast or masonry openings for ductwork, equipment and piping are specified under other divisions. However, drawings and layout work for exact size and location of all such openings are included under this division.

3.3 PROTECTION

A. Adequately protect work, equipment, fixtures and materials. At work completion, all work shall be clean and in good condition.

B. Pipe openings on installed pipes that remain open shall be covered in plastic if they are intended to be left in this open condition for longer than a 7 day period. This plastic wrap is to prevent sand migration from blowing dirt and vermin occupation in open piping.

C. At work completion, all work shall be clean and in good condition.

3.4 LUBRICATION, REFRIGERANT AND OIL

A. Provide a complete charge of correct lubricant for each item of equipment requiring lubrication.

B. Provide complete and working charge of proper refrigerant, free of contaminants, into each refrigerant system. After each system has been in operation long enough to ensure completely balanced conditions, check the charge and modify it for proper operation as required.

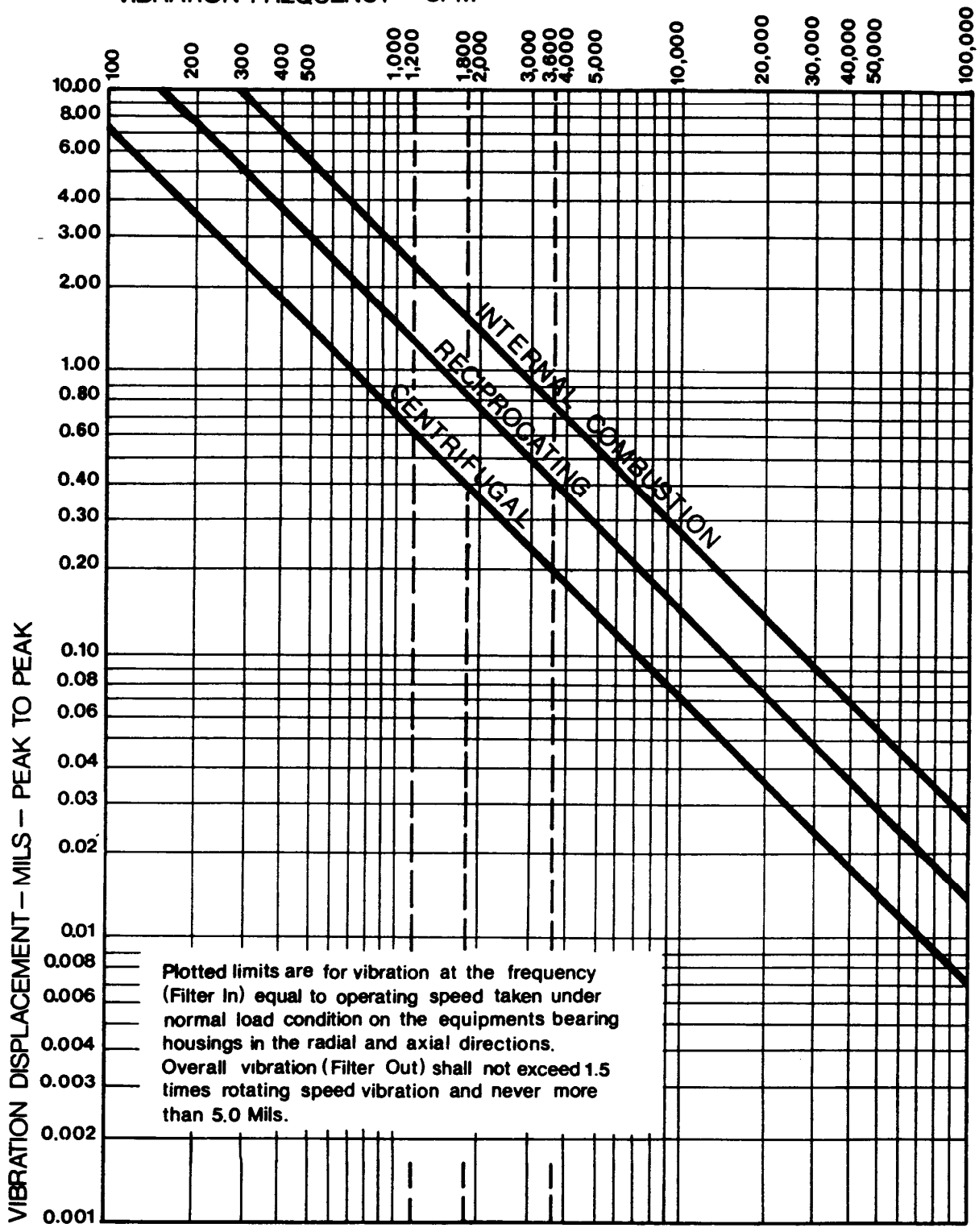
C. Provide a complete charge of special oil for refrigeration use, suitable for operation with refrigerant, in each compressor.

3.5 OPERATING TESTS

A. After all mechanical systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequence and operation throughout the range of operation. Make adjustments as required to ensure proper functioning of all systems. Special tests on individual systems are specified under individual sections.

END OF SECTION 230500

EQUIPMENT VIBRATION CHART



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SECTION 230513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Equipment. This section provides general requirements for 1-phase and 3-phase electric motors with NEMA frame machines sized through 200 horsepower. Unless otherwise specified, provide motors meeting the basic requirements for general-purpose alternating current motors, as defined in ANSI/NEMA MG 1-1.05.

B. Unit Responsibility. Motors are furnished under other sections of this specification as a part of the driven equipment. The Contractor is responsible for all coordination between the various components and for the warranty.

C. Exceptions. Exceptions to this section are indicated either in the various sections that specify motor-driven equipment or on the drawings.

1.2 REFERENCE STANDARDS

A. ANSI/IEEE 117 - Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random Wound AC Electric Machinery.

B. ANSI/NEMA MG 1 - Motors and Generators.

C. ANSI/NEMA MG 2 - Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors.

D. ANSI/UL 674 - Electric Motors and Generators for Use in Hazardous (Classified) Locations.

E. ANSI/UL 1004 - Electric Motors.

F. NFPA 70 - National Electrical Code (NEC).

1.3 SUBMITTALS

A. Provide the following information for each motor:
   1. Manufacturer.
   2. Rated full load horsepower.
   3. Rated volts.
   4. Number of phases.
   5. Frequency in hertz.
   6. Full load amperes (FLA).

7. Locked rotor amperes (LRA) at rated voltage or NEMA code letter.
8. Nominal speed at full load (rpm).
9. Service factor.
10. NEMA design letter.
11. NEMA machine type (ODP, WP-I, TEFC, etc.).

B. For motors 1 horsepower and larger, include the following additional information:
1. NEMA frame size.
2. NEMA insulation system classification. For motors required to be installed outdoors, include information showing compliance with the intent of paragraph 2.4C.
3. Maximum ambient temperature for which motor is designed.
4. Time rating.
5. Bearing type.
6. Efficiency at full load.

1.4 DELIVERY, STORAGE AND HANDLING

A. Delivery. Upon delivery at the job site, the Contractor shall inspect the motor thoroughly for damage.

B. Handling. The motor shall be lifted in accordance with the manufacturer's instruction. All necessary slings and spreader bars shall be provided by the Contractor. Under no circumstances shall the motor be lifted by using the shaft as an attachment point.

C. Storage. The motor should be installed as soon as possible. If storage is required, the motor shall be stored under cover in a clean, dry location and shall be protected from rapid temperature changes. If storage is anticipated to be longer than 2 months, the following additional steps shall be taken:
1. The motor space heaters shall be energized, as applicable.
2. Motors with sleeve bearings shall have the oil reservoirs filled to the proper level with the specified oil.
3. Motors with anti-friction bearings shall receive an initial change of grease and then be re-greased every 6 months.
4. The motor shaft braces shall be removed and the motor shaft rotated every 2 weeks. The shaft braces shall be replaced prior to relocation to the installation site. Under no circumstances shall the motor be lifted without the braces in place.

1.5 SPARE PARTS AND CONSUMABLES

A. Provide sufficient quantity of recommended renewable spare parts (gaskets, O-rings, pins, fasteners, etc.) and consumables (oil, grease, etc.) as required to support operation and required maintenance for one year.

PART 2 - PRODUCTS

2.1 RATING

A. Speed and Size. Speed and approximate horsepower ratings are specified in the driven equipment specification sections or are indicated on the drawings. Furnish motors sufficiently sized for the particular application and with full-load rating not less than required by the driven equipment at specified capacity. Size motors so as not to overload at any point throughout the normal operating range.

B. Voltage.
1. Single phase: 115 volts for 120-volt nominal system voltage.
2. Three phase: 200 volts for 208-volt nominal system voltage.
3. Three phase: 230 volts for 240-volt nominal system voltage.
4. Three phase: 230/460 volts for 240/480-volt nominal system voltage.
5. Three phase: 460 volts for 480-volt nominal system voltage.

C. Frequency. 60 hertz.

D. Service Factor. According to NEMA MG 1-12.47 but not less than 1.15.

E. Efficiency. Provide energy-efficient motors meeting the requirements of NEMA MG 1-12.55A, Table 12Y and MG 1.41.3. Efficiency to be determined by testing in accordance with NEMA MG 112.53 using IEEE 112A - Method B.

2.2 DESIGN TYPE

A. Motors Smaller than 1/6 Horsepower. Provide single-phase squirrel-cage induction motors with integral thermal protectors.

B. Motors 1/6 through 1/2 Horsepower. Provide single-phase NEMA Design Letter N, squirrel-cage induction motors.

C. Motors Larger than 1/2 Horsepower. Provide 3-phase, NEMA Design Letter B, squirrel-cage induction motors.

2.3 SPECIAL APPLICATION REQUIREMENTS

A. Variable speed motors controlled by variable frequency drives (VFD) in general shall be of standard design called out in this specification. The Contractor shall notify the manufacturer on the requisition that the motor will be used in conjunction with a variable frequency drive, and the type of frequency generation. The Contractor shall coordinate with the motor manufacturer to ensure that this motor will be capable of operating under the torque requirements and speed range within temperature specifications. If this requires special design of the motor, the Contractor shall notify the Engineer representative in writing. The normal speed range shall be 4 to 1 ratio. The motor/drive system shall be capable of maintaining full torque throughout. The motors specified for variable speed application shall be capable of operating at 90 hertz maximum frequency as a minimum requirement but at reduced torques above 60 hertz.

2.4 MOTOR INSULATION

A. Class. Use a Class B insulation system meeting the requirements of NEMA MG 1-1.65 and made of nonhygroscopic materials.

B. Temperature Rise. According to NEMA MG 1-12.41 for fractional horsepower motors and NEMA MG 1-12.42 for integral horsepower motors.

C. Outdoor Suitability. Where motors must be suitable for outdoor installation, the insulation must withstand 1 full week (168 hours) of testing in a chamber maintained at 100 percent relative humidity and 40°C ambient temperature. Immediately after the test period, the insulation system must have a minimum resistance of 1.5 megohms. In addition, the inside circumference of the stator and the outside circumference of the rotor and shaft must be coated with the same moisture-resistant insulation.

2.5 LEADS

A. For motor leads, use not less than ASTM B 173, Class G, stranded copper conductors with insulation the same as or better than specified in the preceding Motor Insulation paragraph. Provide permanent identification numbers on leads according to NEMA MG 1-2.02. Use crimp-on, solderless copper terminals on leads and place heat-shrink insulation sleeves or covers between leads and terminals.

2.6 ENCLOSURE

A. Indoors. Open drip-proof (ODP). Use steel frame for motors smaller than 3/4 horsepower, and cast-iron frame for motors 3/4 horsepower and larger.

B. Outdoors. Use cast-iron frame as follows:
   1. Smaller than 100 Horsepower. Totally enclosed, fan cooled (TEFC), with a corrosion-resistant drain plug under each bearing.
   2. Horizontal 100 Horsepower and Larger. ODP suitable for outdoor use. For cooling towers supply TEFC motors as described above.
   3. Vertical Motors.
      a. Weather-protected Type I (WP-I).
      b. For 300 hp and larger, use WP-II. For all other sizes, use TEFC.

C. Hazardous Areas. Provide cast-iron frame motors suitable for use in the classified area.

2.7 BEARINGS

A. Motors Smaller than 1/6 Horsepower. Motor manufacturer's standard bearing is acceptable.

B. Motors 1/6 Horsepower and Larger.
   1. Antifriction. Supply motors with grease-lubricated antifriction ball bearings conservatively rated for long life under the total radial and thrust loads produced by the actual combination of motor-driven equipment. Provide each motor with suitable lubrication fittings and pressure relief devices suitable for in-service lubrication.

2. Oil Lubricated. If the driven equipment section specifies oil-lubricated bearings for motors, include a suitable sight gauge on each bearing with maximum and minimum levels clearly indicated.

2.8 HARDWARE

A. Use structural bolts, washers, nuts, pins, and similar items manufactured of high-strength steel. Use only hexagon-head bolts and hexagon nuts. Use corrosion-resistant materials or protect hardware from corrosion by either hot-dip galvanizing, chrome plating or cadmium plating.

2.9 NAMEPLATES

A. Main Nameplate. Provide each motor with a stainless steel nameplate meeting the requirements of NEMA MG 1-10.38, and the National Electrical Code, Section 430-7. Energy-efficient motors shall be identified in accordance with MG-1-12.54.2.

B. Bearings Nameplate. When bearings are oil lubricated, include oil type information on a suitable nameplate. Also, indicate bearing data if nonstandard.

C. Attachment. Attach the nameplates to the motor with stainless steel fastening pins or screws.

2.10 CONDUIT BOX

A. For each motor not supplied with a cord and plug, provide a conduit box suitably sized for the motor lead terminations, in accordance with the National Electrical Code, Section 430-12. Include a grounding lug for motors 1/6 horsepower and larger. Supply a gasket suitable for the motor enclosure type and application.

2.11 SPACE HEATERS

A. Provide space heaters on motors located outdoors or when specified in the driven equipment section. Use heaters hermetically sealed in stainless steel or equivalent corrosion-resistant sheaths. Rate heaters 115 volts, 60 hertz. Braze heat-resistant insulated leads to the heater and extend to the conduit box. Size heaters according to the motor frame size as follows:

Frame Number Series	Minimum Watts	Corresponding HP at 1800 SRPM
Less than 280	Not required	
280 - 320	100	25 - 50
360 - 400	150	60 - 125
440	200	150 - 200

2.12 FINISH

A. Manufacturer’s standard shop paints for prime and finish coats are acceptable.

2.13 NOISE

A. Provide integral horsepower motors with overall sound power levels meeting the requirements of MG 1-12.49.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Properly install and align motors in the locations shown, except motors which are factory mounted on the driven equipment. Use crimp-on, solderless copper terminals on the branch circuit conductors. Make grounding (earth) conductor approximately 2 inches {50 mm} longer than the ungrounded (phase) conductors at both ends. Refer to Section 260526. When the motor and equipment are installed, the nameplate must be in full view.

3.2 LARGER MOTORS

A. If a motor horsepower rating larger than indicated is offered as a substitute and accepted, provide required changes in size of conductors, conduits, motor controllers, overload relays, fuses, circuit breakers, switches and other related items at no change in the contract price.

3.3 FIELD TESTING

A. General. Provide all necessary instruments, labor and personnel required to perform motor inspection and testing.

B. Inspection. Inspect all motors for damage, moisture absorption, alignment, freedom of rotation, proper lubrication, oil leaks, phase identification and cleanliness, and report any abnormalities to Owner's representative before energizing.

C. Energizing. After installation has been thoroughly checked and found to be in proper condition, with thermal overloads in motor controllers properly sized and all controls in place, energize the equipment at system voltage for operational testing.

END OF SECTION 230513

SECTION 230529

EQUIPMENT BASES AND SUPPORTS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide concrete equipment pads for all direct and isolated floor mounted equipment, and structural equipment supports for horizontal tanks, heat exchangers and similar equipment, where required.

1.2 SUBMITTALS

A. Submit shop drawings on all structural supports.

B. Equipment installed on the exterior of the building refer to section 23 05 48 Vibration Isolation. Specifically the part in this section regarding design for 150 mph winds for 3 seconds.

PART 2 - PRODUCTS

2.1 CONCRETE

A. Provide 3000 psi concrete.

2.2 STRUCTURAL METAL

A. Construct floor stands of structural members or steel pipe for equipment supports.

PART 3 - EXECUTION

3.1 CONCRETE PADS

A. Pour minimum 3-1/2-inch thick pads on roughened floor slabs unless otherwise noted. Reinforce pad with No. 4 rebar set 12 inches on center unless indicated otherwise on structural drawings. Provide 2-inch clearance between top of pad and rebar. Extend outer edges of pads a minimum of 2 inches beyond equipment. Secure equipment with anchor bolts in accordance with equipment installation instructions.

3.2 STRUCTURAL SUPPORTS

A. Existing pipe supports shall be removed and reused as indicated on drawing, supports fabricated of structural members. Provide new galvanized all thread bolts with adequate

adhesive for drilled in placement new level nuts and securing nuts. Grout around bases with a minimum of 3000 psi grout to provide additional support of pipe support.

END OF SECTION 230529

SECTION 230548

VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SUMMARY

A. All mechanical equipment, piping and ductwork as noted on the equipment schedule or in the specification shall be mounted on or suspended from vibration isolators to reduce the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

B. All isolation materials shall be supplied by the same manufacturer.

1.2 SUBMITTALS

A. Product Data.
1. Schedules of flexibly mounted equipment, referencing drawings by number.
2. Catalog cuts or data sheets on vibration isolators.

B. Drawings.
1. Submit details of equipment bases including dimensions, structural member sizes and support point locations.
2. Submit details of isolation hangers for suspended equipment, piping and ductwork.
3. Submit details of mountings for floor supported equipment, piping and ductwork.
4. All hanger, mounting or pad drawings shall indicate deflections and model numbers as well as any other requirements in the specifications.
5. Spring diameters, rated loads and deflections, heights at rated load and closed height shall be provided for all springs shown in the submittals in tabular form.
6. Complete flexible connector details.

C. Certifications.
1. Refer to 3.2 in this section for Delegated-Design Submittal for building appurtenances and other structures.

1.3 STOCK REQUIREMENTS

A. The isolation manufacturer’s representative shall maintain an adequate stock of springs and isolators of type used so that changes required during construction and installation can be made.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Mason Industries, Amber Booth, or Kinetics.

2.2 ISOLATOR DESIGN

A. Materials. Design and treat vibration isolators for resistance to corrosion. Furnish phosphatized steel components with epoxy powder paint coating. Components exposed to the weather shall be epoxy powder paint coated or hot-dipped galvanized. Furnish zinc electroplated nuts, bolts and washers. Clean steel bases thoroughly of welding slag and prime with zinc-chromate or metal etching primer.

B. Design.
1. All spring isolators must be completely stable in operation, have a Kx/Ky ratio of at least 1:1, and must be designed for not less than 50 percent reserve deflection beyond specified deflection.
2. Design isolators for equipment installed outdoors to provide adequate restraint due to normal wind conditions. The isolators must withstand wind loads of 30 pounds per square foot applied to any exposed surface of the isolated equipment.
3. Air handling equipment subjected to horizontal air thrust shall be furnished with isolated thrust resistors to limit displacement to 1/4 inch.

2.3 ISOLATOR TYPES

A. All vibration isolators described in this section shall be the product of a single manufacturer. Mason Industry's products are the basis of these specifications; products of other manufacturers will be considered provided samples comply with the specification. Submittals and certification sheets shall be in accordance with Article 1.03.

B. Type ND. Neoprene mountings shall have minimum static deflection of 0.35 inch {9mm}. All metal surfaces shall be neoprene covered and have friction pads both top and bottom. Bolt holes shall be provided on the bottom and a tapped hole and cap screw on top. Steel rails shall be used above the mountings under equipment such as small vent sets to compensate for the overhang. Mountings shall be type ND or rails type DNR.

C. Type 30N. Hangers shall consist of rigid steel frames containing minimum 1-1/4-inch {32mm} thick neoprene elements at the top and a steel spring, with general characteristics as in paragraph 2.3B, seated in a steel-washer-reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability, the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30-degree arc from side to side before contacting the cup bushing and short circuiting the spring. Submittals shall include a hanger drawing showing the 30-degree capability.

D. Type W. Neoprene Waffle design pads for vibration and friction placement between metal equipment and concrete or to prevent metal on metal contact from occurring between equipment and hangor support.

E. Type HD. Hangers shall consist of rigid steel frames containing minimum 1-1/4-inch {32mm} thick neoprene element. The neoprene element shall have neoprene bushings projecting through the steel box. In order to maintain stability, the boxes shall not be articulated as clevis hangers.

2.4 ISOLATOR APPLICATIONS

	EQUIPMENT	ISOLATOR TYPE/ MINIMUM DEFLECTION	BASE TYPE
A.	Fan Coil Units - Suspended.	HD/1/2″	—
B.	Inline Exhaust Fans. Suspended - Up to 15 HP	30N/1″	—
C.	Exterior Heat Pump, Heat Recovery and Condensing Units.Wind Rated for 150 mph 3 second gust;ultimate applied in accordance with Chapter 29 of ASCE/SEI 7-10		
D.	Generic Equipment on Concrete Surface	Type W/0.10”	—
E.	Heat Pump, Heat Recovery and Condensing Units.	ND/0.35″	—

PART 3 - EXECUTION

3.1 FLEXIBLE CONNECTORS

A. Verify all equipment is hanging level and backing nuts are installed on threaded rods snug to insure equipment mountings stay in place.

3.2 EXTERIOR MOUNTED EQUIPMENT (HPs & CUs)

A. Delegated-Design Submittal for building appurtenances and other structures.

1. Include analysis data indicating compliance with performance requirements and design data signed and sealed by a qualified professional engineer responsible for their preparation who is currently licensed in the State of Texas.

B. In addition to satisfying the requirements of the International Building Code and referenced standards, all building appurtenances (rooftop equipment or devices) and other structures (tanks, exterior enclosures, exterior pad-mounted equipment, etc.) shall be designed and detailed by the delegated-design professional to comply with the following requirements:

1. Wind Loads on Other Structures and Building Appurtenances; applied in accordance with Chapter 29 of the ASCE/SEI 7-10 Standard, “Minimum Design Loads for Buildings and Other Structures.”
   a. Basic Wind Speed, V = 150 mph (3-second gust; ultimate)
   b. Wind Directionality Factor, K_d = 1.0
   c. Exposure Category = C

C. Delegated Design: Engage a qualified professional engineer to design and detail building appurtenances and other structures.

D. Structural Performance: Building appurtenances and other structures shall withstand the effects of gravity and environmental loads without compromising strength and serviceability. Appropriate factors of safety against sliding and overturning shall be ensured through properly designed and detailed positive anchorage of the appurtenance or structure to the supporting structure. Calculations shall be included with the delegated-design submittal.

END OF SECTION 230548

SECTION 230553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Nameplates, labeling and identification methods for mechanical equipment and components, including items located outdoors, in building equipment rooms, in tunnel and on roof.

B. Classroom fan coil units will not have tags.

1.2 SUBMITTALS

A. Submit list of wording, symbols and letter size coding for mechanical identification.

B. Submit valve chart and schedule, including valve tag, number, location, function and valve manufacturer's name and model number.

C. Submit manufacturer's printed installation instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Brady, Seton, or Marking Services, Inc.

2.2 PLASTIC NAMEPLATES

A. Externally mark all mechanical equipment with nameplates which shall be black laminated rigid phenolic with white core. Nameplate minimum size shall be 1 inch high by 3 inches long {25 x 75} with 3/16-inch {4.8} high engraved white letters. Supply blank nameplates for spare units and spaces.

2.3 PLASTIC TAGS

A. Laminated 3-layer plastic with engraved black letters on light, contrasting background color. Tag size minimum 1-1/2-inch {38} diameter.

2.4 METAL TAGS

A. Brass, aluminum with stamped letters; tag size minimum 1-1/2-{38} inch diameter with smooth edges.

2.5 PLASTIC PIPE MARKERS

A. Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and fluid being conveyed.

2.6 PLASTIC TAPE PIPE MARKERS

A. Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.

2.7 UNDERGROUND PLASTIC PIPE MARKERS

A. Bright colored, continuously printed plastic ribbon tape of not less than 6 inches {150} wide by 4 mil {0.10} thick, manufactured for direct burial service.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Plastic Nameplates. Install with corrosive-resistant mechanical fasteners or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Plastic or Metal Tags. Install with corrosive-resistant chain.

C. Plastic Pipe Markers. Install in accordance with manufacturer's instructions.

D. Plastic Tape Pipe Markers. Install complete around pipe in accordance with manufacturer's instructions.

E. Underground Plastic Pipe Markers. Install 6 to 8 inches {150 to 200} below finished grade, directly above buried pipe.

F. Equipment. Identify air handling units, chillers, variable speed drives, compressors, control panels (and major control components outside panel), pumps, heat transfer equipment, tanks and water treatment devices with plastic nameplates. Identify thermostats (or sensors) relating to terminal boxes or valve with nameplates. Small devices, such as in-line pumps, may be identified with plastic or metal tags, and thermostats (or sensor) with clear plastic.

G. Controls. Identify control panels and major control components outside panels with plastic nameplates.

H. Valves. Identify valves in main and branch piping with tags.

I. Piping. Identify piping, concealed or exposed, with plastic pipe markers or plastic tape pipe markers. Tags may be used on small diameter piping. Identify service, flow direction and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet {6000} on straight runs including risers and drops, adjacent to each valve and "T", at each side of penetration of structure or enclosure, and at each obstruction.

J. Provide ceiling tacks to locate valves, dampers, terminal boxes or other concealed equipment above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

3.2 VALVE CHART AND SCHEDULE

A. Provide valve chart and schedule in aluminum frame with clear plastic shield. Install in pump room at a conveniently readable location height approximately 5’ AFF. Suggest on wall with Secondary Pump VFDs between VFDs and exit door.

END OF SECTION 230533

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SECTION 230593

AIR AND WATER BALANCE

PART 1 - GENERAL

1.1 SUMMARY

A. Provide final air and water balance after construction of the air and hydronics systems.

1.2 QUALITY ASSURANCE

A. Air and water balance shall be performed by an independent balance agency with at least 3 years of pertinent experience and belonging to AABC or NEBB. Submit agency name for approval prior to work.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL PROCEDURES

A. Operating Tests. After all mechanical systems have been completed, and prior to air balance, subject each system to an operating test under design conditions to ensure proper sequence of operation in all operating modes. Make adjustment as required to ensure proper functioning of all systems.

B. Certified Data. The Contractor shall provide certified data on fans, grilles, coils, filters and other equipment required for proper balancing of the system.

C. Adjustment. Supervise or perform necessary adjustments to air flow dampers, fans, sheaves, extractors, splitters, and other controls as required to properly balance the system, to obtain quantities shown on drawings, $\pm$ 5 percent.

D. Balancing. Follow balancing and testing procedures published by the Associated Air Balance Council or NEBB.

E. Reports. Compile the test data on a report form, similar to Associated Air Balance Council or NEBB forms. Submit three copies to the Engineer for review. Include data on air volume at supply and return grilles and diffusers. Include exhaust air volume.

F. Equipment. Instruments used shall be accurately calibrated and maintained in good working condition. Equipment shall be as listed by AABC or NEBB for this type of work.

3.2 AIR AND WATER BALANCE

A. General Requirements.
1. Do all work required for complete testing and adjusting of all HVAC and plumbing systems.
2. Provide all instruments and equipment required to accomplish necessary testing, adjusting, and as required by the Engineer to verify performance. All instruments shall be in accurate calibration and shall be calibrated in ranges that will be expected. Instruments and equipment shall include, but not be limited to:
   a. Two mercury thermometers, to become property of Owner, for installation in thermometer wells.
   b. Two pressure gauges, to become property of Owner.
   c. An instantaneous reading air measuring device.
   d. A sling psychrometer.
3. Prior to final observation, submit to the Owner a letter certifying:
   a. That all balancing is complete.
   b. That all controls are calibrated and functioning properly.
   c. That all parts of the various systems are complete and ready to be turned over to the Owner for continuous operation. Submit with letter a report tabulating data required.

B. Design Conditions. The HVAC systems have been designed to maintain the inside conditions indicated below when operating with the outside conditions stated. Install, test and adjust the systems so that they will produce the inside conditions for design; however, Contractor must be prepared to prove by suitable test that equipment is producing capacities scheduled.
1. Inside Conditions.
   Summer: 75 F.D.B. 50% R.H.
   Winter: 70 F.D.B.
2. Outside Conditions.
   Summer: 91.3 F.D.B. 79.1 F.W.B.
   Winter: 36 F.D.B.

C. Adjust all air system dampers and volume controllers to obtain proper air balance throughout the conditioned area. The air quantities shown on the drawings for individual outlets may be changed to obtain uniform temperature within each zone, but the total air quantity shown for each zone must be obtained. Maximum temperature variation within a zone to be 2°F.

D. Adjust all blower drives to obtain proper total amounts of air. Change drive if necessary to accomplish proper air flow, at no additional cost to the Owner.

E. Adjust all valves in the various water systems to obtain proper amount of water to each piece of equipment.

F. Calibrate, set and adjust all automatic temperature controls. Check proper amount of water to each piece of equipment.

G. After balancing is complete and before calling for final observation, record, and submit for record, following data:
1. For each air unit, including make-up air unit:
   a. Suction and discharge static pressure, and total static.

b. Fan rpm, measured by tachometer; verify rotation.
c. Motor nameplate F.L.A., actual amps, voltage.
d. Measured cfm for total supply, return and outside air.
e. Entering and leaving air temperature for each coil.
f. Entering and leaving water temperatures for each water coil.
g. Entering and leaving water pressures for each water coil.

2. For each pump:
   a. Suction and discharge pressure readings at shutoff.
   b. Suction and discharge pressure readings at final balance flow.
   c. Motor nameplate F.L.A., actual amp at rated flow, voltage; verify rotation.
   d. Copy of pump curve, with final balance point marked.
3. For each chilling unit:
   a. Water temperature entering and leaving cooler.
   b. Water pressure entering and leaving cooler.
   c. Air temperature entering and leaving condenser.
   d. Pressure drop-flow curves for cooler with flow points marked.
   e. Motor nameplate F.L.A., actual amp, voltage.
   f. Compressor suction and discharge pressures.
4. Each condensing unit:
   a. Ambient air temperature, condenser discharge temperature.
   b. Motor nameplate F.L.A., actual amps, voltage.
   c. Suction and discharge pressures, temperature.
   d. Verification that moisture indicator shows dry refrigerant.
   e. Settings of all operating and safety controls.
5. For each fan:
   a. Motor nameplate FLA, actual amps, voltage.
   b. Fan RPM.
   c. Measured CFM.
      1) VF fan CFM does not need to be measured. Check for proper fan rotation, dampers open/close and fan operation.
6. For each gas radiant heater (GRH).
   a. Nameplate Btuh value.
   b. Motor nameplate FLA, actual amps, voltage.
   c. Does the heater operational from T'stat adjust at time of testing.
7. Dual gas sensor
   a. Back a vehicle up within 25 feet of the sensor close all doors start the engine. Within 5 minutes the sensor should trigger the fan to come on. Note the actual time between engines start and fan activation and verify fan turns on and turns off.

H. <u>After Owner Occupancy</u>. After Owner has occupied and is using the building, make three additional inspections of the system (at 1-month intervals) to:
   1. Correct any Owner-observed temperature imbalances.
   2. Check correct operation of equipment and verify by letter to the Engineer on each trip. List in the letter corrections made.

END OF SECTION 230593

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SECTION 230700

HVAC INSULATION - GENERAL

PART 1 - GENERAL

1.1 SUMMARY

A. General requirements for insulation. These requirements apply to all other Division 23 sections specifying insulation.

1.2 FIRE HAZARD RATING

A. All duct and piping insulation used on the project shall have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50 as determined by test procedures ASTM E 84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements.

1.3 QUALITY ASSURANCE

A. Applicator shall be a company specializing in insulation application with minimum 5 years' experience.

1.4 SUBMITTALS

A. Product Data. Submit product data on each insulation type, adhesive and finish to be used in the work. Include manufacturer's installation instructions, list of materials and thickness for equipment scheduled.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable manufacturers are listed under individual specification sections.

PART 3 - EXECUTION

3.1 INSULATION

A. Insulate valves, fittings, flanges and special items to the full thickness required for corresponding piping.

B. Replace insulation damaged by either moisture or other means. Insulation which has been wet, whether dried or not, is considered damaged. Make repairs where condensation is caused by improper installation of insulation. Also repair any damage caused by the condensation.

C. Where existing insulated piping, ductwork or other surfaces are taped, remove existing insulation back to undamaged sections and replace with new insulation of the same type and thickness as existing insulation. Apply as specified for insulation of the same service.

3.2 ACCESSORIES

A. Installation of accessories such as jacketing, bands, adhesives, insulation shields, coatings, finishes, etc., are specified under individual specification sections.

END OF SECTION 230700

SECTION 230713

EXTERNAL DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Provide external insulation on low-velocity supply, return and fresh air ducts within unair-conditioned spaces, on all high-velocity supply ducts and all round low-velocity supply ductwork.

B. Consider space above ceiling as air-conditioned space if floor above is air-conditioned. Consider vertical chases not used for return air and vertical chases leading to unair-conditioned spaces as unair-conditioned.

1.2 STANDARD REFERENCES

A. ASTM C 411 - Temperature Range.

B. ASTM C 553 - Mineral Fiber Blanket and Felt Insulation.

C. ASTM C 612 - Mineral Fiber Block and Board Thermal Insulation.

D. ASTM E 96 Procedure A - Jacket Vapor Transmission.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. CertainTeed, Johns-Manville, or Owens-Corning.

2.2 INSULATION

A. Concealed Duct, Round or Rectangular. Provide flexible glass fiber insulation with factory-applied, reinforced foil scrim kraft (FSK) facing vapor barrier, 1.0-pound density, 2 inches thick. A K factor of 0.27 at 75°F mean is required.

B. Exposed Round Duct. Provide flexible fiberglass insulation with foil scrim kraft (FSK) facing vapor barrier, 1.0-pound density, 2 inches thick. A K factor of 0.27 at 75°F mean is required.

C. Exposed Rectangular Duct. Provide rigid board duct insulation of 1-1/2-inch-thick fiberglass. A minimum density of 6 pounds per cubic foot is required. Provide an integral, UL labeled, reinforced foil scrim kraft (FSK) facing vapor barrier on the outside surface. Wrap rigid board insulation with VentureClad 1577CW jacketing system to provide a smooth uniform appearance and puncture and tear resistant.

D. Standing Seams. Insulate standing seams and stiffeners which protrude through insulation with 6-pound density, 1-1/2-inch-thick, unfaced, flexible blanket insulation. As a vapor seal, use glass cloth with vapor barrier coating. Insulation should not prevent adjustment of damper operators.

2.3 COATINGS AND ADHESIVES

A. Coating. Childers CP-30 low-odor vapor barrier coating.

B. Adhesive. Childers CP-82 vapor barrier adhesive.

C. Glass Cloth. No. 10 white glass cloth.

PART 3 - EXECUTION

3.1 FIRE SAFETY REQUIREMENTS

A. Do not extend duct coverings through walls or floors required to be fire stopped or required to have fire resistance rating. Interrupt duct coverings in the immediate vicinity of heat sources such as electric resistance or fuel-burning heaters.

3.2 CONCEALED DUCT, ROUND OR RECTANGULAR

A. Insulation shall be wrapped, in accordance with manufacturer's recommendations, on the ductwork with all circumferential joints butted and longitudinal joints overlapped a minimum of 2 inches. Adhere insulation to ductwork with 4-inch-wide strips of adhesive at 8 inches on center. In addition, secure insulation to the bottom of rectangular ductwork over 24 inches wide by the use of mechanical fasteners at no more than 18 inches on center.

B. On circumferential joints, the 2-inch flange on the facing shall be stapled with outward clinching steel staples on 2-inch centers, and taped with a minimum 3-inch-wide strip of glass fabric and coating. Cover all seams, joints, pin penetrations and other breaks with coating reinforced with glass fabric.

3.3 EXPOSED ROUND DUCT

A. Insulation shall be wrapped in accordance with manufacturer's recommendations. Firmly butt all joints together and seal longitudinal laps of factory-applied vapor barrier jacket with adhesive. Cover butt joints with a 4-inch-wide strip of factory-supplied vapor barrier jacket facing adhered with adhesive.

B. Wrap rigid board insulation with VentureClad 1577CW jacketing system to provide a smooth uniform appearance and puncture and tear resistant.

3.4 EXPOSED RECTANGULAR DUCT

A. Insulation shall be wrapped in accordance with manufacturer's recommendations. Fill and point up all joints, perforations and exposed edges with coating reinforced glass fabric adhered with adhesive. Securely fasten insulation to metal surface with adhesive and mechanical

fasteners on 12-inch centers. Sheet metal screws and discs or other approved fasteners may be used.

B. Provide

END OF SECTION 230713

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SECTION 230716

HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Provide insulation for low temperature equipment.

B. Low temperature installations include driers, accumulators, suction piping and other equipment containing liquids and gases below 60°F.

PART 2 - PRODUCTS

2.1 INSULATION

A. Low Temperature Vessels. Provide 3/4-inch-thick, standard Armstrong Armaflex sheet insulation to filters, driers, accumulators, and other heat exchangers.

2.2 CEMENT AND COATINGS

A. Cement. Provide Ryder One Coat cement to seal insulation for high temperature vessels.

B. Coating. Furnish Childers CP-50AHV2 coating to provide a finish coat and to secure glass cloth for high temperature vessels.

C. Sealant. Use Childers CP-67 to seal the joints of insulation on low temperature vessels.

D. Finish. Use Childers CP-30LO finish to adhere and coat the glass cloth on low temperature vessels.

E. Acoustical Coating. Use Childers Muffl-Lag.

F. Primer. Use Childers CP-53.

PART 3 - EXECUTION

3.1 LOW TEMPERATURE EQUIPMENT (ARMAFLEX)

A. Adhere Armaflex sheet insulation to clean, oil-free metal surfaces by compression fit method and full coverage of Armstrong 520 adhesive. Seal butt joints with same adhesive.

B. Apply a coat of Childers CP-17 finish to insulation with sufficient thickness to provide satisfactory hiding qualities.

3.2 COMPRESSOR AND SUCTION PIPING REQUIRING NOISE CONTROL

A. Apply Childers Muffl-Lag following manufacturer's instructions in place of CP-30LO vapor barrier coating employing a No. 5 glass cloth reinforcing membrane. For compressor discharge piping, crossover piping, condenser and hot gas bypass, apply Childers Muffl-Jac acoustical jacketing in place of CP-30LO vapor barrier coating.

END OF SECTION 230716

SECTION 230719

LOW TEMPERATURE HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Provide low temperature piping insulation. Applications including chilled water, refrigerant, and condensate drains.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Certainteed, Knauf, or Owens-Corning.

2.2 FIBERGLASS INSULATION (INDOOR PIPING)

A. Material. Use fiberglass insulation, 0.23 maximum K factor at 75°F mean, water vapor permeance 0.02 perm-inch maximum, with factory-applied, all service reinforced vapor barrier jacket having integral laminated aluminum vapor barrier, self-sealing laps and butt strips. Provide molded or mitered covers for flanges, valves and fittings.

B. Thickness.

Piping	Thickness (Inches)	mm}
Chilled Water Piping, 6″ {150} and smaller	1-1/2	{38}
Chilled Water Piping, 8″ {200} and larger	2	{50}
Refrigerant Suction Piping	1-1/2	{38}
Condensate Drains and Roof Drain Lines	1/2	{13}
Domestic Cold Water Piping (as noted on drawings)	1	{25}

C. At Contractor's option, factory-made insulation by either "Insul-Phen","Koolphen" or "Trymer 2000" may be provided. Installation shall be per manufacturer's standard procedures in its entirety and shall meet this section as well.

D. Sealant, Adhesive and Finish.
1. Childers CP-76 shall be used at valve covers, anchors and hangers.
2. Childers CP-82 shall be used to seal longitudinal laps of the vapor barrier jacket and adhere butt joint covers.
3. Provide Childers CP-30LO finish for use with 10″ x 10″ glass fabric reinforcement.

2.3 FOAMGLAS® INSULATION (EXTERIOR PIPING)

A. Material. Foamglas® Insulation thickness for pipes listed in 2.03 B of this section, outdoor and aboveground, manufactured by Pittsburgh Corning Corporation and fabricated by a Pittsburgh Corning Corporation-approved fabricator. The insulation shall comply with ASTM C 552 Type II. Products of other manufacturers proposed as equivalent quality shall be submitted for written approval. Supporting technical data, samples, published specifications and the like shall be submitted for comparison. The Contractor shall warrant that proposed substitutions, if accepted, will provide performance equal to the materials specified herein. Provide precut, molded or mitered fiberglass blanket insulation for wrapping flanges, valves and fittings. Provide fiberglass blanket insulation to fill voids around flanges and valves.

B. Thickness.

Piping	Thickness (Inches) mm}	
Chilled Water Piping, 4″ and smaller	2-1/2	{63}
Chilled Water Piping, 6″ {150} thru 12″	3	{75}
Refrigerant Suction Piping	2-1/2	{63}
Condensate Drain Piping	1	{25}

C. At Contractor's option, factory-made insulation by either "Insul-Phen","Koolphen" or "Trymer 2000" may be provided. Installation shall be per manufacturer's standard procedures in its entirety and shall meet this section as well.

1. Ultraviolet (UV) protection is a must for any outdoor insulation whether it is the aluminum jacket defined in this section or a manufacturer approved UV protection information must be submitted as to the UV protection provided.

D. Accessories.

1. Indoor Applications. All-purpose jacketing of kraft paper/aluminum foil/vinyl coating construction by Lamtec Corporation, Compac, Alpha Association, or approved substitution.
2. Outdoor Applications. Embossed aluminum jacketing, 0.016-inch thickness, with bands and seals of the same material, by Childers Products, Premetco International, or approved substitution.

E. Aboveground Mastic Finish Applications. Pittcote® 404 coating reinforced with PC® Fabric 79 available from Pittsburgh Corning Corporation, or approved substitution.

F. Sealant. Pittseal® 444 Sealant by Pittsburgh Corning Corporation or approved substitution.

G. Banding.

1. Aluminum bands, 1/2 inch wide by 0.010 inch thick with matching seals.
2. Reinforced tape for insulation, 3/4 inch with fiber reinforcement, Scotch Brand No. 880 by 3M, or approved substitution.
3. Copper or stainless steel wire, 14 gauge soft-annealed.

2.4 INSULATION SHIELDS

A. Field Fabricated. Furnish a section of high-density insulation at each hanger, support and anchor, as scheduled below. Color code the high-density insulation either by contrasting color or by flecking for positive identification. Further support the insulation with shields of

galvanized metal extending not less than 4 inches on either side of the support bearing area to cover at least half of the pipe circumference. When pipe is guided top and bottom, cover full pipe circumference. Adhere shield to insulation to avoid slippage.

Pipe Diameter	Length of Insulated Section in Inches	Minimum US Standard Gauge of Metal Shield
3″ and smaller	12	18
4″ to 6″	12	16
8″ to 18″	18	14
18″ and larger	24	12

B. Factory-made. Insulation shields as made by Pipe Shields, Inc., or approved substitution may be provided at Contractor=s option. Insulation shall extend at least 1 inch beyond metal. Select proper shield for service and span.

2.5 ALUMINUM JACKETING

A. Acceptable Manufacturers. Jacketing as manufactured by Childers or Quality Service Metals will be acceptable.

B. Piping. Finish insulated pipe with a prefabricated jacket of Type 3105-H14 aluminum alloy, 0.016 inch thick, stucco embossed, with factory-applied, 1-mil Polykraft moisture barrier, Childers Strap-on or approved substitution. Corrugated finish.

C. Valves, Fittings and Flanges. Finish all valves, fittings and flanges, and similar installations with formed aluminum covers, 0.024 inch thick, Type 1100-H14 aluminum alloy with factory-applied acrylic moisture barrier.

D. Straps and Seals. Provide aluminum strapping and seals for jackets and covers according to manufacturer’s recommendation; 3/4-inch by 0.020-inch-thick, Type 3105-H14 aluminum.

PART 3 - EXECUTION

3.1 PREPARATION

A. Tests of the piping system shall be completed prior to insulation application.

B. All piping shall be cleaned of foreign substances and free of surface moisture prior to insulation application.

3.2 INSTALLATION OF FIBERGLASS INSULATION (Indoor)

A. Pipe.
1. Butt insulation joints firmly together. Seal longitudinal laps and butt strips with sealant.
2. Where piping is interrupted by fittings, flanges, valves or hangers and at intervals not to exceed 25 feet on straight runs, an isolating seal shall be formed between the vapor barrier jacket and the bare pipe by liberal application of the sealant to the exposed joint faces carried continuously down to and along 4 inches of pipe and up to and along 2 inches of the jacket. This shall be done only on chilled water service.
3. Finish all piping.

B. Valves, Flanges and Fittings.
   1. Insulate all valves, flanges and fittings with premolded or mitered fitting covers secured with wire. Thickness of insulation shall be equal to that adjoining piping.
   2. Finish with the layer thickness, as recommended by manufacturer, of Childers CP-30LO reinforced with glass fabric.

C. Control Valve Covers.
   1. Valves at fan coil units normally will be located over drip pans so that condensed moisture will be collected. At air handling units, insulate the valve body with finished insulation, complete with troweled-on vapor seal, shaped to accommodate the valve body.
   2. Seal covers to valve insulation proper with adhesive so that the seal may be broken with a knife blade without damage to either part. Arrange so that cover can be removed and replaced as necessary for operation of the valve. Finish valve cover with glass cloth and two coats of finish.

D. Isolation Valve Covers.
   1. Remove valve wheel, tighten packing gland, and fabricate special covers, complete with troweled-on vapor seal, shaped to accommodate the valve stem.
   2. Seal covers to valve insulation properly with adhesive so that the seal may be broken with a knife blade without damage to either part. Arrange so that cover can be removed and replaced as necessary for operation of the valve.
   3. The requirement for special covers may be waived in certain locations where dripping condensate can be tolerated and the valve will be used frequently. Such locations will be identified by the Engineer.

E. Shields and Hangers. Where piping hangers or anchors must be in direct contact with pipe, seal off the pipe insulation on both sides of the hanger by carrying the vapor seal down to the bare pipe. Apply insulation around the hanger ring or anchor and pipe and carry vapor barrier upward and outward along the hanger rod or anchor members to a point not less than 12 inches from the adjacent pipe. Draw wire loops tight over the vapor barrier jacket, with ends of wire bent down. Take care to avoid puncturing the vapor seal. Finish insulation as specified for flanges, and seal over adjacent vapor barrier jacket. Caulk penetrations with vapor barrier sealant.

3.3 INSTALLATION OF FOAMGLAS® INSULATION (Outdoor)

A. Insulation shall be applied to piping with all joints tightly fitted to eliminate voids. For systems operating at or below 35 F, all joints must be sealed full-depth with sealant. Sealant shall not be used to fill voids or cracks.

B. Insulation sections shall be secured with two wires or aluminum bands. Two strips of reinforced tape may be used in place of bands or wire if exterior bands are used with jacketing. The tape shall overlap itself by 50 percent.

C. Fittings shall be insulated in a manner similar to that for piping.

D. Apply all-purpose jacketing in accordance with manufacturer's instructions ensuring a minimum 2-inch lap at all longitudinal joints. All circumferential joints should butt as closely as possible (1/4-inch maximum gap in jacketing). A 4-inch-wide butt strip shall be applied

over the circumferential joints. All laps and butt strips shall be either adhesive faced (self-seal) or sealed by field application of appropriate adhesive.

E. Aluminum jacketing shall be applied with all laps positioned to shed water. All laps shall be a minimum of 2 inches. Aluminum jacketing shall be secured using bands and seals as specified. Band spacing shall be two bands equally spaced per section of insulation, maximum 12 inches o.c.

END OF SECTION 230719

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SECTION 230923

BUILDING AUTOMATION SYSTEM

PART 1 – GENERAL

1.1 SUMMARY

A. This specification defines a totally integrated digital control system for the Administration Building as well as the Warehouse. It includes the expected performance requirements delineated by function, and requirements for the system components, their reliability, packaging and integration.

1.2 GENERAL SCOPE OF WORK

A. General: The building control system (BCS) also known as the building automation system (BAS) shall be comprised of a Network Server and/or System Network Controller(s) (SNC) and application/unitary controllers within the facility. The network server and/or SNC's shall connect to the owner's local or wide area network. Access to the system, either locally in the building, or remotely from a central site or sites, shall be accomplished through standard web browsers, via the Internet and/or local area network. Each SNC shall communicate to MS/TP resident BACnet DDC controllers provided under this section.

1. BCS and BAS are used interchangeably in these specifications and on the drawings they do refer to the exact same thing with regard to this project.

B. The controls shall be bid by to the mechanical contractor and shall not be bundled with any equipment price. The controls price shall be a completely separate from any equipment price. No exceptions.

C. The BCS shall be a BACnet-compliant web-based system that is stand alone in all aspects and shall consist of a high-speed, peer-to-peer network of direct digital controls (DDC), an operator's workstation, the network server, SNC's, application controllers, and all input/output devices. All BCS controllers and workstations shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135–2010, BACnet or latest revision. Management level Ethernet network speeds shall be 1Gbps minimum and DDC level MSTP network speeds shall be 76.8 Kbps minimum.

D. The web server(s) shall gather data from the system and generate web pages accessible through a conventional web browser from all personal computers (PC's) connected to the network. System shall include any and all software and hardware to support at least 50 simultaneous users. Web-browser software shall be Microsoft Internet Explorer 9.0 as a minimum.

E. Operators shall be able to view and configure systems through the standard web browser and all graphical/data representations shall appear identical, whether the user is on site or viewing via the Internet at a remote location. Standard operator functions such as control point manipulation, configuration and viewing of trends, schedules and alarms shall be performed through the standard web-browser. Each mechanical system and building floor plan shall be depicted on the operator workstation by point-and-click graphics.

F. The system shall directly control HVAC equipment as specified in the sequences of operation. Furnish energy conservation features such as optimal start and stop, night setback, request-based logic, and demand level adjustment of set points as specified in the sequences or on the input/output (I/O) summary.

G. The BCS supplier shall provide the following additional services as part of this specification: warranty and service during the warranty period; submittals, samples and record documentation; comprehensive commissioning and testing of the BCS with documentation; training services for the owner and BCS operators; coordination with other site contractors and suppliers; operator and technician training program.

H. Products furnished under this specification but installed by other.

1. Mechanical devices installed under Division 23 by the mechanical contractor or other suppliers: temperature sensing thermowells; automatic control valves; pipe taps for flowmeters; water pressure sensors and switches; automatic control dampers not installed in air handling unit mixing boxes or louver schedules; damper actuators for variable air volume (VAV) terminal units; mounting cost of controller and actuator for VAV terminal units.

2. Electrical devices installed under Division 26 by the electrical contractor:

a. 120 VAC power to controllers and control panels at locations indicated on the drawings. Review and verify that these locations are adequate for the proposed BCS.

b. Interlock wiring to duct mounted smoke detector or fire alarm shutdown relays to HVAC equipment motor starters and variable frequency drives (VFD).

I. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.

1.3 WEB SOFTWARE OVERVIEW

A. Dynamic Colored Floor plans: Dynamic colored floor plans that compare actual space conditions to setpoints shall be provided on all floorplan graphics displayed on the front-end. Floorplan enlargements shall also use the thermographs to display space conditions. Zones within the set point range shall appear transparent white. As the space gets warmer the zone color shall gradually modulate from transparent white to transparent red to identify a hot zone. As the space conditions get cooler the zone color shall gradually modulate from transparent white to transparent blue to identify a cold zone. Each zone shall indicate the current actual zone temperature within the zone. The floor plans shall use a gray scale to indicate schedule occupancy for each zone. If in the unoccupied state (gray), the zone shall still display space conditions through the transparent gray. As the space gets warmer the zone color shall gradually modulate from transparent gray to transparent gray/red to identify a hot zone. As the space conditions get cooler the zone color shall gradually modulate from transparent gray to transparent gray/blue to identify a cold zone. From the floorplan graphic the operator shall be able to click on any zone and go directly to the graphic for the piece of equipment controlling that zone. All dynamic floorplans shall be visible via web interface as well as on the LAN. The authorized system operator shall be able to change the zone or system identifier (or name) on the graphic and that change shall be distributed to other associated graphics and to the equipment controller.

B. Imbedded Trend Logs: Provide trend logs that automatically pop up when the operator mouse clicks on the point from the graphic. Provide imbedded trends for all dampers, control valves, temperature sensors, CO2 sensors, humidity sensors, airflows, static pressures, flow meters,

VFD speeds, etc. The BCS contractor shall set up all trends for the owner. The embedded trend shall include a trend tool that allows the operator to modify the trend time scale and sample interval for up to 10 sample values. The trends shall be graphical on the computer screen but shall provide an output as an .xls/.csv, .pdf, HTML, oBIX or text file. The owner shall not be responsible for setting up trendlogs for those points on each equipment graphic.

C. Interactive Maps: Implement JAVA SCRIPT API 3.0 or newer, such as Google Interactive maps depicting the facility location to indicate the site plan. This is not a static image and must be completely interactive. Only required if directed by owner, but the system shall have the capability to do such.

D. Custom User HTML applications: The BCS shall utilize HTML applications as an extra feature. At minimum provide 7 day forecast, weather radar, traffic map and hurricane tracker. All of these features shall be imbedded into the BCS system.

E. Remote Support: The BCS shall provide a remote support feature allowing the owner and contractor to engage in a remote session where both parties are seeing the same computer screen. The owner and contractor shall be able to swap control of the computer allowing for trouble shooting and training purposes at the same time.

F. Provided a web-based BCS platform; contractor shall provide an Open License software. Licenses that are not open are not acceptable. There shall be no per seat or per user licensing fee charged to the owner by the contractor.

G. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. Schedules, set points, trends, and alarms shall be BACnet Objects.

H. User access shall include 50 assigned operators that shall include five levels of access within the web system. Each operator log-in shall have an expiration date to allow for temporary access to the system. The operator's access description shall include his e-mail address and cell/phone numbers. The operator access can be limited from 5 minutes to permanent access. The user shall be limited to eight bad login attempts before being locked out of the system.

I. Global modification: Provide the capability for global modification of user definable parameters of all points shall be provided. Global modification is defined as the mass adjustment of user definable parameters across a defined group, area, facility, campus, or network. Parameters shall included, but not be limited to temperature set point (VAV boxes, AHU Discharge, VAV AHU Static Pressure Set points etc.), equipment start/stop, equipment status, valve output signal, VFD speed control signal, and damper position signal. User shall be able to lock the definable parameter to a set value, or adjust a set point to an operator adjustable value. This function shall be accomplished through the standard graphical user interface/workstation and is to be selectively applicable by the user to all controllers on the network, all controllers in a specific facility or all controllers in a specific zone within a specific facility.

J. The system operator shall be able to override the output signal to the valves, dampers, variable frequency drives, lighting outputs, etc. with the use of the PC mouse click on the device. The system override shall include a Hand-Off-Auto (HOA) capability. If the output is commanded to the hand position the operator shall designate an output value of 0-100% in 1% increments. The hand override position shall be permanent or expire after an owner designated time period and revert to the auto position. The color-graphic shall indicate the device that has been overridden by a color change of the output value.

K. For non-emergency in-warranty events the system operator may submit a Service Request directly from the floor plan or system graphic. The web interface shall include the BCS

suppliers contact information including phone numbers and e-mail address. The service request will be logged into the BCS suppliers service department. A non-response by the assigned technician shall elevate the request to the next highest manager or supervisor until the system operator receives an response that their request has been received and is scheduled for a resolution. All requests for service shall be maintained in the customer's database for future reference. The service request capability may be extended after the expiration of the warranty as part of a service agreement.

L. The web-based system shall be accessible from Tablet PC's or Smart Phones and provide the same functionality that is available from personal computers connected through the LAN or WAN to the system operator. The tablet PC's as a minimum shall include an Apple iPad and Google Android based tablet PC. Operation shall include touch screen capability and use of the tablet keyboard screen. The operator shall be able to view color-graphics, system trends, override setpoints, change time schedules, and override damper and valve positions and override points the same as you can from a PC.

1.4 CONTRACTOR QUALIFICATIONS

A. The BCS Contractor shall:

1. Have a local staff of trained personnel capable of giving instructions and providing routine and emergency maintenance on the BCS, all components and software/firmware and all other elements of the BCS.
2. Have a proven record of experience in the supply and installation of equivalent BACnet systems over a minimum period of five years. Provide documentation of at least three equal or greater size and complexity, if so requested by the owner's representative.
3. Be a factory certified representative for the native BACnet BCS manufacturer for design, installation, and maintenance of the proposed systems.
4. Have comprehensive local service, training and support facilities for the total BCS as provided. Maintain local, supplies of essential expendable parts.
5. Approved systems are already installed in other City of Galveston facilities.
    - Alerton/Triium installed by Climatec.
        - Contact Santos Contreras (281)642-6973 or scontreras@climatec.com

1.5 RELATED DOCUMENTS & REFERENCES

A. Drawings and general provisions of the contract documents, apply to this section including:

1. General and Supplementary Conditions and Division 1 Specification Sections.
2. Division 23 for mechanical equipment, ductwork, piping, systems
3. Division 26 for electrical, lighting, and fire alarm equipment.

B. The latest edition of the following standards and codes in effect as approved by the authority having jurisdiction and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:

1. ANSI MC85.1 - Terminology for Automatic Control.
2. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
3. ANSI/ASHRAE Standard 135-2010, BACnet (building automation and controls network).
4. BTL Mark by the BACnet Testing Laboratories.

5. Uniform Building Code (UBC), including local amendments.
6. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
7. National Electrical Code (NEC).
8. FCC Part 15, Subpart J, Class A.
9. National Institute of Standards and Technology (NIST).

1.6 SUBMITTALS

A. Shop Drawings:

1. The following information shall be included on the cover page for each shop drawing and equipment documentation submittal:
    a. Project name with date. Refer to the applicable specifications by name and number.
    b. Provide submittal number and re-submittal number and date as applicable.
    c. Provided name and address of Consulting Engineer, Mechanical Contractor, General Contractor
2. Shop drawings shall be CAD generated, plot size of 8-1/2” x 11” or 11” x 17”. Drawings shall include diagrams, mounting instructions, installation procedures, equipment details and software descriptions for all aspects of the system to be installed.
3. Provide schematic of systems indicating instrumentation locations, all interconnecting cables between supplied cabinets on a mechanical floor plan.
4. Software specifications and descriptions including operating sequences.
5. Provide a bill of material that indicates specific manufacturer, part number, part description and quantity of each device for all system components.
6. Provide a list of the wire labels to be installed on each end of the control wiring, at the device and the control panel terminal. Labels shall be machine generated, typed and legible with a maximum of 17 characters. The label description “AHU-1 SAT” shall indicate the supply air temperature of AHU-1.
7. Equipment Schematic: Provide an electronic equipment schematic for each piece of mechanical equipment. The schematic shall display all mechanical equipment characteristics including fans, dampers, valves, sensors and other applicable control devices. The schematic shall show wiring terminations to each control device as shown in the submittal and as-build documentation. Control devices shall be labeled by a symbol that can easily be identified in a bill of material that is shown on this graphic. The bill of material shall show the device symbol, description, manufacture and part number.
8. Sequences of Operation: The sequences of operation shall be viewable for each piece of mechanical equipment and be in a text format as shown in the as built documentation. The sequence of operations shall be selectable at the applicable location for the control program.

B. Control component submittals:

1. Component technical data sheets with mounting and installation details.

2. The documentation shall include comprehensive and complete details of the BIBB and automation level documentation including address, associated controller type, etc. as required and for the interface to the BCS.

3. Details of networks/communications equipment, cabling and protocols proposed. Provide schedule of cabling including details of proposed cable types.

4. Module Drawing: Provide an electronic wiring diagram of each control module (as shown in submittal documentation). Diagram shall display wiring schematic and terminations to end devices. Diagram shall display each input and output terminals and label those that are used for the control application. Diagram shall display module type/name and network address.

5. Field sensor and instrumentation specification sheets. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.

6. Schedule and specification sheets for dampers, valves and actuators.

7. Design and provide layout of all components of panel mounted control devices, terminal strips and power supplies.

C. Color graphics: Provide sample layout of color graphic representations of the systems for review. The submittal shall indicate the quality of the graphic to be provided with the system with a sample of the specific control points to be included. Control points shall as a minimum include points indicated in the input/output summary, control schematic and primary controlling points defined in the sequences of operation. Provide a sample of a floor plan layout, typical AHU, terminal unit, outside air pretreatment unit, variable frequency drive, exhaust/supply fan, chiller plant and hot water plant. For control points to be provided by equipment BACnet integration provide sample of the control points, up to 25 total.

D. Commissioning reports. The submittal shall include a sample of the commissioning reports to be utilized during the commissioning section of this specification. Sample reports shall be approved as submitted or be modified by the engineer or owner's representative. The commissioning reports shall be included in the final operation and maintenance manuals. Reports shall be provided in hard-copy paper forms or electronic (.pdf) format.

1. Project Commissioning/System Verification Form for each controller.

   a. General information for each form shall include: project name; associated equipment with mark number; control panel number and location; controller number and model number; controller device instance number (address); MS/TP LAN segment number; verifying technician and date.

   b. Each connected control point and device shall contain the following columns with a separate line for each connected physical point: point description (same as device label); input/output number for each connected control device (IN-XX or AO-XX).

   c. Check boxes confirming that the commissioning tasks have been completed: device location, proper termination at device; proper termination at control panel; sequence is verified; point trend is enabled.

   d. Data entry boxes indicating measured/confirmed values: preliminary control point value on the graphic; observed control point value; calibration or adjustment value to correct offset; final displayed point value on the color-graphic; date of commissioning; engineer or owner's representative verification.

2. Control Panel Commissioning Form for each control panel.

a. General information: panel location and identification number; panel dimensions and NEMA rating; panel properly installed; Class 1 and Class 2 wiring are properly separated; correct voltage to the panel; no shorts or grounds in panel; no induce voltages in panel wiring; point to point termination match submittal; devices are mounted in the correct location; controller software revision number; address of controllers; panel device checkout is complete; panel startup is complete.

3. Sequence of Operation Commissioning Form per piece of equipment (AHU, VAV, chiller, boiler, etc.).

a. General information: project name; system identifier; building area served; control panel and controller numbers; controller model number and instance number (address); MS/TP LAN segment number; name of verifying technician and date.

b. Each step of the sequence of operation for each piece of equipment shall be documented shall include a “description of test”, “input to trigger test” and “expected outcome”. A pass/fail checkbox shall indicate each of these actions. Provide space for technician approval with associated date.

E. Operating and Maintenance (O&M) manuals: Provide O&M manual with full information to allow the owner to operate, maintain and repair installed products. Include trade names with model numbers, color, dimensions and other physical characteristics.

1. Format: Produce on 8-1/2 x 11-inch pages, and bind in 3-ring/D binders with durable plastic covers. Label binder covers with printed title “OPERATION AND MAINTENANCE MANUAL”, title of project, and subject matter and “Number _ of _” of binder. Provide substantial dividers tabbed and titled by section/component number.

2. Table of Contents for each volume:

a. Part 1: Directory with name, address and telephone number of Designer, Contractor and Subcontractors and Suppliers for each Project Manual section.

b. Part 2: Operation and maintenance instructions, arranged by Project Manual Section number where practical and where not, by system. Include:

3. Product design criteria, functions, normal operating characteristic and limiting conditions. Installation, alignment, adjustment, checking instructions and troubleshooting guide. Operating instructions for start-up, normal operation, regulation and control, normal shutdown and emergency shutdown. Test data and performance curves.

4. Spare parts list for operating products, prepared by manufacturers including detailed drawings giving location of each maintainable part, lists of spares recommended for user-service inventory and nearest source of in-stock spares.

F. Record Documentation:

1. Details of all alarm, diagnostic, error and other messages. Detail the Operator action to be taken for each instance.

2. Detail special programs provided and provide a complete programming instruction manual. Detail operation of all software applications.

3. Detailed list of the database for all installed devices.

4. Record drawings shall be CAD generated and shall include final locations and point ID for each monitored and controlled device.

5. In additional to the required hard-copies, provide a CD with all of the record documentation in PDF format and a CD(s) containing backup copies of all installed software and graphics.

6. Online as-built documentation: provide digital replications of as-builts that shall be accessible from each equipment graphic controlled or monitored by the BCS.

1.7 RELATED WORK IN OTHER SECTIONS

A. Refer to Section 23 for General Mechanical Provisions, VRF systems, Exhaust Fans, air handling units, and computer room units.

1. CRAC unit and packaged DX unit manufacturer shall provide BACnet interface to BAS.

B. Refer to Section 26 for General Electrical Provisions.

1. Division 26 shall provide all conduit and wiring for 120 volts and above, such as power to DDC control panels, 120v valve operators, VAV terminal units, power supplies, etc.

2. Switchgear manufacturer shall provide BACnet or Modbus interface to BCS.

1.8 ELECTRICAL POWER PROVISIONS

A. Power (120 VAC) shall be provided under Division 26 by the electrical contractor to the DDC panel locations indicated on the mechanical & electrical drawings. Provide step down transformers within panel enclosures. Provide all necessary fuses and circuit protection devices

B. Normal power shall be provided to the controllers serving fan powered terminal units with electric heat via the control transformer provided with the unit.

C. All components of the BCS shall be powered from the sources above. Provide final terminations from the locations indicated on the Division 23 Drawings.

D. The BCS Contractor shall provide any additional control (24 volt) power that is required as part of this contract and not indicated by other. This shall include all conduit, cabling, circuit breakers, etc.

1.9 WARRANTY

A. Warranty work and the equipment provided under this contract shall be for a period of one year from the date of Substantial Completion. Warranty shall cover all components, system software, parts and assemblies supplied by this contractor and shall be guaranteed against defects in materials and workmanship for one (1) year from the date of Substantial Completion. Labor to troubleshoot, repair, reprogram or replace system components that have failed due to defects in materials and workmanship shall be provided by this contractor at no charge to the owner during the warranty period. All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks. All warranty work shall be performed by the BCS contractor’s local service group.

B. Warranty shall not include routine maintenance, e.g., equipment cleaning, mechanical parts lubrication, pilot lamp replacement, operational testing, etc. Warranty shall not cover repair or replacement of equipment damaged by under- or over-voltage, misuse, lack of proper maintenance, lightning, water damage from weather or piping failure.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the BCS contractor. The

maximum acceptable response time to provide this service at the site shall be 24 hours, during normal working hours.

PART 2 – PRODUCTS

2.1 SYSTEM NETWORK CONTROLLER (SNC)

A. These controllers are designed to manage communications between the Unitary Controllers, manage communications between itself and other system network controllers (SNC) and with any operator workstations (OWS) that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.

B. The controllers shall be fully programmable to meet the unique requirements of the facility it shall control.

C. The controllers shall be capable of peer-to-peer communications with other SNC's and with any OWS connected to the BAS, whether the OWS is directly connected, connected via cellular modem or connected via the Internet.

D. The communication protocols utilized for peer-to-peer communications between SNC's will be Niagara 4 Fox, BACnet TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between SNC's is not allowed.

E. The SNC shall employ a device count capacity license model that supports expansion capabilities.

F. The SNC shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:
1. BACnet
2. Lon
3. MODBUS
4. SNMP
5. KNX

G. The SNC shall be capable of executing application control programs to provide:
1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of LonWorks, BACnet, and MODBUS controller data.
7. Network management functions for all SNC, PEC and ASC based devices.

H. The SNC shall provide the following hardware features as a minimum:
1. Two 10/100 Mbps Ethernet ports.
2. Two Isolated RS-485 ports with biasing switches.
3. 1 GB RAM
4. 4 GB Flash Total Storage / 2 GB User Storage
5. Wi-Fi (Client or WAP)
6. USB Flash Drive
7. High Speed Field Bus Expansion
8. -20-60 degreesC Ambient Operating Temperature

9. Integrated 24 VAC/DC Global Power Supply
10. MicroSD Memory Card Employing Encrypted Safe Boot Technology

I. The SNC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.

J. The SNC shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.

K. The SNC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via cellular modem, or wide-area network.
1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
   a. Alarm.
   b. Return to normal.
   c. To default.
2. Alarms shall be annunciated in any of the following manners as defined by the user:
   a. Screen message text.
   b. Email of complete alarm message to multiple recipients.
   c. Pagers via paging services that initiate a page on receipt of email message.
   d. Graphics with flashing alarm object(s).
3. The following shall be recorded by the SNC for each alarm (at a minimum):
   a. Time and date.
   b. Equipment (air handler #, access way, etc.).
   c. Acknowledge time, date, and user who issued acknowledgement.

L. Programming software and all controller "Setup Wizards" shall be embedded into the SNC.

M. The SNC shall support the following security functions.
1. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
2. Role-Based Access Control (RBAC) for managing user roles and permissions.
3. Require users to use strong credentials.
4. Data in Motion and Sensitive Data at Rest be encrypted.
5. LDAP and Kerberos integration of access management.

N. The SNC shall support the following data modeling structures to utilize Search; Hierarchy; Template; and Permission functionality:
1. Metadata: Descriptive tags to define the structure of properties.
2. Tagging: Process to apply metadata to components
3. Tag Dictionary

O. The SNC shall employ template functionality. Templates are a containerized set of configured data tags, graphics, histories, alarms... that are set to be deployed as a unit based upon manufacturer's controller and relationships. All lower level communicating controllers (PEC, AUC, AVAV, VFD.) shall have an associated template file for reuse on future project additions.

P. The SNC shall be provided with a 5 Year Software Maintenance license. Labor to implement not included.

2.2 MANAGEMENT LEVEL NETWORK

A. Extension of the management level network shall meet, at minimum, the following requirements: Ethernet TCP/IP network; BACnet standards; cabling shall be Category 5 or higher quality and shall be tested and certified for 1 GBps data transfer rate.

2.3 OPERATING SYSTEM SOFTWARE FOR THE SNC

A. The distributed architecture of the operating system for the CNS and SNC's shall provide the operator a comprehensive interface to allow the operator to configure and customize the BCS to optimize the HVAC system to save energy, schedule and maintain equipment and provide occupant comfort. The provided graphical toolset shall allow the operator to create applications in a drag and drop environment.

1. Input/output capability shall allow the operator to request the current value or status of the control point; command/override equipment to a specific state; add, change or delete control points, alarm limits and controllers; change descriptors to control points and equipment; modify parameters; create or modify DDC loops;

B. Operator System Access: Via software password with five access levels at work stations and at each control unit.

C. Color graphic tools shall allow the user to create equipment and floor plan graphics from a standard library of symbols; allow custom generation of symbols; utilize over 64 or more colors; create real-time dynamic data for the graphics. Up to 60 control points may be displayed on each graphic.

1. Provide a link between compatible graphics to minimize the paths to additional information. For example provide the link from the zone sensor to the VAV terminal to the air handling unit and to the central plant. Web pages shall be provided to allow the operator to zoom into specific areas of the facility and then link the space to the floor plan to the overall building and then to the facility site plan.

2. Graphical tools shall allow the creation of bar graphs, pie graphs and other tools to visualize control information such as run time hours, energy consumed and occupant comfort.

D. Alarm processing tools shall allow the operator to create alarm messages that include as a minimum: time of alarm, point descriptor, alarm condition and remote annunciation. Critical alarms shall be displayed, archived to a storage device or printed on a alarm printer. Alarms shall be displayed in order of occurrence and have an optional audible alarm indicator.

1. Print alarm messages, up to 60 characters in length, for each alarm point specified.

2. Alarms may be routed to other devices including web-enabled cell phones, pagers, tablet PC's and designated personal computers on the network or Internet.

3. Operator specifies when alarm requires acknowledgment. Continue to indicate uSNCknowledged alarms after return to normal. An alarm log shall be maintained to archive alarms for future reference with the above specified parameters as well as indicating the person acknowledging the alarm.

4. The graphical display shall indicate the number of the current uSNCknowledged alarms by individual building site or by sum of all campus-wide facilities.

5. The operator may create and forward an e-mail message to another user directly from the graphical interface so that the message can be read when the second user logs on to the system.

E. Upon a power failure to equipment in the facility the BCS shall automatically start equipment upon the restoration of power. Program a time delay between individual equipment restart on a schedule to minimize demand charges from the utility company.

F. Custom reports may be created by the operator with a requested time and date manually or automatically. All reports may be logged to a storage device for future reference. The data reports shall allow customization and scaling of the X-Y coordinates; plotting of tabular reports; provide multi-point graphical reports with not less than eight variables on the same report. Print reports on daily, weekly, monthly, yearly or scheduled basis as scheduled.

G. The network server current operating system, database, color-graphics, custom reports shall be backed up automatically to a remote server or storage device as directed by the owner's representative.

H. Maintenance Management capability shall allow the system to monitor and log the run-time for HVAC equipment; schedule maintenance reports that include recommended material and labor for the assigned task.

2.4 EXPANDABLE APPLICATION CONTROLLERS (EAC)

A. Expandable application controllers shall be capable of implementing control strategies for the system based on information from any or all connected inputs. The EAC shall utilize factory pre-programmed global strategies that may be modified by field personnel on-site. Global control algorithms and automated control functions should execute via a 32-bit processor

B. Programming shall be object-oriented using control program blocks that will support a minimum of 500 Analog Values and 500 Binary Values. Analog and binary values shall support standard BACnet priority arrays. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing.

C. Controller shall have adequate data storage to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 1.5 years (cumulative). Battery shall be a field-replaceable (non-rechargeable) lithium type. The onboard, battery-backed real time clock must support schedule operations and trend logs.

D. Controller shall include both on-board 10BASE-T/100BASE-TX Ethernet BACnet communication over a twisted pair cable (UTP) and shall include BACnet IP communication

E. The base unit of the EAC shall host up to 8 expansion modules with various I/O combinations including universal 10-bit inputs, binary triac outputs, and 8-bit switch selectable analog outputs (0-10V or 0-20 mA). Inputs shall support 3K and 10K thermistors, 0-5VDC, 0-10VDC, 4-20mA, dry contacts and pulse inputs directly.

F. All outputs must have onboard Hand-Off-Auto switches and a status indicator light. HOA switch position shall be monitored. Each analog output shall include a potentiometer for manually adjusting the output when the HOA switch is in the Hand position. The position of each and every HOA switch shall be available system wide as a BACnet object.

G. BACnet Conformance

1. Standard BACnet object types supported shall include as a minimum: Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program and Schedule object types. All necessary tools shall be supplied for working with proprietary information.

2. The Controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on

the LAN. Must support interoperability on wide area networks (WANs) and campus area networks (CANs) and function as a BACnet Broadcast Management Device (BBMD).

H. Schedules: Each EAC shall support a minimum of 50 BACnet schedule objects.

I. Logging Capabilities: Each controller shall support a minimum of 200 trend logs. Sample time interval shall be adjustable at the operator's workstation. Controller shall periodically upload trended data to system server for long term archiving if desired. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

J. Alarm Generation: Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures. Alarm logs shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site via remote communications. Controller must be able to handle up to 200 alarm setups stored as BACnet event enrollment objects – system destination and actions individually configurable.

2.5 UNITARY CONTROLLERS - GENERAL

A. The BCS Contractor shall provide all Unitary Controllers (UC). UC shall be fully programmable or applications specific controllers with pre-packaged operating sequences maintained in EEPROM or flash RAM.

B. The UC shall be a node on one of the automation LANs and shall control its own communications so that the failure of any one node, shall not inhibit communications on the network between the remaining nodes. UC shall be totally independent of other LAN nodes for their monitoring and control functions.

C. Provide each UC with a battery back-up or EEPROM for the protection of volatile memory for a minimum of 72 hours. Batteries shall be rated for a seven year life.

D. All associated applications programs shall reside at the UC. The UC shall not require communication to any other panel for normal operating sequences other than time scheduled base commands.

E. Control shall be based on algorithms, i.e. proportional plus integral plus derivative (PID), proportional plus integral (PI), or proportional to comply with the sequences of operation PID algorithms shall maintain the system operation within + or - 1.0 Deg. F. of the space temperature set points.

F. The UC shall be configured with sufficient input/output capacity to achieve the required control points to meet the sequence of operations.

2.6 UNITARY CONTROLLER AIR HANDLING UNITS (AHU) & FAN COIL UNITS (FCU)

A. The BCS Contractor shall provide UC's required for chilled/hot water and DX/electric heat air handling units and fan coil units. Provide an enclosure to house the UC and associated components including suitable mounting brackets shall be NEMA 1 rated and located outside the UV's and FCU's.

B. The UC shall be capable of monitoring and controlling the following parameters per the sequences of operation and input/output summary; space temperature; space relative humidity sensor ; cooling/heating stage control or modulating valve control; fan on/off control and status; supply air sensor; occupancy sensor; space CO2 sensor; VFD control and monitoring.

2.7 BCS CONTROLLER LEVEL NETWORK

A. BCS Automation Level LAN shall consist of BACnet/MSTP (76.8 Kbps minimum). Data transfer rate and data throughput as required to meet the alarm annunciation requirements.

2.8 ENERGY SAVING PROGRAMS

A. Demand Limiting: Monitor total power consumption for each power meter and shed associated loads automatically to reduce power consumption to an operator set maximum demand level.

B. Duty Cycling: Periodically stop and start loads, based on space temperature, and according to various on/off patterns.

C. Automatic Time Scheduling: Self-contained programs for automatic start/stop/scheduling of building loads. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary schedules.

D. Start/Stop Time Optimization: Perform optimized start/stop as function of outside conditions, inside conditions, or both. Optimization shall be adaptive and self-tuning, adjusting to changing conditions by modifying occupancy period based upon the desired temperature at beginning and end of the occupancy period. Base optimization on occupancy schedules, outside air temperature, seasonal requirements, and interior room temperature. Employ adaptive model prediction for how long building takes to warm up or cool down under different conditions.

E. Night Setback/Setup Program: Reduce heating space temperature set point or raise cooling space temperature set-point during unoccupied hours in conjunction with scheduled start/stop and optimum start/stop programs.

F. Calculated Points: Define calculations and totals computed from monitored points (analog/digital points), constants, or other calculated points.

G. Event Initiated Programming: Any data point capable of initiating event, causing series of controls in a sequence.

H. Holiday scheduling

I. Direct Digital Control: Furnish software so operator is capable of customizing control strategies and sequences of operation by defining appropriate control loop algorithms and choosing optimum loop parameters.

J. Trend logging shall be provided for all points per the input/output summary where there is a change in the analog or binary signal. Each controller shall be capable of storing trend values and then automatically transfer data to the SNC or the CNS hard disk. Trend data shall be updated continuously per the operator assigned interval at intervals as low as one minute. Collect samples at intervals specified in minutes, hours, days, or month. Output trend logs as line-graphs or bar graphs. Binary points (input and output) shall only be logged upon a change of value (COV). Display trend samples on workstation in graphic format. Automatically scale trend graph with minimum 60 samples of data in plot of time versus data.

2.9 FIELD INSTRUMENTATION

A. Temperature: All temperature sensors to be solid state electronic thermistor or RTD, factory-calibrated to within 0.5°F, totally interchangeable with housing appropriate for application. Sensors shall be 10,000 ohm thermistor @ 77 F (type II or III as applicable) with temperature curve rated for the application. Sensor wiring terminations shall be in a galvanized box (not plastic).

1. Outside air temperature sensor: Sensors shall be installed in weather proof enclosure with ventilated PVC sun-shied

2. Duct mounted temperature sensor shall be averaging type for supply air, mixed air and low temperature applications for air handling units. Duct probe temperature sensor shall be acceptable for terminal units.

3. Provide flat plate stainless steel space temperature sensors with no local set point adjustment for IDF and MDF rooms as indicated on the drawings.

B. Carbon Dioxide Sensor: The CO2 sensor shall be capable of monitoring CO2 concentration with an accuracy of +/- 30 parts per million (PPM). The CO2 sensor shall produce a linear 0-10 VDC or 4-20 ma signal over the range of 0 to 2000 PPM. The CO2 sensor shall measure using non-dispersed infrared (NDIR) technology to measure carbon dioxide gas and shall have

1. Wall mounted carbon dioxide sensors shall be Veris CWE series.

2. Duct Mounted Carbon Dioxide Sensor: CO2 sensors for duct mounted applications shall be installed in the return air path. Duct mounted carbon dioxide sensors shall be Veris CDE series.

3. The BCS contractor shall utilize the required calibration devices to properly commission and calibrate the CO2 sensors per the manufacturer's recommendations.

C. Relative humidity sensors: All relative humidity sensors shall be a two wire type, 4-20 mA output proportional to the relative humidity range of 0-100%. The accuracy of the sensors shall be $\pm$3% over a range of 5-95% r.h. The sensor shall be replaceable. Sensor wiring terminations shall be in a galvanized box (not plastic). Veris HO series or approved equal.

1. Outdoor air relative humidity sensors: provide non-corroding outdoor shield to minimize wind effects and solar heating. Install wall-mount weather proof enclosure with conduit fitting.

2. Interior air relative humidity sensor: wall mounted humidity sensors shall be installed in a wall mounted enclosure with white or off-white cover to match the wall temperature sensors.

3. Duct mounted relative humidity sensor: Duct mounted relative humidity sensors shall be provided with a moister resistant enclosure with conduit fitting. The probe length shall be 8" minimum.

D. Combination Temperature/Humidity wall sensor

1. Humidity sensor shall be 4-20 mA output proportional to the relative humidity range of 0-100%. The accuracy of the sensors shall be $\pm$3% over a range of 5-95% r.h.

2. Temperature sensor shall be solid state electronic thermistor or RTD. The accuracy of the temperature sensor shall be $\pm$0.5°F.

3. Veris HEW series or approved equal.

E. Differential pressure sensors:

1. Duct static pressure sensor: The differential pressure sensors shall have an input range compatible with the medium being measured. The proportional output signal shall be 0-10 Vdc or 4-20 mA. Accuracy of the sensor shall be $\pm$5% over an operating range of 0-2.0 inches w.g.

2. Water differential pressure sensors: The water differential pressure sensor shall be provided with a cast aluminum NEMA-1 enclosure with an operating range of 0-30 psig and an accuracy of ±2% of full scale reading. Sensor shall be installed with a valved piping bypass by the mechanical contractor. See details on the drawings.

F. Air differential pressure switch: For fan shutdown provide air differential pressure switches for all fans controlled by a variable frequency drive (VFD) to shut down the associated fan in the event of sensing high differential pressure. Air differential pressure switches shall have an adjustable setpoint with a range of 0-10 inches w.g. with manual reset at the switch. Provide ¼ inch copper tubing with compression fittings to mount to the side of the duct.

G. Momentary control relays: Provide momentary control relays as indicated. . Relays shall have coil ratings of 120 VAC, 50 mA or 10-30 VAC/VDC, 40 mA as suitable for the application. Contact ratings shall be 10 amp. Provide complete isolation between the control circuit and the digital output. Relays shall be located in the UC or other local enclosures and have pin-type terminals. Relays shall have LED indication of status.

H. Current sensing relay: Current sensing relays shall be rated for the applicable load. The output relay shall have an accessible trip adjustment over its complete operating range. Enclosure shall have an LED to indicate relay status.

2.10 AUTOMATIC DAMPERS

A. Furnish automatic dampers (AD) as indicated on the Division 23 Mechanical Drawings for installation by the Division 23 Mechanical Contractor. The maximum leakage rate for AD shall not exceed 10 cfm per square foot at 4 inches W.C. Provide actuators for BCS furnished automatic dampers and for dampers provided as part of a factory installation within an AHU or fan-coil unit to comply with the sequence of operations including actuator mountings, installation, drive arms, linkages and damper end switches. Actuators shall be directly coupled to damper drive blades with no intermediate linkages or shall be rotary type actuators directly coupled to the damper drive shaft. Where required by the sequences of operation, actuators shall have a spring return to the de-energized position upon loss of power. Damper normal and failure positions shall be as identified within the sequences of operation. Power rating shall be 120 Vac + or - 10% 60 Hz or 24 Vac power supply.

B. Control Dampers. The control contractor shall furnish and size all automatic control dampers unless provided with the HVAC equipment. The sheet metal contractor shall install all dampers unless provided with HVAC equipment.

1. All dampers used for modulating service shall be opposed blade type arrange for normally open or normally closed operation as required to comply with the sequences of operation. The damper is to be sized so that when wide open the pressure drop is a sufficient amount of its close-off pressure drop for effective throttling.

2. All dampers used for two-position or open-close control shall be parallel blade type arranged for normally open or closed operation as required.

3. Damper linkage hardware shall be constructed of corrosion resistant zinc & nickel-plated steel. Blade-to-blade linkage shall be concealed within the frame.

4. Frame shall utilize a heavy duty 5 in. by 1 in. 16 gauge galvanized steel hat channel frame designed for installation inside the ductwork. Frame shall have reinforced corners and low profile head and sill on dampers less than 17 in high.

5. Blades shall be 3-V, single thickness of 16 gauge galvanized steel. Provide dampers with flexible metal compression-type jamb seals and extruded vinyl blade edge seals for low leakage performance.

6. Shafts shall be ½ in. diameter square plated steel axles positively locked to the blades to eliminate slippage between blades and axles. Actuator shaft shall be removable. Provide molded synthetic (acetyl) bearings in a polished extruded frame raceway.

7. Dampers shall be Honeywell D2 or Ruskin CD36 series.

C. Damper Actuators:

1. Outside air and exhaust air damper actuators shall be mechanical spring return. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.

2. Outside and return air modulating actuators shall utilize analog (proportional) control 2-10 VDC. Actuators shall be driven in both the open and closed directions.

3. Electric damper actuators shall be direct shaft mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or setscrew type fasteners are not acceptable.

4. Single section dampers shall have one electronic actuator direct shaft mounted.

5. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per damper section.

6. Damper actuators shall be Belimo or Honeywell.

2.11 PANELS AND ENCLOSURES

A. Provide panels and enclosures for all components of the BCS, which are susceptible to physical or environmental damage.

B. Interior panels and enclosures shall meet be NEMA 1 rated painted steel panels with locking door.

C. Exterior mounted panels and enclosures shall be NEMA 4 painted steel panels with locking door.

D. Panels for UC’s shall be mounted on the outside of all unit ventilators and fan coil units with three feet of wall clearance in front of them and no higher than 7 feet to the bottom of the panel.

2.12 LABELING AND WARNING NOTICES

A. Provide labeling for all control panels and enclosures.

B. Provide labeling of all control wires and input/output points at the controller and at the control device; the label at each end of the wire shall be the same Labels shall be machine generated, typed and clearly legible with a maximum of 17 characters. Hand written labels or labels written on the control wire jacket will not be acceptable. Each label shall be unique to its function and shall reference the applicable system. For example “AHU-1 SAT” will indicate the supply air temperature sensor for AHU-1. Improper labeling shall be removed and shall require re-commissioning of the control device and controller to document correct functionality.

C. Provide high voltage warning notices at all equipment controlled by the BCS and at all associated motor starters when used by equipment controller.

2.13 TUBING AND PIPING

A. Provide tubing and piping as required for the field instrumentation.

B. Tubing within equipment rooms, vertical risers, and penetrations to ductwork shall be either copper pipe or shall be plastic tubing within conduit. Tubing for all water-based instrumentation shall be copper pipe. Identify the type of tubing proposed in the shop drawing submittal.

C. Provide suitable bulk head fittings for duct and panel penetrations.

D. Tubing in plenum rated areas may be plastic tubing. Polyethylene tubing shall meet, at minimum, the following requirements: flame retardant; crack resistant; 300 psi burst pressure.

2.14 CONDUIT AND FITTINGS

A. Provide all conduit, raceways and fittings for the BCS monitoring, communication and control cabling. All work shall meet all applicable codes.

B. Conduit, where required, shall meet, the requirements specified within Division 26 .

C. BCS monitoring and control cable shall not share conduit with cable carrying voltages in excess of 48 volts.

2.15 CABLING

A. Provide all cables for the BCS. Cable shall meet, at minimum, the following requirements:

1. Minimum 98% conductivity stranded copper.

2. Proper impedance for the application as recommended by the BCS component manufacturer.

3. Monitoring and control cable shall be #18 AWG or larger, dependent on the application. Analog input and output cabling shall be shielded. Monitoring and control cable shall be in a YELLOW color jacket.

4. Management Level Area Network (MLAN) cable shall be CAT 6, 24 gauge unshielded, and shall be in a BLUE color jacket.

5. Field Level Area Network (FLAN) cable shall be #24 AWG shielded and shall in a RASPBERRY color jacket.

6. Shield shall be grounded at the CCP, UC, or control panel. Ground at one end only to avoid ground loops.

7. Identification of each end at the termination point. Identification should be indicated on and correspond to the record drawings.

B. 120 VAC power wiring shall be of #12 AWG solid conductor or larger as required.

PART 3 – EXECUTION

3.1 PRE-CONSTRUCTION

A. The BCS supplier shall provide a pre-construction coordination meeting with the affected trades to ensure a cooperative efficient process of installation. The invited trades shall include the general contractor, mechanical contractor, electrical contractor, test and balance contractor, owner’s representative, consulting engineer and others with a direct interest in the coordination of the affected systems. The BCS contractor shall provide an outline of the meeting agenda highlighting the construction schedule, coordination with mechanical and electrical trades.

Provide a sign-in sheet and submit it through the attendees along with a summary of the meeting notes for future reference.

3.2 INSPECTION DURING INSTALLATION

A. Provide a technician to assist the engineer or owner's representative with inspections made during the installation period that are required to review the progress and quality of ongoing work. The engineer/owner's representative shall generate field observation reports on the findings of the inspection. The engineer or owner's representative shall advise the BCS contractor during the inspection of any concerns noted with respect to the installation and shall repeat the concerns in writing as soon as possible after the inspection is completed. The BCS contractor shall take corrective action to meet the requirements of the specifications. Upon correction the BCS contractor shall submit written documentation through the contractors to the engineer.

3.3 INSTALLATION OF COMPONENTS

A. Provide all interlock and control wiring. All wiring shall be installed in a neat and professional manner in accordance with specification division 26 and all national, state and local electrical codes.

B. Provide wire and wiring techniques recommended by equipment manufacturers. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the Owner's Representative prior to rough-in. Provide auxiliary pilot duty relays on motor starters as required for control function.

C. Electrical Contractor shall provide 120 or 277 volt power at a junction box within 48" of the controller. The BAS Contractor shall coordinate with the Electrical Contractor to identify locations of power requirements prior to the installation of the controls.

D. Conduit for control wiring shall be provided whenever one of the following conditions exists:

1. Conduit is indicated on the drawings or specifically required by the specifications.
2. Cabling runs through inaccessible areas such as within partitions/walls, above closed in ceilings, under floor; within trenches and underground; on the exterior of the building; exposed on the surface of the building; when encased in concrete or other material that makes the cable inaccessible or when located such that access to the cable is not readily obtained.
3. Cable within mechanical, telecommunications and electrical equipment rooms and control rooms.
4. Conduit shall be installed, inside wall from sensor box to above the wall, for all wall mounted temperature, humidity and CO2 sensors.

E. Control wiring located above an accessible ceiling space may be plenum rated cable. Plenum rated wire shall be bundled and routed at right angles to the building lines and secured to the building structure every 15 feet.

F. When communication bus enters or exits a building, a surge suppressor shall be installed. The surge suppressor shall be installed according to the controls manufacturer's instructions.

G. Provide sleeves for all cable and conduit passing through walls, partitions, structural components, floors and roof

H. All sensor wiring shall be labeled to indicate the origination (at the device) and destination of data (at the control panel). The description shall indicate the type and location of the control device such as “AHU-1 SA temp” or “VAV 1-1 space temp”.

I. Wall temp sensors at 48” above the finished floor to comply with ADA requirements and to match the height of the light switches. Mount humidity sensor at equal height to wall temperature sensor.

3.4 COMMISSIONING REQUIREMENTS

A. Commissioning shall be provided by the BCS contractor to demonstrate and confirm that the installed system complies with the specifications and the control sequences of operation herein specified. Upon completion of the commissioning process the BCS contractor shall demonstrate to the engineer or owner’s representative the functionality of the control system devices are in compliance with the contract documents.

B. Technicians provided by the BCS contractor shall be factory trained and qualified in the operation of the provided control system. The BCS contractor shall provide, if requested, the factory training certificates of the individuals providing the commissioning services on this project.

C. Commissioning tools, applicable to the system provided, shall be utilized by the factory trained technicians for proper verification of system operation and functionality. Temperature verification sensors shall be NIST certified within the last 12 months. Meters such as Fluke 52 series or better shall be utilized. Use of non-certified meters may require the system to be re-commissioned with certified meters at no cost to the owner.

D. Documentation of the commissioning process shall be provided per the project general conditions in a hard-copy paper or electronic (.pdf) format as requested. Documentation shall include the following forms:

1. Project Commissioning/System Verification Form for each controller provided on the project to verify the proper function of each controller, control device and system component provided.

2. Panel Commissioning Form for each control panel to document the proper installation and function of each control panel provided.

3. Sequence of Operation Commissioning Form for each piece of controlled equipment to confirm compliance of the control system with the specified sequences of operation.

4. Not providing proper documentation for each control devices, panel, or system, upon request by the engineer or owner’s representative, may require the BCS contractor to re-commission the applicable systems at no additional cost to the owner.

E. After completion of the commissioning, the BCS contractor shall be able to demonstrate the sequence of operations for each system to the engineer and the owner’s representative.

F. Equipment checkout sheets are to be produced by this contractor showing checkboxes and compliance with the following procedures for each piece of equipment and turned over to the owner and/or mechanical engineer.

3.5 COLOR GRAPHICS

A. The CNS/SNC color graphics shall be provided for the BCS system prior to system acceptance and owner training.

B. The color graphics provided shall include the following as a template. Provide forward and backward links on the graphic.

1. Site plan with link to overall building plan including detached buildings. The site plan shall be referenced to an automatically updated aerial view or map view of the area such as Google Maps or Bing Maps. Provide link to proceed to the overall building floor plan.

2. The overall building plan shall indicate space temperature conditions referenced by the color of the zone. Specific details of the zone temperatures and equipment are not required. Provide a link to the floor plan wings, upper floors and remote buildings.

3. The floor plan colorgraphics shall indicate the space temperatures by color references. Additional information shall indicate the space temperature, the occupancy of the zone, air handling units, VAV terminals and ductwork with diffusers. A link at each terminal unit or AHU shall automatically connect the system operator to the equipment colorgraphic.

4. The color graphics for the equipment shall as a minimum be equal to the points from the input/output summary or control schematic. Primary control devices as required by the sequences of operation shall also be provided.

5. Control points from equipment that are integrated into the BCS via a factory BACnet card shall be provided to convey the operating conditions of the attached equipment. Up to 25 key operating points per equipment graphic may be required. Coordination of the specific points shall be provided during the submittal phase.

3.6 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Startup testing documentation: Prepare the checklist documenting startup testing of each input and output device, with technician's initials and date certifying each device has been tested and calibrated prior to acceptance testing. This document shall indicate proof that the following functions have been commissioned and shall be included in the as-built documentation: short to ground check, configuration of trends, confirmation that color-graphics are accurately representing actual systems, point to point checkout, all damper and valve actuators respond to input change, control modules are addressed and have functional descriptors, specified interlocks are functional, calibration report of all sensors, discrete outputs respond to time schedule or manual enable command.

B. Demonstration. Prior to acceptance, demonstrate the following performance tests to demonstrate system operation and compliance with specifications.

1. Engineer, owner’s representative and mechanical contractor shall be invited to observe and review system demonstration. Provide attendees at least 10 days notice.

2. Demonstration shall follow process approved as part of the submittal and shall include complete checklists and forms for each system as part of system demonstration.

3. Demonstrate actual field operation of each sequence of operation as specified. Demonstrate calibration and response of any input and output points requested by engineer or owner’s representative.

4. Demonstrate complete operation of operator interface including review of color-graphics, time schedules, trend logs, alarm notification, functionality of tablet PC operation.

    a. DDC loop response. Supply graphical trend data output showing each DDC loop's response to a set point change representing an actuator position change of at least

25% of full range. Trend sampling rate shall be selectable from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show set point, actuator position, and controlled variable values.

b. Demand limiting if applicable in the sequence of operations. Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand-limiting set point, and status of set points and other affected equipment parameters.

c. Trend logs for each system. Trend data shall indicate set points, operating points, valve positions, and other data as specified. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs.

5. Alarms and Interlocks. Check each alarm with an appropriate signal at a value that will trip the alarm. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction. Alarm verification shall include temperatures exceeding alarm threshold (high and low), fan failure safety, duct high static pressure switch, freezestat, smoke detector shutdown.

6. Tests that fail to demonstrate proper system operation to the engineer shall be repeated after contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

C. Acceptance.

1. After tests described in this specification are performed to the satisfaction of both engineer and owner’s representative, the engineer shall accept the control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond BCS contractor's control. Engineer shall provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.

2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved by the engineer.

3.7 DEMONSTRATION AND OWNER TRAINING

A. Furnish basic operator training for multiple persons on data display, alarm and status descriptors, requesting data, execution commands and log requests. Include a minimum of 16 hours: 8 hours instructor time for onsite training and 8 hours of hands on class environment training. Training sessions may be provided in 4-hour increments as approved by the owner’s representative.

1. Change/modify temperature setpoints.

2. Change/modify time of day, holiday and override schedules.

3. Display, create, and modify trends of system points.

4. Update room numbers on the color-graphics.

B. Demonstrate complete and operating system to Owner. Provide written documentation listing the attendees of the specified training with sign-in sheet and training time and date.

3.8 SEQUENCES OF OPERATION

A. VRF Integration

1. DDC System controls scheduling of equipment and space temperature setpoints via the BACnet interface provided by the unit manufacturer.
2. Coordinate integration and mapping requirements with the VRF Manufacturer.
3. VRF internal controls will maintain desired space temperature in areas served
4. Controls contractor will mount the thermostat furnished by the VRF manufacturer and run the communication wire between the VRF split systems

B. Exhaust / Ventilation Fans

1. DDC System controls system off / on and occupied / unoccupied times (adjustable). When the system is on, the fan runs continuously. When the system is in the un-occupied mode the fans will be de-energized.

C. Outside Air Units

1. Occupancy DDC System controls system off / on and occupied / unoccupied times (adjustable).
2. Fan Control When the calculated start time arrives, the Building Automation System (BAS) will send a signal to the fan and energize the fan. A current switch will prove status to the BAS and alarm the central site if the switch is not made within 20 seconds (operator adjustable). There will also be a 10 second (operator adjustable) de-bounce time to prevent nuisance alarms from a bouncing switch.
3. Temperature Control A duct mounted temperature sensor will monitor the supply air temperature. The BAS will output separate signals to energize stages of DX cooling and electric duct heat in sequence to maintain the space temperature within its operator adjustable heating and cooling set points.
4. Equipment Control Points
   Fan status - current switch – BI
   Fan start/stop – BO
   DX cooling coil – BO
   Heating – BO
   Discharge air temperature – AI
   Damper control – AO

END OF SECTION 230923

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SECTION 232300

REFRIGERANT PIPING AND APPURTENANCES

PART 1 - GENERAL (Not Used)

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Refrigerant Piping:
   1. Furnish ACR, nitrogen charged, refrigerant piping of Type L, hard-drawn temper copper tubing, for refrigeration use (per ASTM B 640.88), with sweat-type, wrought copper fittings brazed with minimum 15 percent silver solder. Use long sweep elbows. Cast fittings are not permitted.
   2. Precharged Piping: Furnish copper tube, Type L, annealed, with “quick connect” fittings matched to units.

B. All flare joints must be clean and made up tight without any pipe joint compound. Tubing should be flared using tools specifically designed for the purpose. All flanged joints to be made up with gaskets lightly coated with oil. All nonferrous slip joints to be polished clean before assembly, then brazed. For copper-to-brass or bronze joints, use brazing material per ASTM B 260, Class BAG-2 (Easy-Flo 35, typical). For copper-to-copper joints, use brazing material per ASTM B 260, Class B CUP-5 (Sil-Fos, typical).

2.2 SERVICE VALVES

A. Provide angle or globe service valves, with sweat connections. Use packed-type valves with gasketed seal cap and back seat feature. Valves must be wrench operated. Furnish valves especially designed for refrigerant service, in conformance with the ARI code.

B. Place service valves at the inlet and outlet of each compressor, on both sides of each strainer and solenoid valve, and as otherwise shown and specified.

C. Furnish valves manufactured by Henry, Mueller Brass or approved substitution.

2.3 FILTER DRYER

A. Provide replaceable filter/dryers for liquid and suction line installation as shown on drawings. Provide isolation valves as recommended by manufacturer. Provide units manufactured by Sporlan, Parker or approved substitution.

PART 3 - EXECUTION

3.1 PRESSURE TEST

A. After all refrigeration equipment and piping are installed, charge the system with the proper refrigerant and dry nitrogen to 150 psig minimum, 200 psig maximum, or “bond dry CO2” to the test specified in ANSI B9.1.

B. Test all joints with a Halide torch or an electronic leak detector.

C. Repair all leaks and retest each system until proved absolutely tight.

3.2 EVACUATION AND DRYING

A. After refrigerant system has been pressure-tested, connect a rotary-style vacuum pump capable of pulling a vacuum of 100 microns or below, and evacuate piping system, including all lines and equipment.

B. Operate the system for the equivalent of 8 hours at full load, with refrigerant passing through the driers. Check oil levels frequently and add oil whenever required. Use only refrigerant oil in sealed cans furnished by the compressor manufacturer.

C. An authorized representative of the (condensing unit) (compressor) manufacturer shall witness the entire testing, evacuation and charging operation to see that it fully complies with the procedures recommended by the manufacturer.

END OF SECTION 232300

SECTION 233113

DUCTWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Provide low-velocity and high-velocity ductwork, including duct construction and support.

1.2 SUBMITTALS

A. Submit ductwork product data. Indicate duct fittings, particulars such as gauges, sizes, weld and configuration prior to start of work for low, medium and high pressure and kitchen hood exhaust systems.

1.3 CONTRACTOR COORDINATION

A. Erect all ducts in the general locations shown on the drawing(s), but conform to all structural and finish conditions of the building. Before fabricating any ductwork, Contractor shall check the physical conditions at the job site and make all necessary changes in cross sections, offsets and similar items, whether they are specifically indicated on drawings or not.

1.4 STANDARDS AND CODES

A. Except as otherwise indicated, sheet metal ductwork material and installation shall comply with the latest edition of SMACNA HVAC Duct Construction Standards, metal and flexible in all pressure ranges. Fiberglass ductwork material and installation shall comply with the latest edition of SMACNA Fibrous Glass Duct Construction Standards. All air distribution devices (such as dampers) included in this specification shall comply with the latest applicable SMACNA manual.

B. Construct ductwork and all air distribution devices to NFPA 90A, NFPA 90B and NFPA 96 standards.

1.5 DEFINITIONS

A. Low Pressure. Less than 2 inches w.g. positive or negative static pressure and velocity less than 2500 fpm.

B. Medium Pressure. 2 inches through 4 inches w.g. positive static pressure and velocities greater than 2000 fpm.

1.6 WARRANTY

A. Ductwork warranty shall cover workmanship, noise, chatter, whistling or vibration. Ductwork shall be free from pulsation under all conditions of operation.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. United McGill (for round and oval ducts only), or approved equivalent.

2.2 DUCT MATERIAL

A. General. Noncombustible or conforming to requirements for Class I air duct materials or UL 181.

B. Steel Ducts. G-60 coated galvanized steel sheet (ASTM A 653-96-CS-TYPEA/A 924), lock-forming quality, having zinc coating of 1.25 ounces per square foot for each side in conformance with ASTM A 90.

C. Flexible Ducts. Interlocking spiral of galvanized steel or aluminum construction, or fabric supported by helically wound spring steel wire or flat steel bands; rated to 6 inches w.g. positive and 1 inch w.g. negative for low pressure ducts, and 15 inches w.g. positive and 2 inches w.g. negative for medium-high pressure ducts.

D. Insulated Flexible Ducts. Flexible duct wrapped with flexible glass fiber insulation, enclosed by seamless aluminum pigmented plastic vapor barrier jacket; maximum 0.23 K value at 75°F {0.034 ksi at 24°C}.

E. Sealant. Nonhardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic, gasket.

F. Hanger Rod. Galvanized steel, threaded at both ends.

2.3 DUCTWORK (LESS 2 INCHES STATIC PRESSURE)

A. Fabricate and support in accordance with the latest edition of SMACNA HVAC Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gauges, reinforcing and sealing for minimum operating pressures indicated. Pressure between the terminal box and outlet shall be considered 2-inch static pressure.

B. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE Table of Equivalent Rectangular and Round Ducts. No variation of duct configuration or sizes permitted except by written permission. Pressure between terminal box and outlet shall be considered 2-inch static pressure.

C. Insulated Flexible Duct. Provide factory-fabricated flexible duct (UL 181, Class 1) for connections between low pressure trunk ducts and supply air diffusers. Furnish flexible duct with an airtight inner liner, insulation and outer jacket. Construct the inner liner of corrosion-resistant coated steel helix and fabric substantially bonded together to prevent the duct from collapsing or kinking in short radius bends. Provide fiberglass insulation at least 1 inch thick (C=0.23) and 3/4-pound minimum density around the inner liner. Sheath the entire assembly with heavy, fire-retardant outer vapor barrier jacket of reinforced aluminum foil kraft. Maximum length of flexible duct is 6 feet, and hold in place with strap or clamp. Use a supply duct rated at a minimum positive working pressure of 6 inches of water. Exhaust ducts must

withstand a negative pressure of 1 inch of water. Provide duct listed by UL at flame spread rate of not over 25 and smoke developed rate of not over 50, and complying with NFPA Standard 90A.

D. Construct tees, bends and elbows with radius of not less than 1-1/2 times the width of duct on centerline. Where not possible or where rectangular elbows are shown, provide double-wall, airfoil, galvanized sheet metal turning vanes. The turning vanes shall be fabricated in accordance with SMACNA HVAC Duct Construction Standards.

E. For round and oval duct, provide the elbows with a centerline radius of 1-1/2 times the duct diameter or duct width. For round ducts, furnish smooth elbows or 5-piece, 90-degree elbows and 3-piece, 45-degree elbows.

F. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.

G. At divided flow branches (split), provide volume damper at each branch duct. Also, where shown on the drawings. Also, at each return air and exhaust air branch duct.

2.4 DUCTWORK WITH 2 INCHES THROUGH 4 INCHES STATIC PRESSURE

A. Rectangular. Provide rectangular, medium-pressure ducts constructed of sheet metal in the following gauges:

Largest Dimension	U.S. Gauge
18″ and less	No. 24
19″ through 48″	No. 22
49″ through 72″	No. 20
73″ and over	No. 18

A. Fabricate and support in accordance with SMACNA HVAC Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gauges, reinforcing and sealing for operating pressures indicated. Upstream of terminal boxes shall be ranges from 2 to 6 inches static pressure.

B. Round. Furnish round duct construction, gauges and reinforcing in accordance with Tables 3-2A and 3-3, HVAC Duct Construction Standards. Use spiral-wound ducts up to 84 inches in diameter, equal to those of United McGill Company. Also provide fittings equal to those of United McGill Company.

Major Axis Dimension	U.S. Gauge
7 to 36 inches	No. 20
37 to 60 inches	No. 18
61 to 144 inches	No. 16

C. Insulated Flexible Supply Duct. Provide factory-fabricated flexible ducts (UL 181, Class 1) for connection between medium-pressure ducts and air terminal boxes consisting of an inner liner, insulation and outer jacket. Construct the inner liner of corrosion-resistant coated steel helix and neoprene-impregnated fiberglass fabric substantially bonded together to prevent the duct from collapsing or kinking in short radius bends. Provide fiberglass insulation of 1-inch

minimum thickness and 3/4-pound minimum density (C=0.23) around inner liner. Sheath the entire assembly in a heavy, fire-retardant, outer vapor barrier jacket consisting of 3-ply laminate of kraft paper, fiberglass reinforcement and aluminum foil, or closely woven fiberglass cloth impregnated with rubber or vinyl. Maximum length of flexible duct is 1 foot. Do not use flexible duct to change direction. Provide duct listed by UL at flame spread of not more than 25 and smoke developed rate of not more than 50, and complying with NFPA Standard 90A, paragraph 2-1.3.1.

D. Construct tees, bends and elbows with radius of not less than 1-1/2 times the width of duct on centerline. Where not possible or where rectangular elbows are shown, provide double-wall, airfoil, galvanized sheet metal turning vanes. The turning vanes shall be fabricated in accordance with SMACNA HVAC duct construction standards. Where acoustical lining is required, provide turning vanes of perforated metal with glass fiber insulation. Weld in place.

E. Transform duct sizes gradually, not exceeding 15 degrees divergence and 30 degrees convergence.

F. Fabricate continuously-welded round and oval duct fittings 2 gauges heavier than duct gauges indicated in SMACNA standard. Joints shall be minimum 4-inch cemented slip joint, brazed or electric welded. Prime coat welded joints.

G. Provide standard 45-degree lateral wye takeoffs, unless otherwise indicated, where 90-degree conical tee connections may be used.

2.5 SEAL OF SEAMS AND JOINTS

A. The entire duct systems shall be sealed in accordance with Table 1-2, Standard Duct Sealing Requirements, in the latest edition of SMACNA HVAC Duct Construction Standards.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Contractor shall make every effort to keep all duct, equipment and air handling devices clean and free of dust and debris on the inside air path of equipment and duct. Cover all openings with plastic until final connections are made and sealant is applied to connections. Cover the open ends of installed duct with plastic.
   1. Any duct or equipment not covered and found to be contributing to excessive dust and debris such that ceilings and or walls are discolored to the casual glance within the first 3 months of operation, the contractor shall be responsible for hiring a duct cleaning contractor who is a member of National Air Duct Cleaners Association (NADCA) to clean the newly installed duct and equipment to insure a healthy and clean work environment for the end user.

B. Construction Standards. Use construction methods which follow the requirements outlined in Article 1.5, as well as SMACNA Balancing and Adjusting publications, unless indicated otherwise in these specifications or accompanying drawings.

C. Reinforcement. Reinforce ducts having one side equal to 25 inches or more in accordance with recommended construction practice of SMACNA.

D. Plenum Construction. Construct plenum chambers of not less than No. 20 U.S. gauge metal reinforced with galvanized structural angles.

E. Cross Breaking or Beading. Cross break or bead sheet metal for rigidity, except ducts which are 12 inches or less in the longest dimension.

F. Wall Penetrations. Where ducts pass through walls in exposed areas, install suitable escutcheons made of sheet metal angles as closers. At all locations where ductwork passes through floors, provide watertight sleeves projecting 3 inches above finished floor and flush with bottom of floor slab. Fabricate sleeves of 1/8-inch-thick steel, galvanized after fabrication. Anchor into adjacent floor slab as required. Provide sleeves inside as well as outside chases. Support ducts where passing through floors with steel structural angles of adequate bearing surface, galvanized after fabrication and resting on top of the sleeve.

G. Interior Painting. Interior painting of metal ductwork exposed to view through grilles, registers, and other openings is specified in Section 09910. Do not install grilles, registers, or similar items until painting is complete.

H. Ductwork Openings. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

I. Ductwork Location. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

3.2 DUCTWORK (LESS THAN 2 INCHES STATIC PRESSURE)

A. Construction. Construct rectangular ducts in accordance with the SMACNA HVAC Duct Construction Standards Manual. Construct round ducts in accordance with the SMACNA HVAC Duct Construction Standards Manual.

B. Controls. For control devices concealed by ceilings, furring, or in other inaccessible locations, furnish extension rods and appropriate recessed-type Young regulators, mounted on the surface of the ceiling or the furring, unless specified, or shown otherwise. For ducts which are not concealed, or ducts which are above lay-in ceiling but accessible, provide heavy-duty, quadrant-type, adjustable regulators having wing nuts for locking in position. Saw-mark the ends of all operating rods for dampers and air control devices to indicate damper position.

C. Obstruction. Install streamline deflectors at any point where dividing a sheet metal duct around piping or where other such obstruction is permitted. Where such obstructions occur in insulated ducts, fill space inside streamliner and around obstructions with glass fiber insulation.

D. Insulated Flexible Duct. Do not exceed 6 feet in length with any flexible duct. Make end connections with 3M 900 mastic and _____. Support duct independently of lights, ceiling and piping.

E. Duct Supports.

1. Horizontal Ducts Up to 40 Inch. Support horizontal ducts up to and including 40 inches in their greater dimension by means of No. 18 U.S. gauge band iron hangers attached to the ducts by means of screws, rivets or clamps, and fastened to inserts with toggle bolts, beam clamps or other approved means at the bottom of ducts per SMACNA. Place supports on at least 8′-0″ centers. Use clamps to fasten hangers to reinforcing on sealed ducts.
2. Horizontal Ducts Larger Than 40 Inch. Support horizontal ducts larger than 40 inches in their greatest dimension by means of hanger rods bolted to angle iron trapeze hangers. Use double nuts and lock washers on threaded rod supports. Place supports on at least 8′-0″ centers according to the following:

Angle Length	Angle	Rod Diameter
4′-0″	1-1/2″ x 1-1/2″ x 1/8″	1/4″
6′-0″	1-1/2″ x 1-1/2″ x 1/8″	1/4″
8′-0″	2″ x 2″ x 1/8″	5/16″
10′-0″	3″ x 3″ x 1/8″	3/8″

3. Vertical Ducts. Support vertical ducts where they pass through the floor lines with 1-1/2″ x 1-1/2″ x 1/4″ angles for ducts up to 60 inches. Above 60 inches, the angles must be increased in strength and sized on an individual basis considering space requirements.

F. Test. After ducts are sealed (prior to insulation installation), ducts shall be tested at 3 inches static pressure.

3.3 DUCTWORK (2 INCHES THROUGH 4 INCHES STATIC PRESSURE)

A. Rectangular. Construct rectangular ducts as noted in Article 1.5. Provide reinforcing method without tie rods through 60-inch size. For rods 61 inches and over, use tie rods to keep reinforcing angles to 2-inch minimum. Use sealant (3M EC-800) or equal and 4-inch-wide Glasfab or continuous welds at all of the longitudinal seams, and flanged (caulk or gasket) transverse joints on rectangular ducts in shop and field fabrication to provide positive seal.

B. Round. Provide round duct construction as noted in Article 1.5. Seal joints secured with sheet-metal screws and covered with sealant, United Duct Sealer water based. Apply additional sealant until the cloth is completely embedded, or welded. Make 90-degree branch take-offs with conical tees. Weld take-off fittings to fittings or to the main duct. Clean and coat all welds with rust-inhibiting paint. Stamp elbows as smooth-type, or 5- or 3-piece segmented or segmented standing seam type, with either type having a centerline radius of 1-1/2 times the duct diameter.

C. Insulated Flexible Duct. Seal flexible duct connections with 3M 900 mastic and stainless steel clamp. Support duct independently of lights, ceiling and piping.

D. Duct Supports. Provide hangers and supports in accordance with Article 1.5.

E. Testing of Ductwork. (Includes from fan discharge up to the inlet of terminal units. Terminal units not to be included.)

1. All ducts shall be pressure tested (prior to installation of insulation) according to SMACNA Chapter 10 test procedures. Design pressure for testing ductwork shall be 6 inches of water. Total allowable leakage shall not exceed 1 percent of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all Sections shall not exceed the total allowable leakage.
2. The entire system of medium pressure ductwork shall be tested, excluding the VAV/constant volume terminal units. After testing has proven that the ductwork is installed and performs as specified, the terminal units shall be connected to the ductwork and the connections sealed with extra care. The Contractor shall inform the project inspector when the joints may be visually inspected for voids, splits or improper sealing of the joints. If any leakage occurs in the terminal unit connections/joints after the systems have been put into service, the leaks shall be repaired by: 1) complete removal of the sealing materials, 2) thorough cleaning of the joint surfaces, and 3) installation of multiple layers of sealing materials.
3. The Contractor shall be allowed to eliminate the terminal units from testing by capping the supply ductwork prior to the terminal units, then inspecting the connection to the terminal units when complete.

END OF SECTION 233113

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SECTION 233300

DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Volume control dampers.

B. Fire dampers.

C. Combination fire and smoke dampers.

D. Backdraft dampers.

E. Flexible duct connection.

F. Duct access doors.

G. Duct test holes.

1.2 SUBMITTALS

A. Shop Drawings. Provide shop drawings for shop-fabricated assemblies indicated, including volume control dampers, duct access doors and duct test holes.

B. Product Data. Provide product data for hardware used.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Fire Dampers. Ruskin, National Controlled Air, or Greenheck.

B. Combination Fire and Smoke Dampers. Ruskin, National Controlled Air, or Greenheck.

C. Backdraft Dampers. Ruskin or American Warming & Ventilating.

D. Flexible Duct Connections. Thermaflex, Flexmaster, or Clevaflex.

E. Duct Access Doors. Ruskin, Flexmaster, or United McGill.

2.2 VOLUME CONTROL DAMPERS

A. Furnish and install dampers where shown on the Drawings and wherever necessary for complete control of the air flow, including all supply, return and exhaust branches, “division” in main supply including after duct is split, return and exhaust ducts, each individual air supply outlet and fresh air ducts. Where access to dampers through a fixed suspended ceiling is necessary, the Contractor shall be responsible for the proper location of the access doors.

B. Splitter dampers shall be fabricated of steel not lighter than 16 gauge. The leading edge of the damper shall be hemmed. Each splitter shall be a minimum of 12 inches long or 1-1/2 times the width of the smaller of the two branches it controls, whichever is greater. Dampers shall be carefully fitted, and shall be controlled by locking quadrants equal to Ventlok No. 555 on exposed uninsulated ductwork, No. 644 on exposed externally insulated ductwork and No. 677 (2-5/8 inch diameter) chromium-plated cover plate for concealed ductwork not above lay-in accessible ceilings. Furnish and install end bearings for the damper rods on the end opposite the quadrant when No. 555 or No. 644 regulators are used, and on both ends when No. 677 regulators are used.

C. On concealed ductwork above lay-in accessible ceilings use Ventlok No. 555 or No. 644 locking quadrant for splitter dampers.

D. Dampers larger than 3 square feet in area shall be controlled by means of rods hinged near the leading edge of the damper with provisions for firmly anchoring the rod and with end bearings supporting the axle.

E. Volume dampers shall be equal to those of American Foundry. Blades shall not exceed 48 inches in length or 12 inches in width and shall be of the opposed interlocking type. The blades shall be of not less than No. 16 gauge galvanized steel supported on 1/2-inch diameter rust-proofed axles. Axle bearings shall be the self-lubricating ferrule type.

F. Install all dampers furnished by the temperature control manufacturer in strict accordance with the manufacturer’s recommendations and requirements of these Specifications.

G. All adjustable dampers installed in externally insulated ductwork shall be installed with Ventlok No. 639, or accepted substitution, elevated dial operators. Insulation shall extend under the elevated dial. All adjustable dampers installed in internally insulated ductwork shall be installed with Ventlok No. 635, or accepted substitution, dial operators. All damper shaft penetrations in the ductwork shall be installed with Ventlok No. 609 end bearings.

H. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.

I. Provide locking, indicating quadrant regulators on single- and multi-blade dampers. Where rod lengths exceed 30 inches, provide regulator at both ends.

2.3 FIRE DAMPERS

A. Provide, where shown on the drawings or required by the Specifications, fire dampers meeting the following requirements:

1. Each fire damper shall be constructed and tested in accordance with Underwriters Laboratories Safety Standard 555, 4th Edition. All dampers shall possess a 1-1/2 hour or 3-hour (as appropriate for the construction shown in the architectural drawings) protection rating, 160°F or 165°F fusible link (UL 33), and shall bear a UL label in accordance with Underwriters' Laboratories labeling procedures. Fire dampers shall be constructed such that the damper frame material and the curtain material shall be 20-gauge galvanized steel.
2. Fire dampers shall be curtain blade type and the damper shall be so constructed that the blades are out of the air stream to provide an approximately 95 percent free area of the duct in which the damper is housed.
3. Fire dampers shall be equipped for vertical or horizontal installation as required by the locations shown in the drawings. Fire dampers shall be installed in wall and floor openings utilizing steel sleeves, angles and other material and practices required to provide an installation equivalent to that utilized by the manufacturer when the respective dampers were tested by Underwriters Laboratories. (Note: Prefco Model 5500 E6-M fire dampers do not require sleeves.) Mounting angles shall be a minimum of 1-1/2 inches by 1-1/2 inches by 14 gauge and bolted, tack welded or screwed to the sleeve at maximum spacings of 12 inches and with a minimum of two connections at all sides. Mounting angles shall overlap at least equal to the gauge of the duct defined by the appropriate SMACNA Duct Construction Standard, latest edition, and as described in NFPA 90A. The entire assembly, following installation, shall be capable of withstanding 6-inch water gauge static pressure.
4. The damper installation shall be in accordance with the damper manufacturer's instructions.
5. All fire dampers shall be dynamic rated type and comply with the specification as written above.
6. The Contractor shall completely caulk the damper into the sleeve if recommended by the damper manufacturer using manufacturer recommended material(s).

2.4 COMBINATION FIRE/SMOKE DAMPERS

A. Provide, where shown on the Drawings or as required by the Specifications, combination fire/smoke dampers meeting the following requirements.

1. Each combination fire/smoke damper shall be dynamic rated type and 1-1/2 hour fire rated under UL Standard 555 and 555S (NFPA 90A), and shall be further classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. The 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 no higher than Leakage Class I (4 cfm per square foot at one inch water gauge pressure and 8 cfm per square foot at 4 inches water gauge pressure). The maximum air pressure drop through each combination fire/smoke damper shall not exceed 0.10 inch water gauge at the design air quantity. (Note that this may require a larger damper than the connected duct size.) All ratings shall be dynamic.

2. The damper frame shall be a minimum of 20-gauge galvanized steel formed into a structural hat channel shape with tabbed corners for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be integral high surface area non-electrolytic materials construction to incorporate a friction-free frame blade lap seal, or molybdenum disulfide impregnated stainless steel or bronze oilite sleeve type turning in an extruded hole in the frame or an extruded frame raceway. The dampers shall be opposed blade type. The blades shall be constructed with a minimum of 14-gauge equivalent thickness and shall be of an airfoil shape design. The blade edge seal material shall be able to withstand 450°F. The jamb seals shall be flexible stainless steel compression type or lap seal type.
3. In addition to the leakage ratings specified herein, the combination fire/smoke dampers and their operators shall be qualified under UL555S to an elevated temperature of 250°F. Electric or pneumatic operators shall be installed by the damper manufacturer at the time of damper fabrication. The damper and operator shall be supplied as a single entity which meets all applicable UL555 and UL555S qualifications for both dampers and operators. The manufacturer shall provide a factory-assembled sleeve. The sleeve shall be a minimum of either 20 gauge for dampers where neither width nor height exceeds 48 inches or 16 gauge where either dimension equals or exceeds 48 inches.
4. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures of at least 4 inches water gauge in the closed position, and 2000 fpm air velocity in the open position.
5. Each combination fire/smoke damper, except as noted hereinafter, shall be equipped with a UL classified firestat/releasing device. The firestat/releasing device shall electrically (24 VAC) and mechanically (or pneumatically) lock the damper in a closed position when the duct temperatures exceed 165°F and still allow the appropriate authority to operate the damper as may be required for smoke control functions. The damper must be operable while the temperature is above 250°F. The actuator/operator package shall include two damper position indicator switches linked directly to damper blade to provide capability of remotely indicating damper position. One switch shall close when the damper is fully open, and the other switch shall close when the damper is fully closed. The firestat/releasing device and position indicator switches shall be capable of interfacing electrically with the smoke detectors, building fire alarm systems, and remote indicating/control stations as part of the smoke management system only.
6. The damper releasing device shall be mounted within the airstream. The device shall be activated and the damper shall close and lock when subjected to duct temperatures in excess of approximately 285°F.
7. Motors for operation of smoke dampers shall be smoke system fail safe, spring return normally open supplies and normally closed returns, or as indicated in the plans, and shall be furnished and installed by the damper manufacturer as required by the UL rating mentioned above. Motors shall be electric or pneumatic to match the type of temperature control system specified elsewhere in this specification. All required relays, EP switches, wiring piping and other labor and material necessary to completely interconnect the smoke detector system shall be furnished by the Contractor.
8. Each damper shall be furnished in a square or rectangular configuration. The Contractor shall furnish and install sleeves manufactured by the approved damper manufacturer for each damper. The sleeves shall be constructed with square or rectangular to square, rectangular, round, or oval adapters as required. Dampers shall be installed in the sleeves in accordance with manufacturer's UL installation instructions. The entire assembly,

following installation, shall operate smoothly and be capable of withstanding 6 inches W.G. static pressure.

9. All combination fire/smoke dampers shall be dynamic type and comply with the specification as written above and shall be Ruskin Model FSD-60, Greenheck Model FSD-33, NCA Series FSD-AF or Air Balance, Inc. Model FA-1.
10. The Contractor shall completely caulk the damper into the sleeve as recommended by the damper manufacturer using manufacturer recommended material(s).

2.5 BACKDRAFT DAMPERS

A. Gravity backdraft dampers, size 18 by 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturer's standard construction.

2.6 BACKDRAFT DAMPERS

A. Fabricate multi-blade, parallel-action gravity balanced backdraft dampers of 16-gauge galvanized steel or extruded aluminum, with center pivoted blades of maximum 6-inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90-degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure; Model BD2/A2 manufactured by Ruskin.

2.7 FLEXIBLE DUCT CONNECTIONS

A. Furnish and install where ducts connect to fans, including roof exhausters.

B. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards and as indicated.

C. UL listed fire-retardant neoprene-coated woven glass fiber fabric to NFPA 90A, minimum density 20 ounces per square yard, approximately 3 inches wide, crimped into metal edging strip.

D. Leaded vinyl sheet, minimum 0.55 inch thick, 0.87 pounds per square foot, 10 dB attenuation in 10 to 10,000 hertz range.

2.8 DUCT ACCESS DOORS

A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards and as indicated.

B. Review locations prior to fabrication.

C. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick-fastening locking devices. For insulated ductwork, install minimum 1-inch-thick insulation with sheet metal cover.

D. Access doors smaller than 12 inches square may be secured with sash locks.

E. Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 by 48 inches. Provide an additional hinge for larger sizes.

F. Access doors with sheet metal screw fasteners are not acceptable.

G. Provide access door for access to all fire dampers, mixed air plenums, upstream of coils, automatic dampers, etc.

2.9 DUCT TEST HOLES

A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

B. Permanent test holes shall be factory fabricated, airtight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.10 SCREENS

A. Furnish and install screens on all duct, fan, etc., openings furnished by this Section which lead to, or are, outdoors. Screens shall be No. 16 gauge, 1/2-inch mesh in removable galvanized steel frame. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

2.11 CONICAL BELLMOUTH FITTINGS AND TAPS

A. The conical bellmouth fitting shall be made from 26-gauge G-90 galvanized sheet metal. The construction shall be a fabricated two-piece fitting with a minimum overall length of 6 inches and shall be factory sealed for high pressure requirements. Average of loss coefficient for sizes 6, 8 and 10 shall be less than 0.055.

B. Each to be provided with minimum 24-gauge damper plate with locking quadrant operator and sealed end bearings. Damper blade shall be securely attached to shaft to prevent damper from rotating around shaft. Shaft shall be extended to clear insulation.

C. Provide a flange and gasket with adhesive peel-back paper for ease of application. The fitting shall be further secured by sheet metal screws spaced evenly at no more than 4 inches o.c. with a minimum of four screws per fitting.

D. The conical bellmouth fitting shall be Series 3000G as manufactured by Flexmaster U.S.A., Inc.; Buckley Air Products, Inc., “AIR-TITE”; or approved substitution.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install accessories in accordance with manufacturer’s instructions.

B. Provide fire dampers, combination fire and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion-resistant springs, bearings, bushings and hinges.

C. Demonstrate resetting of fire dampers to authorities having jurisdiction and Owner's representative.

D. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.

E. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Cover connections to medium and high pressure fans with leaded vinyl sheet, held in place with metal straps.

F. Provide duct access doors for inspection and cleaning before and after filters, coils, fans and automatic dampers; at fire dampers; and elsewhere as indicated. Provide minimum 8-by-8-inch size for hand access, 18-by-18-inch size for shoulder access, and as indicated. For fire dampers, service openings shall be identified with letters no less than 2 inches in height to indicate the location of the fire protection device(s) within.

G. Provide duct test holes where indicated and required for testing and balancing purposes.

H. All fire dampers installed shall be tested per NFPA, Chapter 5 in its entirety.

I. Access doors as specified elsewhere shall be provided to make all parts of the fire and combination fire and smoke damper accessible. Doors shall open not less than 90 degrees following installation and shall be insulated type where installed in insulated ducts.

J. Contractor shall install each fire and combination fire and smoke damper square and true to the building. The installation shall not place pressure on the damper frame, but shall enclose the damper as required by UL555.

K. After each fire damper and combination fire and smoke damper has been installed and sealed in their prescribed openings and prior to the installation of the ceilings, the Contractor shall, as directed by the Construction Inspector, activate part or all the dampers as required to verify "first-time" closure. Activation of the damper shall be accomplished by manually operating the resettable link, disconnecting the linkage at the fusible link of the fire damper, and manually operating the fire/smoke damper through the pneumatic or electronic controls as appropriate. Failure of the damper to close properly and smoothly on the first attempt will be cause to replace the entire damper assembly. Coordinate interlock requirements with the fire alarm system on the smoke damper system.

END OF SECTION 233300

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SECTION 233400

FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide fans, including centrifugal, axial and propeller types, with all supplemental equipment.

1.2 PERFORMANCE

A. Provide fan type, arrangement, rotation, capacity, size, motor horsepower, and motor voltage as shown. Fan capacities and characteristics are scheduled on the drawings.

B. Rate fans according to appropriate Air Moving and Conditioning Association, Inc. (AMCA), approved test codes and procedures. Supply fans with sound ratings below the maximums permitted by AMCA standards. All fans provided must be licensed to bear the Certified Ratings Seal.

C. Statically and dynamically balance all fans.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Greenheck,

B. Loren-Cook,

C. Or approved equivalent.

2.2 PROTECTIVE COATINGS

A. Manufacturer's Standard. Apply to all fans, motors and accessories, the manufacturer's standard prime coat and finish, except on aluminum surfaces or where special coatings are required.

B. Galvanizing. After fabrication of the parts, hot-dip coat all surfaces which require galvanizing. Where galvanizing is specified, a zinc coating may be used. After fabrication, apply the zinc coating and air-dry the coating to 95 percent pure zinc. Acceptable zinc coatings include Zincilate, Sealube, Amercoat, Diametcoat, or an approved substitution.

2.3 SUPPLEMENTAL EQUIPMENT

A. Motor Covers. Provide weatherproof motor covers for installations out of doors. Apply the same finish as used on the fan.

B. Belt Drives.
1. Unless otherwise specified for belt-driven fans, equip the fan motors with variable pitch sheaves. Select the sheave size for the approximate midpoint of adjustment and to provide not less than 20 percent speed variation from full open to full closed. Size drives for 150 percent of rated horsepower. Key the fan sheave to the fan shaft.
2. Nonadjustable motor sheaves may be used for motor sizes over 15 horsepower, at the Contractor's option. However, if changing a nonadjustable sheave becomes necessary to produce the specified capacity, the change must be made at no additional cost.
3. Provide belt guards and apply the same finish as used for the fan.

C. Safety Disconnect Switch. Provide a factory-wired, safety disconnect switch on each unit equipped with a 115/1/60 motor.

D. Relief Vents and Air Inlets. Provide vents and inlets with aluminum frames and 1/2-inch mesh, galvanized bird screens. Include dampers where shown.

E. Prefabricated Roof Curbs. Furnish prefabricated roof curbs with built-in cant strips and lined with glass fiber insulation. Curbs may be made of No. 18 U.S. standard gauge galvanized steel or 0.063-inch aluminum. The minimum height is 8 inches. Include on each roof curb a resilient pad for equipment mounting on the top flange.

F. Sound Attenuating Bases. Construct sound attenuating bases of No. 18 U.S. standard gauge galvanized steel or 0.063-inch aluminum. Include a built-in cant strip for curb mounting and a resilient pad for equipment mounting on the top flange. Line the base with 2 inches of glass fiber insulation and fit internally with glass fiber acoustical baffles.

2.5 IN-LINE CENTRIFUGAL FANS

A. Provide in-line fans with backward inclined wheels. Select a fan model with 1-piece inlet cone, heavy gauge welded steel casings, steel shaft, internal and external belt guards, and adjustable motor mounts. Air will flow axially. Enclose fan bearings and drive shaft to isolate them from the air stream. Provide lubrication tubes extending from the shaft bearings to the housing or otherwise make the bearings accessible for lubrication.

2.6 WALL-MOUNTED SUPPLY OR EXHAUST FAN (DIRECT DRIVEN)

A. Furnish direct-driven, propeller-type fans designed for mounting in the wall. Mount the fan wheel and motor on a square, flanged panel made of steel and formed with a venturi orifice. Finish the panel in baked enamel. Provide fans with a drive-side, galvanized wire guard and a standard-duty, automatic shutter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans according to the manufacturer’s written instructions and in the locations shown on the drawings.

END OF SECTION 233400

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SECTION 233700

AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 SUMMARY

A. Diffusers.

B. Diffuser boots.

C. Registers/grilles.

D. Interior wall louvers.

E. Roof hoods.

F. Goosenecks.

1.2 REFERENCES

A. AHRI 885 – Procedure for estimating occupied space sound levels.

B. SMACNA – HVAC Duct Construction Standard – Metal and Flexible.

1.3 QUALITY ASSURANCE

A. Test and rate performance of air outlets and inlets in accordance with AHRI 885 and ASHRAE 70.

B. Test and rate performance of louvers in accordance with AMCA 500-L.

1.4 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A.

1.5 SUBMITTALS

A. Submit product data for items required for this project.

B. Submit schedule of outlets and inlets indicating type, size, location, application and noise level.

C. Review requirements of outlets and inlets as to size, finish and type of mounting prior to submitting product data and schedules of outlets and inlets.

1.6 COOPERATION WITH OTHER TRADES

A. Coordinate this work with work under Division 16 - Electrical to ensure that intended functions of lighting and air system are achieved.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Ceiling Supply Diffusers
1. Titus.
2. Metal-aire.
3. Anemostat.
4. Price Industries.

B. Wall Registers/Grilles
1. Titus.
2. Metal-aire.
3. Anemostat.
4. Price Industries.

C. Ceiling Return Diffusers
1. Titus.
2. Metal-aire.
3. Anemostat.
4. Price Industries.

D. Interior Wall Louvers Returns (In Gym)
1. Titus.
2. Metal-aire.
3. Anemostat.
4. Price Industries.

2.2 PERFORATED FACE CEILING SUPPLY DIFFUSERS (Titus Model PAS)

A. Perforated face with fully adjustable pattern and removable face.

B. Provide surface mount type frame to be used with lay in type diffuser. In plaster ceilings, provide plaster frame and ceiling frame.

C. Fabricate of steel with steel or aluminum frame and baked enamel, off-white finish.

D. Provide radial opposed blade damper with damper adjustable from diffuser face only in a hard deck ceiling locations. Lay in ceiling diffusers will only require a volume damper at the supply duct tap location for the diffuser.

2.3 WALL SUPPLY REGISTERS/GRILLES (Titus Model 272RS)

A. Steel aeroblade double deflection supply grille, ¾" blade spacing, front blades parallel to the short dimension.

B. Fabricate 1 1/4-inch margin frame with countersunk external screw mounting and gasket.

C. Fabricate of roll formed steel with factory standard finish.

D. Provide integral screw adjustable opposed blade dampers operable from face.

2.4 CEILING EXHAUST AND RETURN DIFFUSER (Titus Model PAR)

A. Perforated face with removable face for ducted diffusers.

B. Provide surface mount type frame to be used with lay in type diffuser. In plaster ceilings, provide plaster frame and ceiling frame.

C. Fabricate of steel with steel frame and baked enamel, white finish.

D. Provide radial opposed blade damper with damper adjustable from diffuser face only in a hard deck ceiling locations. Lay in ceiling diffusers will only require a volume damper at the return duct tap location for the diffuser.

2.5 INTERIOR WALL RETURN GRILLES (Titus Model 350 FL)

A. Streamlined blades with 35 degree, fixed blade deflection, 3/4 inch blade on spacing.

B. Fabricate of rolled steel with 20 gauge minimum frames with factory standard white finish.

PART 3 - EXECUTION

3.1 INSPECTION

A. Do not install ceilings tiles in ceiling grid adjacent to light fixtures until installation of light fixtures, air supply assemblies, return-air blank-off strips and flexible duct have been properly approved. Remove and reinstall any part of the installation found incorrect.

3.2 INSTALLATION

A. Install items in accordance with manufacturers' instructions.

B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry and lighting arrangement.

C. Install diffusers to ductwork with airtight connection.

D. Provide balancing dampers on duct takeoff to diffusers, and grilles and registers, regardless of whether opposed blade dampers are specified as part of the diffuser, or grille and register neck assembly.

E. Paint ductwork visible behind air outlets and inlets matte black.

F. Diffusers. Rectangular diffuser mount tight against the ceiling. Fasten outlets securely to ductwork with nylon strap. For perforated diffusers allow diffuser to be lifted out of frame assembly to allow access above ceiling. Select an outer frame compatible with the type of ceiling on which the diffuser is installed.

END OF SECTION 233700

SECTION 234100

FILTERS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide filters as required in other sections.

1.2 SUBMITTALS

A. Submit shop drawings and product data.

1.3 QUALITY ASSURANCE

A. Filter media shall be ANSI/UL 900 listed, Class 1 or Class 2, as approved by local authorities.

B. Provide all filters as product of one manufacturer.

C. Assemble filter components to form filter banks from products of one manufacturer.

1.4 EXTRA STOCK

A. Provide 2 set(s) of disposable panel filters.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Camfil Farr, Air Guard, or American Air Filter.

2.2 MEDIUM-EFFICIENCY ASHRAE PLEATED FILTERS

A. Media. Air filters shall be medium-efficiency, pleated, disposable type. Each filter shall consist of a cotton and synthetic media, media support grid, and enclosing frame. The filter shall be listed and identified on the frame as Underwriters Laboratories Class 2. Filter shall have not less than 4.6 square feet of media per square foot of filter face area and not less than 15 pleats per linear foot of filter face area. A 96 percent open area media support grid of welded wire construction, coated with rust inhibitor shall be bonded to the air exiting side of the filter. The enclosing frame shall be of high wet-strength beverage board with diagonal support members bonded to the air entering and air exiting side of each pleat. The inside periphery of the enclosing frame shall be bonded to the filter pack.

B. Rating. Filters shall have an average efficiency of 25 to 30 percent, and an average arrestance of not less than 90 percent in accordance with ASHRAE Standard 52.1-1992. The minimum

MERV when tested under ASHRAE 52.2 shall be no less than MERV 8. Initial resistance at 500 feet per minute approach velocity shall not exceed 0.25 inch w.g.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air cleaning devices in accordance with manufacturer's written instructions.

B. Prevent passage of unfiltered air around filters with felt, rubber or neoprene gaskets.

C. Filter supports and retention elements shall be coordinated to provide a substantial, structurally sound, leak-proof installation.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction.

E. Install filter gauge static pressure tips upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and level.

END OF SECTION 234100

SECTION 238143

AIR CONDITIONER - HEAT PUMP SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide heat pump (HP) and heat recovery unit (HRU) air conditioner systems including indoor ceiling mounted fan coil split-systems, controls, above ceiling Heat Redirect Unit Boxes (HRU-B) on the drawings, as well as outdoor units, operable with refrigerant R410A with smell additive.

B. This section also includes 4 way ceiling mounted fan coil cassettes and 1 way ceiling mounted fan coil unit cassettes.

Ceiling mounted units are supported from the structure above and shall not use the ceiling for any type of support for the unit.

1.2 REFERENCES

A. AHRI 210/240-94 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.

B. AHRI 340/360-00 - Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.

C. AHRI 1230-2010 with Addednum 2 June 2014– Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment.

D. AHRI 350-00 - Sound Rating of Non-ducted Indoor Air-Conditioning Equipment.

E. AHRI 310/380-93 - Packaged Terminal Air-Conditioners and Heat Pumps.

F. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

1.3 PERFORMANCE

A. Performance criteria are scheduled on drawings. Must meet current ASHRAE 90.1 minimum requirements.

1.4 SUBMITTALS

A. Submit product data and installation instructions.

1.5 EXTENDED WARRANTY

A. Provide 5-year manufacturer’s written warranty for compressor.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. LG is the design reference brand the project was designed around. Other brands that make a similar product, but are not necessarily equal are Daikin and Samsung.

2.2 SPLIT-SYSTEM HEAT PUMP and HEAT RECOVERY UNIT OUTDOOR UNITS

A. Heat Pump (HP) system is a variable refrigerant flow (VRF) system that can operate in either cooling or heating mode, whereas a Heat Recovery Unit (HRU) system is a VRF system that can operate with its indoor units in heating or cooling simultaneously. The HP can only operate all indoor units in heating or all indoor units in cooling at the same time. HP and HRU are both outdoor units of the split system heating and cooling system, operable with refrigerant R410A with smell additive.

B. Unit casing shall be constructed of galvanized steel and painted with a weather-resistant baked enamel finish.

C. The outdoor heat pump unit shall have a single refrigerant circuit with a filter dryer.

D. The compressor shall be hermetic with a crankcase heater. The compressors shall be equipped with over-temperature and over-current controls and high and low pressure protection.

E. Provide horizontal or vertical discharge, statically and dynamically balanced, direct-drive condenser fans. The motor shall have permanently lubricated bearings with built-in current and thermal overload protection.

F. The outdoor coil shall be constructed of aluminum plate fins mechanically bonded to copper tubes.

G. Provide 24-volt control circuit including control power transformer. The unit shall be wired complete with magnetic contactors for the compressor overload protection, internal pressure relief and low pressure cutouts.

H. Provide an outdoor coil defrost control system to prevent frost accumulation during heating cycle down to 15 F degrees.

2.3 SPLIT-SYSTEM FAN COIL INDOOR UNITS – 4 WAY CEILING CASSETTES

A. Provide ceiling cassette type fan coil unit for overhead installation in lay in ceiling. None ducted type fan coil units.

B. Provide units complete with coils, motors and drives.

C. Furnish insulated cabinets which are corrosion-resistant.

D. Unit shall have four modulating supply dampers at the edges of the unit in the same plane as the return filter located in the center of the unit.

E. Provide motors of the permanent, split capacitor type wired for multiple speeds.

F. Control the motors with easily accessible, multispeed switches located within the fan coil unit housing.

G. Provide built-in thermal overload protection.

H. Provide heavy-duty, rust-inhibited drain pans extending under coils, valves and pipe connection assembly within units that might sweat. Unit to have built in Condensate pumps.

2.4 SPLIT-SYSTEM FAN COIL ONE WAY – CEILING CASSETTES

A. Provide ceiling cassette type fan coil unit for overhead installation in lay in ceiling. None ducted type fan coil units.

B. Provide units complete with coils, motors and drives.

C. Furnish insulated cabinets which are corrosion-resistant.

D. Unit shall have a single modulating supply damper at the edge of the unit in the same plane as the return filter located in the center of the unit.

E. Provide motors of the permanent, split capacitor type wired for multiple speeds.

F. Control the motors with easily accessible, multispeed switches located within the fan coil unit housing.

G. Provide built-in thermal overload protection.

H. Provide heavy-duty, rust-inhibited drain pans extending under coils, valves and pipe connection assembly within units that might sweat. Unit to have built in Condensate pumps.

2.5 INDOOR THERMOSTAT

A. Provide simple controller with mode selection equivalent to LG Model PQRCVCL0QW (the white one) as indicated on drawings. To be installed approximately where indicated on drawings with ADA constraints in mind, mount at 48” AFF.

B. At a minimum the thermostat shall be capable of:
1. Operation display.
2. Room Temperature Setting.
3. Fan speed selection.
4. Air Flow Direction
5. On/Off Button
6. Operation Mode selection Button.
7. Child lock.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General. Install equipment and components in a manner to ensure proper and sequential operation of the equipment and equipment controls. Installation of equipment not covered herein or in manufacturers' instructions shall be installed as recommended by manufacturers' representatives. Provide proper foundations for mounting equipment, accessories, appurtenances, piping and controls including, but not limited to, supports, vibration isolators, stands, guides, anchors, clamps and brackets. Foundations for equipment shall conform to equipment manufacturer's recommendation, unless otherwise indicated on drawings. Set anchor bolts and sleeves accurately using properly constructed templates. Anchor bolts shall be of adequate length and provided with welded-on plates on the head end embedded in the concrete. Level equipment bases, using jacks or steel wedges, and neatly grout-in with a nonshrinking type of grouting mortar. Locate equipment to allow working space for all necessary servicing such as replacing compressor, replacing or adjusting drives, motors or shaft seals, tube cleaning or replacement, access to automatic controls, refrigerant charging, lubrication, oil draining and working clearance under overhead lines. Provide electric isolation between dissimilar metals for the purpose of minimizing galvanic corrosion.

3.2 FIELD TEST

A. General. Equipment and materials certified as having been successfully tested by the manufacturer in accordance with referenced specifications and standards will not require retesting before installation. Equipment and materials not tested at the place of manufacture shall be tested before or after installation, as applicable, where necessary to determine compliance with referenced specifications and standards.

B. Leak Testing. Upon completion of installation of the air conditioning equipment, test all factory- and field-installed refrigerant piping with an electronic type leak detector to acquire a leak-tight refrigerant system. The type of refrigerant to be used in the system shall be used for leak testing. If nitrogen is used to boost the system pressure for testing, ensure that it is completely eliminated from the system before charging. The minimum refrigerant leak field test pressure shall be as specified in ASHRAE 15, except that the test pressure shall not exceed 150 psig on hermetic compressors unless otherwise specified as a low side test pressure on the equipment nameplate. If leaks are detected at time of installation or during the guarantee period, remove the entire refrigerant charge from the system, correct the leaks, and retest the system. Take precautions to preserve the cleanliness of the system and to prevent scale and acid formation during repair of leaks.

C. Evacuation and Charging. After field-charged refrigerant system is found to be without leaks, or after leaks have been found and repaired on either field-charged or factory-charged systems, evacuate the system in accordance with the equipment manufacturer's printed instructions. The hermetic compressor in the system being installed shall not be used to evacuate the system. Evacuation shall be done from both sides of the system simultaneously and with the largest diameter connecting tubing that is possible or practical. Charge the system in accordance with the equipment manufacturer's printed recommendations. Ensure proper procedures are observed for purging all charging lines of air before admitting refrigerant to the system.

D. Startup and Initial Operation Tests. Follow the manufacturer's startup and initial operation procedures and place the system under all modes of operation to ensure that it is functioning correctly. Adjust safety and automatic control instruments as necessary to ensure proper operation and sequence. Record manufacturer's recommended readings hourly. Initial operation period shall be not less than 8 hours.

END OF SECTION 238143

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SECTION 238219

FAN COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide horizontal fan coil units (FCU) for concealed overhead installation.

B. Provide wall mounted vertical fan coil units (FCU) for exposed wall installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. LG is the design reference brand the project was designed around. Other brands that make a similar product, but are not necessarily equal are Daikin and Samsung.

2.2 WALL MOUNTED FAN COIL UNIT

A. General: Indoor units shall be a wall mounted fan coil unit, operable with refrigerant R410A with smell additive, for installation onto a wall within a conditioned space. This compact design with finished white casing shall be available from 8,800 Btu/h to 24,200 Btu/h capacities. Computerized PID control shall be used to maintain room temperature within 2°F. The unit shall be equipped with a programmed dehumidification cycle. A mildew-proof filter and condensate drain pan shall be included as standard equipment. The indoor units sound pressure shall range from 20 dB(A) to 41 dB(A) at low speed measured at 3.3 feet below and from the unit.

B. Performance: Each unit's performance is based on ARI nominal operating conditions:

C. Indoor Unit:
   1. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set multiple steps of discharge angle. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart. The drain pipe can be fitted to from either left or right sides.

2. Indoor unit will be charged with dehydrated air prior to shipment from the factory.
3. Both refrigerant lines shall be insulated from the outdoor unit.
4. Return air shall be through a resin net mold resistant filter.
5. The indoor units shall be equipped with a condensate pan.
6. The indoor units shall be equipped with a return air thermistor.
7. The voltage range will be 253 volts maximum and 187 volts minimum.

D. Unit Cabinet:
1. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.
2. The cabinet shall be constructed with sound absorbing foamed insulation.

E. Fan:
1. The fan shall be a direct-drive cross-flow fan, statically and dynamically balanced impeller with high and low fan speeds available.
2. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz.
3. The air flow rate shall be available in high and low settings.
4. The fan motor shall be thermally protected.

F. Coil:
1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
3. The coil shall be a 2 row cross fin copper evaporator coil with 14 fpi design completely factory tested.
4. The refrigerant connections shall be flare connections and the condensate will be 1-1/4 inch outside diameter PVC.
5. A thermistor will be located on the liquid and gas line.

G. The unit shall have a standard 24 Hour on/off timer, and be able to connect to a 7 day timer via an additional PCB adaptor board.

H. The unit shall have the following features as standard; on/off switch, signal reception indicator, night setback mode, auto restart after power failure, self diagnosis, either side refrigerant piping and condensate drain connection, intelligent eye motion sensor, program dry function, fan only mode, inverter powerful mode and home leave function.

2.3 DUCTED CONCEALED ABOVE CEILING FAN COIL UNIT

A. General: Indoor units shall be a concealed ducted above ceiling fan coil unit, operable with refrigerant R410A with smell additive, for installation above ceiling of a conditioned space. The fan will supply air horizontally into a ducted supply system. The unit casing will be metal. This compact design shall be available from 7,500 Btu/h to 95,900 Btu/h capacities. Computerized PID control shall be used to maintain room temperature within 2°F. The unit shall be equipped with a programmed dehumidification cycle. A mildew-proof filter and condensate drain pan shall be included as standard equipment. The indoor units sound pressure shall range from 20 dB(A) to 41 dB(A) at low speed measured at 3.3 feet below and from the unit.

B. Performance: Each unit's performance is based on ARI nominal operating conditions:

C. Indoor Unit:
1. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. Indoor unit will be charged with dehydrated air prior to shipment from the factory.
2. Both refrigerant lines shall be insulated from the HRU or outdoor unit.
3. Return air shall be through the rear of the unit in the horizontal direction with MERV 13 filter modules with plenum. The indoor units shall be equipped with a condensate pan.
4. The indoor units shall be equipped with a return air thermistor.
5. The voltage range will be 253 volts maximum and 187 volts minimum.

D. Unit Cabinet:
1. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.
2. The cabinet shall be constructed with sound absorbing foamed insulation.

E. Fan:
1. The fan shall be a direct-drive cross-flow fan, statically and dynamically balanced impeller with high and low fan speeds available.
2. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz.
3. The air flow rate shall be available in high and low settings.
4. The fan motor shall be thermally protected.

F. Coil:
1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
3. The coil shall be a 3 row cross fin copper evaporator coil with 14 fpi design completely factory tested.
4. The refrigerant connections shall be flare connections and the condensate will be 1-1/4 inch outside diameter.
5. A thermistor will be located on the liquid and gas line.

G. The unit shall have a standard 24 Hour on/off timer, and be able to connect to a 7 day timer via an additional PCB adaptor board.

H. The unit shall have the following features as standard; on/off switch, signal reception indicator, night setback mode, auto restart after power failure, self diagnosis, either side refrigerant piping and condensate drain connection, intelligent eye motion sensor, program dry function, fan only mode, inverter powerful mode and home leave function.

2.4 INDOOR THERMOSTAT

A. Provide simple controller with mode selection equivalent to LG Model PQRCVCL0QW (the white one) as indicated on drawings. To be installed approximately where indicated on drawings with ADA constraints in mind, mount at 48" AFF.

B. At a minimum the thermostat shall be capable of:
   1. Operation display.
   2. Room Temperature Setting.
   3. Fan speed selection.
   4. Air Flow Direction
   5. On/Off Button
   6. Operation Mode selection Button.
   7. Child lock.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. The system must be installed by a factory trained contractor.

C. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

D. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to unit to allow service and maintenance.

C. Duct Connections: Duct installation requirements are specified in Division 15 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors.

D. Ground equipment according to Division 16 Section "Grounding and Bonding."

E. Electrical Connections: Comply with requirements in Division 16 Sections for power wiring, switches, and motor controls.

3.3 OPERATION

A. Operating Range: The operating range in cooling will be 14°F DB ~ 115°F DB. The operating range in heating will be 5°F DB ~ 64°F DB.

B. Refrigerant Piping:

C. The system shall be capable of refrigerant piping up to 350 equivalent feet.

D. The distance between the condensing unit and fan coil unit shall be no more than 49 feet maximum vertical difference, without any oil traps or additional equipment.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service. Complete installation and startup checks according to manufacturer's written instructions.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Refer to Division 1 Section "Closeout Procedures”.

END OF SECTION 238219

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