SECTION 23 01 00

GENERAL PROVISIONS OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide all labor, materials, tools, and services for a complete installation of equipment and systems contained in contract documents.

B. Principal features of work included are:

1. Heating, ventilating, and air-conditioning system.
2. Control system including low voltage control wiring and conduit.
3. Seismic bracing and anchorage for equipment, ductwork, and piping.

1.2 RELATED WORK

A. Electrical power and interlock wiring and conduit.

B. Field painting of equipment, ductwork, and piping.

1.3 INNOVATION MEMORANDUMS

A. The owner has obtained purchase agreements for select equipment and materials. These purchase agreements are documented as Innovation Memorandums and are to be included as part of this project.

1. Innovation Memorandum No. 7: All piping, valves, pipe fittings and related products to be purchased from Ferguson Enterprises. Refer to Section 23 21 13.
2. Innovation Memorandum No. 9: All VAV boxes to be purchased from JCI/Siemens. Refer to Section 23 36 10.

1.4 GENERAL

A. The contract documents form a guide for a complete system. Provide all items necessary to provide a complete system but not specifically mentioned, such as hangers, transitions, offsets, and drains.

B. Layouts indicated on drawings are diagrammatical only. Coordinate exact location of equipment, ductwork, and piping to eliminate conflict with other divisions. Designer reserves right to make reasonable changes in location of equipment, ductwork, and piping prior to construction. Coordination drawings shall be submitted prior to any equipment/systems being installed to ensure that installation conflicts between trades are minimized.

C. Should Contractor find during progress of work that in his judgment existing conditions make desirable a modification, report such item promptly to Designer for instructions. Do not make deviations from contract documents without review of Designer.

D. Supervise all work with a competent mechanic specifically qualified in mechanical discipline.

1.5 PERMITS

A. Secure and pay for permits, licenses, and inspections for work under this division.

1.6 CODES

A. Comply with all pertinent local, state, and national codes. Refer to Division 01.

1.7 STANDARDS

A. Comply with all pertinent standards. This list is provided as a convenience to Contractor and is not to be considered all inclusive.

1. Sheet Metal and Air-Conditioning Contractors National Association (SMACNA).
2. American Gas Association (AGA).
3. Air Moving and Conditioning Association (AMCA).
4. Air-Conditioning, Heating and Refrigeration Institute (AHRI).
5. American Society of Mechanical Engineers (ASME).
6. American Society of Heating Refrigeration Air Conditioning Engineers (ASHRAE)

1.8 SUBMITTALS

A. Submit for review complete brochures and shop drawings for materials and equipment proposed in accordance with Division 01.

1. Brochures: Submit complete descriptions, illustrations and specification data for materials and equipment proposed. Clearly indicate proposed items when other items are shown on same sheet. Submit samples on request and/or set up for inspection. Samples will be returned to Contractor.
2. Submittals shall be submitted in line by line format. Each submittal shall be provided with a cover letter and supporting documentation indicating how the submittal meets each line of the referenced specification section. All discrepancies between the construction documents and the submitted product shall be clearly identified for engineer evaluation.
3. If a product other than the basis of design is rejected by the engineer for any reason, the Contractor shall provide the basis of design product at no additional cost to the Owner.
4. Shop Drawings:
    a. Control systems.
    b. Complete equipment, ductwork, and piping systems.
    c. Firestop systems.

B. Seismic Certification: Refer to Seismic Specification Section 23 05 47 for all project requirements.

1.9 PROJECT MAINTENANCE MANUALS

A. Prior to final acceptance of project, provide Owner with bound maintenance manuals in accordance with Division 01.

1.10 PROJECT TECHNICAL INSTRUCTION

A. Prior to final inspection of project, provide technical instruction to Owner as follows:

1. Field Instruction: Provide explanation of how systems and equipment are to operate during each season and during emergencies.
2. Field Demonstration: Demonstrate operation and routine maintenance for systems and equipment.
3. Video: Provide digital video of all field instruction and demonstration to Owner at completion.

1.11 PROTECTION

A. Protect all materials and equipment in accordance with Division 01.

B. The contractor must take appropriate precautions, during construction, to prevent unnecessary dust and debris from getting into air and water handling systems by covering equipment, controls and open-ended ducts and pipes as the installation progresses.

1.12 CONSTRUCTION RECORD DOCUMENT

A. Provide construction record documents in accordance with Division 01. Keep at the project one set of drawings and daily record changes at the time they are made. Give drawings to Owner at project completion.

1.13 EXISTING SERVICES

A. Maintain existing services in operation during construction. Coordinate and schedule all service interruptions with Owner.

1.14 OWNER NOTIFICATION

A. Notify Owner two weeks prior to activation of central chilled water and steam service to project.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Provide materials and equipment of domestic manufacture bearing the U.L. label when such label is available.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate work in accordance with Division 01. Coordinate locations of equipment, ductwork, and piping to eliminate conflict with other divisions.

B. Carefully examine contract documents to be thoroughly familiar with items which require plumbing or mechanical connections and coordination.

C. Provide proper chases and openings. Place sleeves and supports prior to pouring concrete or installation of masonry.

3.2 CUTTING AND PATCHING

A. Repair or replace routine damage caused by cutting in performance of contract.

B. Correct unnecessary damage caused due to installation of mechanical work.

C. Perform repairs with materials that match existing in accordance with the appropriate section of these specifications.

3.3 FLASHING, COUNTERFLASHING, AND SEALING

A. Flash, counterflash, and seal ductwork and piping at penetrations of roofs and outside walls.

3.4 TRENCHING, EXCAVATION AND BACKFILLING

A. Provide trenching, excavation, and backfilling necessary for performance of mechanical work accordance with Division 02.

B. Trenching and excavation of rock to be as described in Division 02.

C. Excavate to a depth at least 6" below bottom of pipe and a minimum of 36" above top of pipe. Fill below pipe, around pipe, and minimum of 12" above pipe with sand or Class "B" crushed stone tamped firm and even. Provide topsoil for final layer of dirt (12" minimum). Provide 6" spacing between pipes and between pipe and trench sides. Hand-grade with batterboards placed every 25'. Backfill by hand. Do not use rock or stone above sand or Class "B" crushed stone.

3.5 CONNECTION TO EQUIPMENT

A. Rough-in and connect to lab equipment and Owner furnished equipment and provide a shutoff valve and union at each connection. Operating valves and/or controls for this equipment will be provided as an integral part of the equipment. Do not rough-in until shop drawings showing rough-in locations have been reviewed by Designer.

3.6 IDENTIFICATION

A. Identify exposed or accessible piping with stenciling contents indicating pipe contents and direction of flow on piping not more than 20 feet apart, at valves, at access panels, and at least once above each space.

B. Contractor's option to identify exposed or accessible piping with snap-on or strap-on type markers. Color code markers in accordance with ANSI. Indicate pipe contents and direction of flow on marker. Install markers on piping not more than 20 feet apart, at valves, at access panels, and at least once above each space.

C. Identify all mechanical equipment with engraved brass, aluminum, or stainless steel nameplates or tags. Use equipment names and numbers appearing in schedules on drawings. Fasten nameplates to equipment using screws. Glue or adhesive is not acceptable. Fasten tags to equipment using brass, aluminum or stainless steel chains.

D. Frame and mount control diagrams and sequences in each equipment room. Use non-fading black and white prints encased in aluminum frame with Plexiglas cover.

3.7 CLEANING

A. Thoroughly clean ductwork and equipment casings before fans and filters are operated.

B. Repair damaged factory finishes covering all bare places and scratches.

C. Cleaning HVAC Systems Water Piping:

1. Clean all equipment and piping of iron cuttings and other foreign matter as they are installed.

2. Thoroughly flush HVAC water systems with pre-cleaning chemicals designed to remove depositions such as pipe dope, oils, rust, mill scale, and other extraneous materials. Provide dosages of pre-cleaner chemicals recommended by water treatment supplier and add and circulate throughout the water systems. Drain, refill, and flush water systems thoroughly until no foreign matter is observed and total alkalinity of the drain water is equal to that of the make-up water.

3.8 TESTING

A. Test all installed equipment and systems and demonstrate proper operation. Correct and retest work found defective when tested.

B. Thoroughly check piping system for leaks. Do not add any leak-stop compounds to the system. Make repairs to piping system with new materials. Peening, doping, or caulking of joints or holes is not acceptable.

C. Conduct air or smoke test if in opinion of Designer reasonable cause exists to suspect leakage or low quality workmanship.

D. Test compressed air piping with Nitrogen at 100 psi for two hours without leaks.

E. Test HVAC systems water piping and steam supply and steam condensate return piping at a water pressure of 125 psig for two hours without leaks.

F. Vibration Tests:

1. Test vibration isolation system in accordance with methods and procedures described in the Testing, Adjusting, and Balancing Chapter in the latest edition of ASHRAE Applications Handbook.

2. Verify all vibration isolation systems are free floating and not short circuited by any connection between equipment and building structure.

3. Operate mechanical systems and verify visually and audibly that there is no excessive vibration or noise generated by the system.

END OF SECTION

SECTION 23 05 13

ELECTRIC MOTORS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide and install electric motors for mechanical and plumbing equipment.

1.2 SUBMITTALS

A. Submittal data is NOT required for products under this section as separate items. It is assumed they will be reviewed with appropriate equipment submittal.

PART 2 - PRODUCTS

2.1 MOTORS

A. Electric motors shall be new NEMA Standard, sized and designed to operate at full load and full speed continuously without causing noise, vibration, and temperature rise in excess of their rating.

B. Motors on belt driven equipment shall have slide rails with adjusting screws for belt tension adjustment. Motors exposed to the weather shall be weather protected.

C. High efficiency electric motors shall be provided for all motors 3 horsepower and greater. Any motor used with a variable speed motor controller shall be high efficiency type and VFD compatible.

D. High efficiency motors shall have efficiency and losses determined in accordance with the latest revisions of IEEE Standard 112. Polyphase squirrel-cage motors rated 1 through 125 horsepower shall be tested by dynamometer method B. The efficiency shall be determined using segregated losses in which stray load loss is obtained from a linear regression analysis to reduce the effect of random errors in the test measurements. Guaranteed minimum full load efficiency shall be as follows:

MINIMUM NOMINAL FULL-LOAD EFFICIENCY (%)		
	Open Motors	Enclosed Motors
Number of Poles	4	4
Synchronous Speed (RPM)	1750	1750
Motor Horsepower		
3	86.5	87.5
5	87.5	87.5
7.5	88.5	89.5
10	89.5	89.5
15	91.0	91.0
20	91.0	91.0
25	91.7	92.4
30	92.4	92.4
40 – 75	93.0	93.0
100 above	94.1	94.5
Refer to Latest Edition of ASHRAE 90.1 for other motor rpm and efficiencies.		

E. Motor sound power levels shall not be greater than recommended in NEMA M61-12.49.

F. Motors shall be provided with drive shafts long enough to extend completely through belt sheaves.

G. Motor characteristics shall be as follows:

1. 120V/1/60 Hz: Capacitor start, open drip-proof type, ball bearing, rated 40 degrees C. continuous rise.
2. 460V/3/60 Hz: NEMA Design B, normal starting torque, single speed, squirrel cage type, open drip-proof, rated 40 degrees C. continuous rise, with ball bearings rated for B-10 life of 100,000 hours and fitted with grease fittings and relief ports. Provide motors with aluminum end brackets with steel inserts in bearing cavities.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Arrange and set motors.

B. Line up motors on direct drive equipment using dial type gauges.

C. Electrical Contractor to make connections and test motor for proper rotation/phasing.

3.2 ADJUSTMENTS

A. All motors together with driven equipment shall be statically and dynamically balanced by equipment supplier, start-up representative, or this contractor using approved balancing equipment. Fan vibration should be limited to manufacturers' recommendations, but should not exceed 2 mils in any case.

END OF SECTION

SECTION 23 05 47

SEISMIC RESTRAINT OF MECHANICAL EQUIPMENT AND SUSPENDED UTILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide engineered seismic restraint systems for suspended and base mounted Mechanical Piping, HVAC Duct, Mechanical Equipment utilities compliant with the 2021 International Building Code (IBC) with local building code amendments.

B. All equipment manufacturers shall submit, as part of the equipment submittal, compliance certifications. Contractor to be responsible for equipment anchorage details.

C. At seismic restraint installation locations, provide vertical support systems engineered to accommodate dead load plus seismic force reactions.

1.2 RELATED SPECIFICATION SECTIONS

A. Mechanical Piping

B. HVAC Duct

C. Mechanical Equipment

1.3 REFERENCES

A. Publications, codes and standards listed below form a part of this specification to the extent referenced.

1. 2021 International Building Code (IBC)
    a. Chapter 16 - Structural Design
    b. Chapter 17 – Structural Tests And Special Inspections
2. ASCE 7-16, Chapter 13, Minimum Design Loads For Buildings and Other Structures, American Society of Civil Engineers (ASCE).
3. ACI 318, Building Code Requirements for Structural Concrete, American Concrete Institute (ACI).

1.4 COMPONENT IMPORTANCE FACTOR

A. In order to identify systems requiring seismic restraint and to define those from which restraints may be excluded, utility components are assigned an ASCE 7 Importance Factor (Ip) on the basis of the following:

B. Ip = 1.5

1. Occupancy Category III IV, essential facilities required for post-earthquake recovery – all “Designated Seismic Systems” per IBC Chapter 17 required for the continued operation of the facility.
2. Life-safety component which is required to function after a seismic event including fire protection sprinkler systems.
3. Components that contain hazardous or flammable materials.

C. Ip = 1.5: All other components.

1.5 SUBMITTALS

A. Equipment Certification.

1. Equipment manufacturer to provide certificate of compliance for 2021 IBC proxing on line capability for the project use group and seismic design category. Provide certifications for the following equipment: variable frequency motor, vibration isolators, controllers, air conditioning single zone units on emergency power, equipment support curbs, chillers, cooling towers, indoor air handlers, rooftop air handlers, exhaust fans, control panels, above ground tanks. Equipment manufacturer certification to be based

on shake table or three dimensional shock testing or experience data as required by ASCE/SEI 7-16.

2. The following equipment is considered rugged and does not require a certificate of compliance: pumps, valves, motors, and underground tanks.

B. Contractor to identify and convey each overhead deck condition to which seismic attachments will be made. Information to include type and density of concrete, concrete thickness, size and gage of metal deck and any point load limitations or restrictions.

C. Provide Seismic Design Force calculations per ASCE 7-16, Formulas 13.3-1 thru 13.3-3 stamped by a registered design professional qualified civil or structural engineer licensed to practice in the State where project is located. For multi-story projects, provide calculated Seismic Design Force for each floor.

D. Submit seismic restraint layouts stamped by a registered design professional qualified engineer licensed to practice in the State where project is located. Seismic restraint layouts to show:

1. All vertical support and seismic brace locations.
2. All anchorage connections to structure. Anchor brand, type, quantity, and size.
3. Vertical support and brace reaction point load at all connections to structure. For review by engineer of record in checking suitability of the building structure to accommodate imposed loads.
4. Plan set sheets showing appropriate installation details reflecting actual job site conditions.

E. Include cover sheet with Seismic Restraint Bracing Legend delineating:

1. Maximum Allowable Size or Utility Weight (Lbs/Lf).
2. Minimum Vertical Support Rod Diameter.
3. Support Rod Total Vertical Load.
4. Maximum Allowable Transverse Brace Spacing.
5. Transverse Brace Reaction.
6. Maximum Allowable Longitudinal Brace Spacing.
7. Longitudinal Brace Reaction.
8. Minimum Required Seismic Restraint Brace Arm Assembly.
9. Minimum Required Seismic Restraint Anchorage To Overhead Structure.
10. Installation Detail Drawing References.

1.6 QUALITY ASSURANCE

A. Registered design professional who completed seismic submittal to check suitability of structure to accommodate applied seismic loads.

B. Registered design professional who completed seismic submittal is to provide a “Statement of Special Inspections” in conformance with 2021 IBC, Chapter 17.

C. Each contractor responsible for the construction of a “Designated Seismic System” shall submit to the building official and owner prior to the commencement of work on the system or component a written “statement of responsibility” per IBC Chapter 17.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Seismic restraint hardware and engineering by International Seismic Application Technology (ISAT), Mason Industries, Tolco, or approved equal.

B. Vertical support and seismic restraint anchorages to utilize Cast-In Place Deck Inserts, or Post Installed Anchors. All deck inserts or post installed anchors to have a valid ICC ESR evaluation report (or equal) substantiating the insert or anchor capacity.

C. Vertical support and seismic restraint connections to structural steel are to utilize fixed Beam Clamp connections or Welded or bolted connections.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Roof mounted equipment: All roof mounted equipment is to be positively attached to roof support curb or isolators by bolting or welding. All support curbs to resist compressive, shear, tension, and rotational loads (including seismic loads) and translate these loads to building structure. The design of all support curbs shall be performed by an engineer licensed in the project state. Curb design to minimize rotational loads to structure and be positively attached to building structure by bolting or welding.

B. For conditions not covered within pre-engineered drawings, the required engineering is to be performed by a registered Engineer.

C. Manufacturer shall provide field installation training prior to commencement of install.

D. Field relocation of any seismic installation points away from that shown on the furnished shop drawing layouts shall be coordinated with registered design professional who completed seismic submittal.

E. Consult Registered design professional who completed seismic submittal when field conditions prohibit compliance with the supplied installation details.

F. In order to satisfy ASCE 7 minimum yield strength requirements, the allowable brace spacing for non-ductile systems (eg. cast iron, plastic, and glass pipe) shall be no more than half that for ductile systems.

3.2 EQUIPMENT CONNECTIONS

A. Where seismic bracing is allowed to be omitted due to size or proximity to overhead deck, all terminations to fixed equipment, panels, etc. or to other portions of the system requiring seismic restraint are to utilize flexible connectors.

B. Where seismic bracing is allowed by code to be omitted due to size or proximity to overhead deck, contractor shall be responsible for assuring that damaging impact or vertical support failure cannot occur.

3.3 SPECIAL INSPECTION

A. Special Inspection Requirements: All Designated Seismic Systems are subject to Special Inspection per IBC Chapter 17.

B. Special inspection for mechanical components shall be provided as follows:

1. For all Designated Seismic Systems within seismic design categories D, E or F.
2. Periodic special inspection during the installation for flammable, combustible or highly toxic piping systems and their associated mechanical units in Seismic Design Categories C, D, E or F.
3. Periodic special inspection during the installation of HVAC ductwork that will contain hazardous materials in Seismic Design Categories C, D, E or F.
4. Periodic special inspection during the installation of vibration isolation systems where the construction documents indicate a maximum clearance (air gap) between the equipment support frame and restraint less than or equal to 1/4 inch.

C. Install identification tags at all seismic brace locations. Tags to include the following information:

1. Specific seismic forces (g-force) the location was designed to resist.
2. Maximum brace reaction at connection to structure.

3. For single hung items, the maximum pipe/conduit size the brace location was designed to accommodate.
4. For trapeze supported items, the maximum weight (lbs/lf) the brace location was designed to accommodate.
5. For suspended equipment, the maximum unit operating weight (lbs) the brace location was designed to accommodate.
6. Location identifier cross matched to that on plan set layout.
7. Company name of installing contractor.

D. Upon completion of construction a Quality Assurance Representative of registered design professional who completed seismic submittal shall review the installation of the seismic-force-resisting system and provide documentation indicating general conformance to seismic restraint layout drawing.

END OF SECTION

SECTION 23 05 48

VIBRATION ISOLATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Isolate equipment as shown on drawings and specified herein with factory-fabricated vibration isolators in accordance with recommendations in the latest edition of ASHRAE Applications Handbook. Provide isolators of proper sizes and weight loading to meet the requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Kinetics Noise Control, Mason Industries, Vibration Eliminator Co., or approved substitute. Provide isolators by a single manufacturer.

2.2 FIBERGLASS OR NEOPRENE PADS

A. Provide Kinetics Model KIP for:

1. Hot water pumps.

2.3 SPRING AND RUBBER ISOLATION HANGERS

A. Provide Kinetics Model SFH or SRH for:

1. Suspended square in-line centrifugal fans (minimum 1.0" deflection).
2. Horizontal fan coil units (minimum 1.0" deflection).
3. First three (3) piping hangers on each side of pumps (minimum 1.5" deflection and all hot water piping in mechanical rooms (minimum 1.5" deflection).

2.4 FLEXIBLE PIPE CONNECTORS

A. Provide Metraflex or approved substitute twin-sphere flexible rubber pipe connectors with female unions or floating flanges on piping connections to equipment subject to vibration.

B. Provide connectors rated for 150 PSI working pressure.

C. Provide flexible pipe connectors for the following:

1. Water connections to pumps.
2. Vacuum connections to vacuum pump.

2.5 SPRING VIBRATION ISOLATION ROOF CURBS

A. Support all rooftop air handling units with spring vibration isolation roof curbs, Kinetics Model KSR or approved substitute. The isolation curbs shall be complete assemblies designed to resiliently support the equipment at the proper elevation and shall provide a fully enclosed, air- and weathertight system. Refer to Specification Section 230547 for all site specific curb requirements.

B. The isolation curb shall consist of an upper support frame on which the equipment rests and a lower support assembly which is attached to the roof structure separated by freestanding unhoused laterally stable steel springs.

C. The lower support assembly shall incorporate means of attachment to the building as well as a continuous 2" x 2" wood nailer for attachment of the roofing material. The lower support assembly shall also contain provisions for supporting rigid insulation board.

D. Select spring isolators to provide minimum 2" operating static deflection. Space spring isolators a maximum of 96" O.C. Provide a neoprene pad under springs.

E. Design springs with lateral stiffness greater than one times the rated vertical stiffness and minimum 50 percent overload capacity.

F. Include an adjustment bolt to permit leveling of the equipment after installation. Each spring isolator shall be fully accessible for adjustment without interfering with the integrity of the roof.

G. Provide isolation curb with vertical and lateral restraints as required in order to withstand the project specific wind loads as indicated on the structural drawings.

H. The isolation curb shall be air and weathertight using an elastomeric boot which is attached to the upper support frame, extends down past the wood nailer of the lower support assembly, and is counterflashed over the roof materials.

I. Provide isolation curb with cross bracing on the upper and lower assemblies as required to assure stability.

2.6 SPRING VIBRATION ISOLATION ROOF CURB RAILS

A. Support rooftop air handling unit condenser section with continuous spring vibration isolation roof curb rails, Kinetics Model KSR or approved substitute. The isolation curb rails shall be complete assemblies and provide a fully enclosed, air and weathertight system. Refer to Specification Section 230547 for all site specific curb requirements.

B. Isolation curb rails shall consist of extruded aluminum or roll-formed steel top and bottom members connected with spring isolators. Provide continuous air and water seal for the entire rail perimeter. Select and space spring isolators according to weight distribution of the supported equipment.

C. Provide means for attachment to the roof curb and the supported equipment. Provide additional stiffening members as required to assure stability. Provide vertical and lateral restraints as required in order to withstand the project specific wind loads as indicated on the structural drawings.

D. Select spring isolators to provide minimum 2" operating static deflection. Spring components shall be freestanding, unhoused, laterally stable steel springs. Design springs with lateral stiffness greater than 0.8 times the rated vertical stiffness and minimum 50 percent overload capacity.

2.7 OUTDOOR APPLICATIONS:

A. All isolators located outside exposed to weather shall be corrosion resistant construction with hot dip galvanizing or PVC coating.

2.8 SEISMIC RESTRAINTS AND ISOLATORS

A. Provide Kinetics Model FYS seismic control restrained spring isolators for:

1. Belted Vent Sets (min 1” deflection).

B. Assemble springs into a welded steel housing assembly engineered to limit movement of supported equipment during an earthquake without degrading the vibration isolation of the spring during normal equipment operating conditions. Vibration isolators shall incorporate a steel angle and plate motion limit assembly and steel spring isolator engineered as a system to accept a force in any direction equal to a minimum of 1.0 times the rated load capacity of the spring isolator without yield or failure and shall limit movement of the point of level bolt connection to supported equipment to less than ½" in any direction relative to any fixed point on the isolator assembly, while subjected to the rated force specified. Weld the motion limit assembly to a steel base plate having a ribbed neoprene pad and drill holes for bolting to the supporting structures. Position a drilled and tapped load plate and leveling bolt assembly on the base plate.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install vibration isolation in accordance with the isolator and equipment manufacturer's published installation instructions.

B. Size vibration isolation in accordance with weight distribution, pull or the imposed torque of actual equipment provided.

C. Set anchor bolts when concrete is placed.

1. Install vibration isolation roof curb and vibration isolation roof curb rails in accordance with manufacturers' published installation instructions to provide an air and watertight seal.

3.2 SEISMIC RESTRAINTS AND ISOLATORS

A. Provide seismic restraints and isolators for Seismic Design Category C. Provide static seismic calculations with submittals. Refer to Section 230547.

END OF SECTION

SECTION 23 05 49

BASIC MATERIALS AND METHODS FOR HVAC

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Work required under this section of the specifications consists of basic materials and methods applicable to work under Division 23.

PART 2 - PRODUCTS

2.1 V-BELT DRIVES

A. Provide all fan drives with V-belts rated for 150% of nameplate motor horsepower. Provide adjustable pitch motor sheaves for motor sizes through 20 hp. For motor sizes 25 hp and larger provide fixed pitch motor sheaves after balancing to within plus 5% of design air quantity. Select motor sheaves so centerline does not extend past end of motor shaft and such that motor bearing grease fitting and relief port is not obstructed.

B. Provide belt guards for all belt driven equipment. Provide expanded metal cover with access to driven shaft for tachometer.

2.2 FOUNDATIONS AND PADS

A. Provide foundations, pads, and bases required for equipment. Concrete to be in accordance with concrete division of specifications.

B. Coordinate proper sizes and locations of foundations, pads, bases, louvers, anchors, supports, and other items to be built into structure.

2.3 FASTENINGS TO STRUCTURES

A. Provide structural fastening devices for equipment, materials, piping and ductwork. Devices to be concrete inserts, expansion shields and lag bolts, and through bolts-washers-nuts. All bolted devices to use jamb nuts. Inserts to be continuous type as manufactured by Unistrut or approved substitute. Install per manufacturer's published installation instructions in lengths to suit specific application, complete with spring nuts, end caps, and plastic coated filler to prevent concrete seepage.

B. Use of power drive "shot-pins" is permitted only for ducts 20" in width and smaller and single pipes 1" and smaller.

2.4 ACCESS PANELS

A. Provide ceiling and wall access panels for installation by other Divisions. Coordinate locations so panels will provide proper access to equipment served. Notify Designer of proposed wall or ceiling access panel locations prior to installation of such panels. Minimum size: 24" x 24".

B. Panels shall be manufactured by Bilco or approved substitute. Provide panels with minimum 16 gauge steel construction with screwdriver operated locks and primer finish.

C. Provide fire-rated panels for installation in fire-rated partitions.

2.5 ROOF CURBS

A. Provide prefabricated metal roof curbs at all roof ductwork and piping penetrations and for support of all roof-mounted equipment, fans and ductwork. Construct curbs according to National Roof Contractor's Association guidelines. Prefabricated metal roof curbs shall be manufactured by ThyCurb, Custom Curb, or approved substitute.

B. Construct curbs with minimum 18 gauge galvanized steel (14 gauge for curbs with any side longer than 4'-0" and for all curbs supporting equipment) with fully mitered and welded corners, raised 3" integral cant for roof deck insulation, integral base plate, internal reinforcing with 1" x 1" x 1/8" steel angle for curbs with any side longer than 3'-0", factory installed 1-1/2" thick, 3-pound density fiberglass insulation and factory installed pressure treated wood nailer. Minimum height of curb shall be 12" above finished roof surface.

(Consult architectural plans for roof type and thickness.) Construct curbs to match slope of roof and provide a level top surface for mounting of mechanical equipment.

C. Curb types shall be as follows:

1. Fan and duct penetration curbs with standard curb construction as described above - ThyCurb Model TC.
2. Equipment and ductwork support curbs with minimum 18 gauge galvanized steel shell, base plate and counterflashing, wood nailer, and internal bulkhead reinforcement - ThyCurb Model TEMS.
3. Pipe penetration curbs with standard curb construction as described above and insulated metal piping cover - ThyCurb Model TC with Model TP-2 piping cover.

D. Install curbs in strict accordance with manufacturer's published installation instructions and as detailed on the drawings. Coordinate proper curb size, construction, and base prior to fabrication.

2.6 ROOF PIPE SUPPORTS

A. Support horizontal piping across roof with Miro Industries Roof Pillow Block Pipestands or ThyCurb or Custom Curb Pipe Support Curbs.

PART 3 - EXECUTION - NOT APPLICABLE

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Perform test and balance work by a Test and Balance Agency which is engaged solely in full time test and balance work, is a member of the Associated Air Balance Control (AABC) or approved equal, and is selected and employed by the General Contractor.

B. Perform test and balance in accordance with AABC Standards.

C. Contract to the Test and Balance Agency shall be issued by the General Contractor. Coordination with the agency at the job site shall be the responsibility of the contractor in order to ensure proper scheduling and operation of the systems. All correspondence (reports, letters and communications) between any parties shall have copies sent directly to the designer and contractor.

D. The TAB agency shall review construction plans and specifications. If any discrepancies are noted which would hinder balancing, notify the designer with copy to the contractor. Make inspections of the job during construction for proper installation of the system(s) and of balancing aids in the system(s). Any discrepancies noted shall be brought to the attention of the contractor and designer. The number of inspections varies with the size and complexity of the job and shall be adequate for the purpose intended. Report ALL job visits in writing - MANDATORY.

E. The TAB agency shall work in close coordination with the contractor in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor / transmitters. The tests shall be documented and included in the final TAB report.

F. The Owner has hired an independent Cx agent to commission the mechanical and controls systems serving this facility. The TAB agency should refer to Specification 23 0809 General Commissioning Requirements and 23 0810 HVAC Commissioning Procedures and Checklists, in order to be apprised of, and become familiar with his responsibilities and accountabilities throughout the Cx process.

1.2 RESPONSIBILITIES OF PROJECT CONTRACTOR

A. The contractor shall:

1. Provide approved Test and Balance Agency with copy of plans and specifications upon issue of construction documents.
2. Have the building and HVAC systems in operational readiness for TAB work to begin.
3. Correct prompt deficiencies of materials and workmanship identified as delaying completion of TAB work.
4. Be responsible for any added costs to the owner resulting from his failure to have the building and HVAC systems ready or from his failure to correct deficiencies promptly.

B. Complete operational readiness of the building requires that construction status of the building shall permit closing of doors, windows, ceilings installed, etc., to obtain projected operating conditions.

C. Complete operational readiness of the air conditioning systems requires that the following be accomplished:

1. Air Distribution Systems:
   a. Verify installation conforms to design. All supply, return and exhaust ducts terminated and pressure tested for leakage as required by specifications.
   b. All volume, control, fire and smoke dampers properly located and functional. All dampers shall be fully open. MVD gradients and spin damper handles should be exposed through insulation. Dampers serving requirements of minimum and

maximum outside, return and relief air shall provide tight closure and full opening, smooth and free operation.

c. All supply, return, exhaust and transfer grilles, registers, diffusers, terminal boxes and filters installed.

d. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be sealed to eliminate bypass or leakage of air.

e. All fans operating at full load and verified for freedom from vibration, proper fan rotation and belt tension; heater elements in motor starters to be of proper size and rating. Check motor amperage and verify that it is under nameplate rating.

2. Water Circulating Systems:

a. Check and verify pump alignment and rotation. Verify location of thermometers, gages, and PT test plugs.

b. Open all valves to full open position. Close bypass stop valves. Set mixing valves to full flow through system components. Remove and clean all strainers. Verify specified pipe cleaning has taken place. Repeat operation until circulating water is clean.

c. Record pump motor amperage on each phase and voltage after reaching rated speed. Readings shall not exceed nameplate rating. Verify heater elements in motor starters to be of proper size and rating.

d. All water circulating systems shall be full and free of air; expansion tanks set for proper water level; all air vents installed at high points of systems and operating freely. System static pressure to be set minimum 5 psig above highest system elevation.

e. Check and set operating temperatures of heat exchangers to design requirements.

f. Verify that piping to coils is complete and set for counter flow. Verify location of thermometers, gauges, PT test plugs, and flow balancing/measuring valves.

3. Automatic Controls:

a. Verify that all control components are installed and functional in accordance with project requirements, including all electrical interlocks, damper sequences, temperature resets, and safeties.

b. Verify that pressure controllers are calibrated and control variable speed motor controllers as required to maintain a stable pressure.

c. All controlling instruments calibrated and set for designed operating conditions.

4. Notification of System Readiness: After completion of the work above, the contractor shall notify the TAB firm and designer certifying that the work has been accomplished and that the building and HVAC systems are in readiness for testing, adjusting, and balancing.

D. As part of this project contract, the contractor shall make any changes in the sheaves, belts and dampers required for correct balance as required by the TAB firm.

E. The contractor shall provide and coordinate services of qualified, responsible contractors, suppliers and personnel as required to correct, repair, or replace any and all deficient items or conditions found during the testing, adjusting and balancing period.

F. In order that all systems may be properly tested, balanced, and adjusted, the contractor shall operate systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB.

G. Project schedules shall provide sufficient time to permit the completion of TAB services prior to owner occupancy.

H. The plans and specifications have indicated valves, dampers and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the contractor shall provide access as requested by the TAB firm. Also, any malfunction encountered by TAB personnel shall be reported to the contractor and designer and corrected by the contractor immediately so the balancing work can proceed.

I. The TAB fieldwork shall not begin on any system / equipment item until signed prefunctional, startup checklists, pertaining to applicable equipment, have been submitted by the installing contractor to the Cx team.

1.3 QUALIFICATIONS OF THE TAB CONTRACTOR

A. The firm shall submit six (6) completed projects of like size and scope. Provide references for each project.

B. The test and balance firm shall submit a resume for the individual proposed to directly supervise the project. The supervisory personnel for the test and balance firm shall be certified test and balance engineers. All project managers and technicians shall be permanent, full-time employees of the agency.

C. The test and balance firm shall submit a list of its calibrated instrumentation to perform the work.

1.4 DOCUMENTS

A. The contractor shall furnish to the TAB firm the following:

1. One set of mechanical specifications.
2. Three sets of mechanical drawings.
3. All pertinent addenda and change orders.
4. One set of control submittal drawings.
5. Approved submittal data on equipment installed, and related changes as required to accomplish the TAB test procedures outlined below.

PART 2 - PRODUCTS – NOT APPLICABLE

PART 3 - EXECUTION

3.1 RESPONSIBILITIES OF THE TAB FIRM

A. The TAB personnel shall check, adjust, and balance the components of the HVAC system which will result in minimum noise, specified temperature, and air flow conditions in the conditioned spaces of the building while the equipment of the system is operating economically. This is intended to be accomplished after the system components are installed and operating as provided for in the contract documents.

3.2 LIAISON AND EARLY INSPECTION

A. The personnel on the job shall act as liaison between the owner, designer and contractor. They shall inspect the installation of piping systems, ductwork systems, control systems, and other component parts of the HVAC systems during the construction stage to verify proper arrangement and adequate provisions for the testing and balancing.

B. During the balancing process, as abnormalities and malfunctions of equipment or components are discovered by the TAB personnel, the contractor shall be advised in writing so that the condition can be corrected by the contractor. The TAB firm shall suggest solutions to noted problems. Data from malfunctioning equipment shall not be recorded in the final TAB report.

3.3 THE TAB REPORT

A. TAB activities shall culminate in a report to be provided in triplicate to the designer. The intent of the final report is to provide a reference of actual operating conditions for the owner's operating personnel.

B. All measurements and recorded readings (of air, water, electricity, sound, etc.) that appear in the reports must be done on-site by permanently employed technicians or engineers of the firm.

C. All comment sheets (punch lists) shall be signed by the contractor to acknowledge receipt. Any outstanding items at the time of completion shall be included in the report.

D. The report shall be certified and approved by the firm's test and balance engineer. The report shall be recorded on standard forms.

3.4 ACTUAL TESTING AND BALANCING PROCEDURES

A. Airside:

1. Supply Fan:
    a. Fans checked for rotation, amperage, static pressure, etc.
    b. Terminal boxes set to maximum cfm and adjust supply fan to within 10% of design cfm.
    c. Main supply duct pitot tube traverse and adjustment of fan speed to produce design cfm while maintaining minimum system static pressure for proper terminal box operation.
    d. The report shall record the VFD speed for the supply fan.
2. Return Fans:
    a. Fans checked for rotation, amperage, static pressure, etc.
    b. With supply system in the maximum mode, traverse and adjust return fan to within 10% of design cfm.
    c. The report shall record the VFD speed for the return fan.
3. Outside Air:
    a. Fans checked for rotation, amperage, static pressure, etc.
    b. With supply system in the maximum mode, traverse and adjust minimum outside air damper and/or fan to design cfm.
4. Exhaust Fan:
    a. Fans checked for rotation, amperage, static pressure, etc.
    b. With supply system in the maximum mode, traverse and adjust exhaust fan to within 10% of design cfm.
5. Diffusers, Registers, and Grilles:
    a. Balance each supply air outlet to within 10**%** of design cfm.
    b. Balance each return air outlet to within 10% of design cfm.
    c. Balance each exhaust air outlet to within 10% of design cfm.
    d. Check and/or adjust pressure relationships so that each positive pressure and each negative pressure area is at least 10% positive or negative as appropriate.
6. After completion, take total air-handling system static profile and record all final statics, amperages, rpm, cfm, etc.

B. Waterside:

1. Hot Water:
    a. Check system for cleanliness.
    b. With all hot water coils (including terminal box reheat coils) calling for full heating, test, set and record pump head and flow.
    c. Test, set and record pressure drop and flow through each boiler to within 5% of design.

d. Test, set and record pressure drop and flow through each flow balancing station.
e. Test, set and record pressure drop and flow through each heating coil to within 0% to 5% of design.
f. Verify that piping system is vented.
g. Verify removal of pump start-up strainer and replacement with operating strainer.

2. Domestic Hot Water Recirculation System:
a. Balance recirculation pumps ±5% of design gpm flow.
b. Set balancing valves to gpm settings as noted on plumbing drawings.

C. Controls:
1. AHU Controls:
a. Check temperature controls for proper calibration and setpoint.
b. Check economizer controls for proper damper operation and control calibration.
c. Check building pressurization under maximum and minimum conditions for proper operation.
d. Check static pressure control under maximum and minimum conditions for proper operation.
e. Record the following: The supply duct static pressure reading, VFD Hz, and fan rpm when the AHU supply fan is meeting the design airflow of all terminal units simultaneously. Also record the supply static pressure set point established and transmitted to the controls subcontractor.

2. Thermostats and Controllers:
a. Check for proper control of valves, dampers, terminal boxes, exhaust fans, etc.
b. Set at design set point.

D. Capacity and Performance Test:
1. Terminal Box Heating Coils: Test, set and record flow through terminal box heating coil.

E. Noise Level: The TAB Contractor shall measure the HVAC background noise level in all the spaces as follows: HVAC system produced noise shall not exceed the following levels: patient rooms, nurses stations, offices, exam rooms, therapy rooms, diagnostic rooms, waiting rooms, and treatment rooms shall not exceed a NC 37; toilets, laboratories, and utility rooms shall not exceed a NC 42.

F. The General Contractor and the Mechanical Contractor shall be responsible for reviewing the NC curve for spaces which exceed the required levels and make appropriate adjustments to the system to bring the NC level into range. The final TAB report shall document all spaces with appropriate NC levels.

3.5 REPORTS

A. Problems Encountered: Any items not installed, improperly installed or not functioning properly shall be reported to the contractor.

B. Final Report:
1. Any unresolved problems shall be reported in a general remarks section in front of the test and balance report.
2. Any unusual operations or pertinent remarks which may aid the maintenance personnel or ease the reading of the report shall be made in the general remarks section of the report.
3. All operating data and final tests shall be reported in the final report. This data shall include, but not necessarily be limited to the scope of work outlined above.

4. TAB contractor shall compile an Excel spreadsheet for all terminal boxes, listing each box by its unique identification number, the inlet flow area established by the box manufacturer, the manufacturer's gain factor for the box, final TAB calibrated gain factor for the box if field calibrated, and the ratio of the calibrated gain factor to the manufacturer's gain factor.

3.6 CALLBACK

A. Test and Balance Agency shall retest any unresolved problems noted in the final report. The revised results shall be forwarded after completion of test.

B. At the discretion of the designer before final acceptance of the TAB report, the report data shall be verified one time on the job site by selection of random check points in the presence of the designer. Representatives of the testing firm shall be present and provide the necessary equipment for test data verifications.

C. The firm shall be responsible for testing, adjusting, balancing, and reporting on the performance of all fans, dampers, air distribution devices, pumps and heat exchangers, the flow through all coils, pumps and heat exchangers, and the power consumption of all motors. The contractors and the suppliers of the equipment installed shall cooperate with the balancing agency to provide all necessary data on the design and proper application of the system components and shall furnish all labor and material required to eliminate any deficiency.

D. Make one (1) inspection within ninety (90) days after occupancy of the building to insure that satisfactory conditions are being maintained.

3.7 OPPOSED SEASON TESTING

A. This service allows for testing of equipment that, due to extreme weather conditions, cannot be accurately tested at the time of the initial balance. If a project is balanced during the summer, the opposed season testing is performed during the winter months and vice-versa.

B. During the opposed season testing, any necessary modifications to the initial adjustment required to produce optimum operation of the system components shall be made to produce the proper seasonal conditions in each conditioned space. At the time of opposite season testing, the designer and owner shall be given timely notification before any readings or adjustments are made so that he may participate.

END OF SECTION

SECTION 23 07 10

INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Contractor shall provide all necessary labor, materials, tools, and equipment to perform work required on the drawings and specified herein.

B. Certain equipment and/or systems to be factory insulated by manufacturer. Factory insulation materials to be as specified in applicable sections of the specifications.

C. All pipe fittings, valves, and strainers in insulated pipe systems to be insulated.

D. Thermal resistance "R" values used herein are expressed in units of "Hour, Degrees F., Sq. Ft./BTU per Inch of Thickness" on a flat surface at a mean temperature of 75 degrees F.

E. "Contractor's Option" referred to in Materials below indicates optional materials which may be used as equals.

1.2 DEFINITIONS

A. "Exposed" equipment, ducts, and piping are areas which will be visible without removing ceilings or opening access panels.

B. Outdoors is considered exposed to the weather.

C. Underground is buried, whereas in a trench below grade is considered concealed.

1.3 CERTIFICATION/QUALITY ASSURANCE

A. Products shall meet applicable national, state, and local building codes and be U.L. (or other recognized testing lab) listed for intended service.

B. All insulations, jackets, adhesives, coatings, sealers, and tapes shall have a flame spread rating of 25 or less and smoke development rating of 50 or less when tested in accordance with ASTM E-84, NFPA 225, U.L. 723, and further must meet the requirements of NFPA 90-A and applicable building, plumbing, and mechanical codes.

C. All insulation materials shall be delivered and stored in manufacturers' containers and kept free from dirt, water, chemical, and mechanical damage.

D. Insulation shall be applied in a workmanlike manner by experienced, qualified tradesmen.

E. Insulation shall not be applied until all pressure testing has been completed, inspected, and released for insulation application.

F. Surfaces shall be clean and dry.

G. Insulation joints shall be butted firmly together and all jackets and tapes shall be smoothly and securely installed.

H. Insulation for duct, pipe, and equipment for above grade exposed to weather outside building shall be certified as being self-extinguishing for 1" thickness in less than 53 seconds when tested in accordance with ASTM D-1692.

1.4 APPLICABLE CODES AND STANDARDS

A. ASTM E-84.

B. U.L. 723.

C. NFPA 90-A.

D. ASHRAE 90.1

PART 2 - PRODUCTS

2.1 MATERIALS FOR PIPE AND EQUIPMENT

A. Materials for Pipe and Equipment: Provide factory pre-molded or shop or site mitered segment type insulation for pipe, pipe fittings, and valves. Fitting insulation to be of same thickness and material as adjoining pipe insulation. All insulation and related materials such as tape and mastic to meet applicable building code requirements for fire and smoke development.

1. Flexible Tubular: Provide 25/50 rated, closed-cell, flexible tubular rubber type pipe insulation. Product to have continuous operational temperature limit of 200 degrees F. and a minimum "R" value of 3.7 per inch (K=0.27) at 75 degrees F mean temperature. Product to be Armstrong AP Armaflex or approved equal pipe insulation. Use flexible tubular for the following services:

   a. Moisture condensate drains: 1" thick.

   b. Refrigerant suction lines for split systems: 1" thick.

   c. Provide multiple layers as required to obtain minimum thickness.

2. Fiberglass: Provide factory-formed, factory-jacketed fiberglass piping insulation. Product to be Manville "Micro-Lok 650" with "Type AP-T" jacketing or equivalent product manufactured by CertainTeed, Knauf, or Owens-Corning. Product to have continuous operational temperature limit of 850 degrees F and a minimum "R" value of 4.3 per inch thickness (K=0.23) at 75 degrees F mean temperature. Jacket to be fiberglass reinforced kraft paper with aluminum foil and pressure sensitive closure system. Vapor-barrier mastic for application to **below** ambient pipe insulation shall be fungus resistant per ASTM D 5590 with 0 growth rating; Water based; Permeance per ASTM E 96, Procedure B, 0.013 perm or less at 43-mil dry film thickness suitable for indoor and jacketed outdoor use. Products: Foster 30-80 AF. Color: White. A breather mastic for application to above ambient pipe insulation (fittings, tees, valves, etc) shall be water based Foster 46-50 mastic or Childers CP-10 / CP-11. Use fiberglass piping insulation for the following services:

   a. Heating hot water piping: 1-3/8" and under – 1.5" thick; 1-5/8" and greater - 2" thick.

2.2 MATERIALS FOR DUCTS

A. Blanket Type Duct Insulation: Provide minimum 3/4 pound per cubic foot density, flexible blanket fiberglass duct insulation with FSKL aluminum foil vapor barrier facing and 2" tab. Insulation shall have minimum ‘R’ value of 3.4 per inch (K=0.29) at 75 degrees F mean temperature. Product to be Manville "Microlite" or equivalent standard duct wrap by CertainTeed, Knauf, or Owens-Corning. Use blanket type duct insulation for the following:

1. Unlined heating and/or cooling supply air and return ductwork concealed from view: 2" thick.

B. Board Type Duct Insulation: Provide minimum 3 pound per cubic foot density, semi-rigid fiberglass duct insulation with FSKL aluminum foil vapor barrier facing. Insulation shall have a minimum ‘R’ value of 3.8 per inch (K=0.26) at 75 degrees F mean temperature. Product to be Manville "800 series Spin-Glas" or equivalent by CertainTeed, Knauf, or Owens-Corning. Use board type duct insulation for the following services:

1. Unlined exposed heating and/or cooling supply air ducts: 1-1/2" thick.

C. Fire-Rated Duct Enclosures: Provide noncombustible, inorganic fireproofing board or jacketed wrap for fire-rated duct enclosures equivalent to PABCO Super Firetemp, Thermal Ceramics Firemaster, CertainTeed Flamecheck, Johns Manville Firetemp, or Nelson FlameShield. The system shall be designed for 1800 degree F. continuous service and meet the following testing standards: ASTM E-84 and E-119; U.L. 263, 1479, and 1709; U.L. Classification for fire-rated duct enclosures. A total 2-hour fire-rated assembly shall be created.

2.3 MATERIALS FOR FITTINGS, VALVES, AND SPECIAL COVERINGS

A. Provide coverings and finishes for specific items hereinafter specified.

1. Use pre-molded insulation fabricated by the manufacturer of insulation material or shop or site mitered segment type insulation for: All pipe fittings, elbows, tees, valves, and couplings.

2. PVC fitting covers over blanket fiberglass are NOT acceptable.

B. For heat exchangers, air separators, large pipes, etc., in systems operating over 60 degrees F., when exposed-to-view inside building or in equipment rooms, cover insulation with a smoothing coat of Keane Powerhouse cement, one layer of white colored glass mesh embedded and finished with Foster 46-50 mastic or Childers CP-10 / CP-11 mastic.

C. For pipe fittings, valves, strainers, air separators, and other irregular surfaces, in systems operating below 60 degrees F., when exposed to view inside building or in equipment rooms, cover insulation with white colored glass mesh embedded in white, fungus resistant vapor barrier coating Foster 30-80 AF. Coating shall meet ASTM D 5590 with 0 growth rating.

D. Fabricate and install readily removable insulation caps to facilitate service and maintenance accessibility to all strainers including suction diffusers in systems operating below 60 degrees F.

E. For any service when above grade exposed-to-the-weather outside building, cover straight pipe insulation with 0.016" thick aluminum jacket equivalent to ITW or RPR and cover valves and fittings with .024" thick aluminum factory formed covers equivalent to Childers Ell-Jacs.

F. For any service when below grade direct buried, cover straight pipe and fitting insulation with equivalent of Pittsburgh Corning "Pittwrap", Foster C.I. Wrap 50 or "Pittwrap SS11" jacketing. Valves in systems operating above 60 degrees F. and installed in valve boxes shall not be insulated; however, the valves shall be painted with a rust resistant product equivalent to Rustoleum.

G. For flexible tubular pipe and fitting insulation when exposed-to-view inside building or exposed to the weather, finish with two coats of paint, custom color blended to match surrounding surfaces.

H. When specifically approved by designer, when it is impossible to completely insulate pipe, fittings, or valves with specified insulation, Armstrong Armaflex insulation tape may be used to prevent condensate drip on small piping. Use of cork insulation tape is prohibited.

PART 3 - EXECUTION

3.1 GENERAL

A. No insulation shall be cut where a hanger is located. If hangers have been installed by pipefitter tradesmen which violates this strict requirement, notify Designer immediately.

B. Piping and ductwork systems shall be tested and found free of all leaks prior to installation of insulation covering.

C. All surfaces shall be clean and dry when covering is applied. Covering to be dry when installed and during application of any finish unless such finish specifically requires a wetted surface for application.

D. All adhesives, cements, and mastics shall be compatible with materials applied and shall not attack materials in either wet or dry state.

E. Install insulation using professional insulators who have adequate experience and ability.

F. Exposed-to-view insulation shall have a well-tailored appearance.

G. See Section 23 21 13 for sleeves and insulation requirements.

H. Stop all duct coverings, including jacket and insulation, at fire and smoke dampered penetrations of partitions. "Fan-Out" or extend jacketed insulation at least 2" beyond angle frames of dampers and secure insulation to partition. Maintain vapor barrier. Where

insulated duct access door is not used, install covering over damper access panel so as to be readily removable and identifiable.

I. Treat insulated pipe and duct surfaces in equipment rooms and where exposed to normal view, so surfaces may be painted with water base latex paint. Use of mastics, adhesives, or jacketing which cause "bleeding" is prohibited.

3.2 INSTALLATION OF DUCT COVERING

A. Apply jacketed blanket type fiberglass covering to ducts pulled snug but not so tight as to compress corners more than 1/4". Use insulation having 2" tab, or cut insulation long enough to allow for "peel off" of insulation from jacket to effect a minimum overlap of 2". Secure 2" jacket laps using equivalent of Foster 85-75 or CP-82 adhesive and staple lap with flare type staples on 2" centers. Cover standing seams, stiffeners, and braces with same insulation blanket, using 2" jacket lap and staple lap as hereinbefore outlined. Cover and seal all staples with Foster 30/80 AF, fire resistant vapor barrier coating reinforced with glass cloth.

B. For duct 24" or wider, mechanically fasten insulation to duct bottom, using weld pins or nylon "stick-clip" base plates having self-locking coated metal or nylon discs. Locate fasteners on not over 12" centers laterally and longitudinally. Seal pins as above.

C. For ducts more than 20” deep, mechanically fasten insulation to duct sides, using one row of pins, plates, or discs located on not over 12" centers longitudinally and equidistant laterally between duct top and bottom. For ducts over 24" deep, apply fasteners as before only using minimum of two rows.

D. Apply jacketed board type fiberglass covering to ducts using weld pins or nylon "stick-clip" base plates having self-locking coated metal or nylon discs. Locate fasteners on not over 12" centers laterally and longitudinally. If insulation is grooved to fit around corners, in order to eliminate as many joints as possible, pin as required to hold insulation tight to duct, especially on bottom of duct. Seal pins and joints with Foster 30-80 AF reinforced with glass mesh.

E. Cover all joints, rips, tears, punctures, disc heads, staples, or breaks in vapor barrier jacket with 4" wide woven glass fabric tape embedded in Foster 30-80 AF fire resistant vapor barrier coating. PRESSURE SENSITIVE TAPE NOT ALLOWED.

F. Prior to application of flexible sheet insulation, thoroughly clean all metal surfaces, making sure that all dirt, scale, loose paint, plaster, and oil have been removed and that surfaces are dry. If surface has been primed, test a 2 square foot section using adhesive equivalent to Armstrong 520, Foster 85-75 or Childers CP-82 in order to determine whether solvent in adhesive will loosen or lift the primer. If primer is loosened, then remove it. When testing proves acceptable, adhere insulation with smooth side out, using thin but adequate coating of same adhesive. Follow manufacturers’ instructions. Coat all butt edges of each sheet. Stagger all joints. Insulate all standing seams or flanges with same thickness of insulating material as that used on main surface. Seal all butt joints, miter joints, and torn or damaged insulation with adhesive.

G. Install fireproof grease duct enclosures in strict accordance with manufacturers’ published U.L. installation instructions.

H. Ductwork manual volume damper (MVD) handles, airflow station pressure ports, access door handles, duct-mounted instrumentation, etc., shall be left exposed and/or accessible above the insulation vapor barrier.

3.3 INSTALLATION OF PIPE AND EQUIPMENT COVERING

A. Where fiberglass or flexible tubular insulation is used on piping sized 2" and larger, insert a section of foamglass insulation at hanger or support points between pipe and metal shield for full length of shield to prevent crushing of insulation. Insulation thickness to be same as adjoining insulation. Where insulation passes through pipe hangers and across trapeze supports, 12" long metal saddles shall be used. On cold pipe, vapor barrier should be carried through the hanger and sealed.

B. Apply flexible tubular insulation to pipe and fittings using the slip-on method with all joints tightly fitted and sealed with Armstrong 520, Foster 85-75, Childres CP-82 adhesive or approved equal. Seal butt joints, miter joints and torn or damaged insulation with adhesive.

C. Prior to application of flexible sheet insulation, thoroughly clean all metal surfaces, making sure that all dirt, scale, loose paint, plaster, and oil have been removed and that surfaces are dry. If surface has been primed, test a 2 square foot section using adhesive equivalent to Armstrong No. 520, Foster 85-75, Childers CP-82 in order to determine whether solvent in adhesive will loosen or lift the primer. If primer is loosened, then remove it. When testing proves acceptable, adhere insulation with smooth side out, using thin but adequate coating of same adhesive. Follow manufacturers' instructions. Coat all butt edges of each sheet. Stagger all joints. Insulate all standing seams or flanges with same thickness of insulation material as that used on main surface.

D. All hot water pump casings shall be insulated with readily removable insulation sections that allow easy access to all pump components, pressure gauges, P/T ports, etc., requiring testing or maintenance access.

E. Piping insulation on in-line mounted P/T ports, circuit setting pressure ports, calibrated balancing valve pressure ports, etc. shall be made easily removable so that access to the ports can be readily obtained without destroying the insulation.

END OF SECTION

SECTION 23 08 10

HVAC COMMISSIONING PROCEDURES AND CHECKLISTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning: Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the Owner's operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment start-up/checkout, control system calibration and point-to-point (PTP) checkout, testing and balancing, verification, field functional performance testing and Owner training.

B. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

C. Abbreviations: The following are common abbreviations used in these Specifications:

1. A/E - Architect and Design Engineer
2. OR - Owner’s Representative
3. FPT - Functional Performance Verification Test
4. PC - Pre-Functional Checklist
5. MC - Mechanical Contractor
6. TAB - Test and Balance Contractor
7. CM - Construction Manager

1.2 SYSTEMS TO BE COMMISSIONED

A. The following systems will be commissioned in this project: HVAC Systems: Boilers, fuel oil pumps, water pumps, air handlers and rooftop units, variable frequency drives, terminal boxes, fan coil units, unit heaters, electric heaters, fans, fire and smoke dampers, Building Automation System (and EMS).

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of plus or minus 0.1 degree F. Pressure sensors shall have a accuracy of plus or minus 2.0 percent of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

3.1 PREFUNCTIONAL CHECKLISTS

A. General: Prefunctional checklists are important to ensure that the equipment and systems are operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The checklist is intentionally designed as a broad, high level check of the completed installation and is not intended to cover all the detailed checks necessary during the installation process or during the vendor startup required for some equipment. The PC for a given system must be successfully completed prior to the beginning of the TAB field work and formal functional performance testing of equipment or subsystems of the given system.

B. PC forms have been developed and are included in this specification section under subparagraph 3.3, Submittal Forms. The PC should be used to inspect the completed installation of major HVAC equipment. Since the checklist is generic, intended for use on multiple projects, some line items may not apply to this project or certain pieces of equipment. If a PC line item does not apply, indicate this by checking the N/A column rather than the OK column. PC line items that are not complete or are not in compliance at inspection should not be checked as OK until they are completed. The section below each PC shall be utilized for recording comments or making notes. As the work progresses, other forms may be developed as necessary for special pieces of equipment not adequately covered by the included PC forms.

C. Copy the PC and complete a separate form for each individual piece of equipment where multiple similar or identical pieces of equipment are installed.

D. The MC representative shall inspect the installed HVAC equipment using the PC and initial and date each item that passes inspection. Only individuals that have direct knowledge and witnesses that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

E. The CM shall oversee the subs and the vendors in collecting and retesting deficiencies or uncompleted items. The installing subs or vendors shall correct all areas that are deficient in the checklists and tests in a timely manner, and shall notify the CM as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original non-compliance report.

F. Items left incomplete, which later cause deficiencies or delays during functional testing, may result in backcharges to the responsible party.

G. When each item on the checklist has passed inspection, the MC and CM shall also inspect the installed equipment and sign the checklist to certify the installation is complete and acceptable from a quality standpoint. The signed checklist is to be included in the project closeout documents delivered to the owner.

3.2 FUNCTIONAL PERFORMANCE TESTING

A. Objectives and Scope: The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.

B. Specific FPT forms have been developed and are included in this specification section under subparagraph 3.3, Submittal Forms. Prior to execution, the CM shall provide a copy of the test procedures to the sub(s) who shall review the tests of feasibility, safety, equipment, and warranty protection. As the work progresses, other forms may be developed as necessary for special pieces of equipment not adequately covered by the FPT forms included with this specification section.

C. The contractor and subs shall witness and document the results of all FPT using the included procedural forms. Once the FPT has been completed successfully, the contractor shall repeat the FPT in the presence of the OR and/or A/E. The OR and/or A/E will decide during the Performance Verification site visit whether all or a representative sample of systems will be subject to this testing.

D. The contractor is responsible for including the FPT verification in the construction schedule. The contractor is responsible for contacting the project architect and scheduling the design consultants and owners representative to witness the FPT. The design consultants and owners representatives reserve the right to terminate the FPT if in their opinion the test results indicate the systems are not progressing properly. The contractor shall be responsible for return travel expenses for any retest. All systems required for owner

occupancy will have their FPT completed and approved prior to Owner occupancy, opposed season test excluded.

E. The contractor shall incorporate in the project closeout documents all the approved results and procedures.

3.3 SUBMITTAL FORMS

A. Prefunctional Checklist.

B. Functional Performance Test Report.

END OF SECTION

SECTION 23 08 10A

HVAC PRE-FUNCTIONAL CHECKLIST

The HVAC Pre-functional Checklist should be used to inspect the completed installation of the major HVAC equipment. The Division 23 specifications, the mechanical drawings, and vendor submittal information are to be referenced in determining whether the installation is acceptable. Any conflicts among these sources should be presented to the Design Consultant through the appropriate means for resolution.

Since the checklist is generic, some line items in the checklist may not apply to every project. If a checklist line item does not apply to the particular project being inspected, please so indicate by checking the N/A column (not applicable) rather than the OK column in the checklist. Checklist line items that are not complete or not in compliance at time of inspection should not be checked as OK until they are complete. The checklist for each kind of the major HVAC equipment contains a section below the checklist for recording comments or making notes.

Please copy the checklist and complete a separate form for each piece of equipment where multiple similar or identical pieces of equipment are installed. (The checklist has a space to identify a boiler or chiller, etc. as #1, #2, etc.)

When all the applicable checklist items for a piece of major equipment have been inspected and found in compliance with the contract documents, the checklist is to be signed by Mechanical Subcontractor's superintendent and the General Contractor's Project Manager or Systems Engineer. The signed checklist should be included in the project closeout manual.

	AIR HANDLING UNIT #_____	OK	N/A
	FANS AND CASING SECTIONS:		
1.	Spring isolators installed and not bottomed out.		
2.	Motor rotation correct and free fan wheel rotation.		
3.	Motor belts aligned and properly tensioned.		
4.	Proper VFD installed and labeled.		
5.	Bearing races secured tight to fan shaft.		
6.	Bearing grease zert fittings accessible and lubricated.		
7.	All bolts, fasteners, and set screws checked & tightened.		
8.	At full speed, fans have no unusual noise or vibration.		
9.	All safety guards are properly installed.		
10.	Access doors close tightly, door gaskets installed.		
11.	Casing/duct sealed with proper sealant.		
12.	Proper insulation installed on casing and duct, and joints sealed.		
13.	No evidence of air escaping unit or insulation ballooning w/fans on.		
14.	Duct static pressure control sensor installed at proper location.		
15.	Supply duct static pressure safety sensor installed at proper location.		
16.	Return duct static pressure safety sensor installed at proper location.		
17.	Flex connections at Supply & Return plenum installed.		
18.	Condensate drain trapped properly and run to floor drain.		
19.	Manufacturer's required clearances for unit/components maintained.		
20.	Dampers/actuators properly installed & close tightly.		
21.	Damper linkage checked for binding, min. play & right blades.		
22.	Filters installed tightly and checked for no bypass.		
23.	All filters are front loading, not slide in.		
24.	Filter manometers installed, calibrated and clean/dirty AP marked.		
25.	Air Handler control system operational.		
26.	Smoke and fire dampers installed in proper locations w/access doors		
27.	Mixed Air sensor located properly w/lft of sensor per sq. ft. of coil.		
28.	All surfaces are clean and free of rust.		
29.	No water or condensate observed except or coil and drain pan.		

	D/X COOLING:	OK	N/A
1.	Coils clean and fins are in good condition.		
2.	No open area around coil for air bypass.		
3.	Coil piped for counter flow.		
4.	Chilled water pipe complete and piping properly supported.		
5.	Chilled water pipe is properly insulated and labeled.		
6.	Chilled water pipe pressure test complete and no leaks.		
7.	Air bleed valves with caps installed.		
8.	Strainers, drain valve, hose bib and cap installed.		
9.	Dirt leg drain valve whose bib connections & caps installed.		
10	Piping, valves, and clearances accommodate coil removal.		
11	Balance valve properly installed per detail.		
12	Control valves properly installed.		
13	Thermometers, PT plugs, pressure gages properly installed per detail.		
14	Condensate pan, traps & drain remove condensate properly.		

Air Handing Unit and Coil Comments:

_____

_____

_____

_____

_____

Approvals:

Date	Date
Mech. Contractor Signature	GC PM/Sys. Engineer Signature

	BOILER #_____	OK	N/A
1.	Unit is level.		
2.	All bolts are tight.		
3.	Clearance for maintenance and tube pull verified.		
4.	Gas line connected.		
5.	Gas pressure correct for burner.		
6.	Gas pilot with ability to function when running on propane.		
7.	Gas vents are installed correctly.		
8.	Relief valves are correctly installed.		
9.	Flue stack installed and complete with thermometer mounted.		
10.	Verify external pipe connections are to the correct boiler opening.		
11.	Verify PRV's are at the correct settings.		
12.	D.W. make up installed, pressure correct, and back flow preventor in place		
13.	Verify boiler has been boiled out properly.		
14.	Boiler condensate neutralization kit installed.		
15.	Flue drain installed.		
16.	Propane lines connected.		
17.	Water treatment test completed and chemicals added.		
18.	Factory representative start-up completed & documented.		
19.	Boiler and pumping system connected to emergency power		

Boiler Comments: _____

_____

_____

_____

_____

Approvals:

Date Date _____

Mech. Contractor Signature GC PM/Sys. Engineer Signature

	VAV/CV TERMINAL BOX #_____	OK	N/A
1.	Minimum of 1 & 1/2 box inlet diameter of hard duct at box inlet.		
2.	Duct run out from lateral greater than 15' shall be 1 size larger than inlet of VAV		
3.	Required clearance for servicing box controls is maintained		
4.	Correct piping package for reheat coil and proper clearance maintained		
5.	Hot water return and air bleed at top of coil.		
6.	Piping supported properly within 3 ft of box		
7.	Electrical connections complete.		
8.	Box properly located and supported.		
9.	Hot water return line not elevated above air bleed valve.		

Terminal Box Comments: _____

_____

_____

_____

_____

Approvals:

Date _____ Date _____

Mech. Contractor Signature GC PM/Sys. Engineer Signature

	HHW PUMP #_____	OK	N/A
1.	Pressure gauge connection at pump inlet & outlet flanges.		
2.	Single pressure gauge installed with valves to select entering strainer, leaving strainer (pump suction) or discharge pressure.		
3.	Rotation correct.		
4.	Strainer w/valve, hose bib and cap installed.		
5.	Piping supported so that pump bears no pipe weight or lateral force.		
6.	Drains piped to floor drain.		
7.	Motor and pump coupling alignment verified.		
8.	Cleanout of system piping complete.		
9.	Suction start up strainer has been replaced w/ permanent strainer.		
10.	Expansion tank connected to suction side of pump.		
11.	Makeup water PRV set at correct pressure.		
12.	Starters installed.		

Pump Comments:

_____

_____

_____

_____

_____

Approvals:

Date Date

Mech. Contractor Signature GC PM/Sys. Engineer Signature

	EXHAUST or MISC. FANS	OK	N/A
1.	Spring isolators installed and not bottomed out.		
2.	Motor rotation correct and free fan wheel rotation.		
3.	Motor belts aligned and properly tensioned.		
4.	Proper starter/VFD installed and labeled.		
5.	Bearing races secured tight to fan shaft.		
6.	Bearing grease zert fittings accessible and lubricated.		
7.	All bolts, fasteners, and set screws checked & tightened.		
8.	At full speed, fans have no unusual noise or vibration.		
9.	All safety guards are properly installed.		
10.	Manufacturer's required clearances for unit/components maintained.		

Exhaust or Misc. Fan Comments:

_____

_____

_____

_____

_____

Approvals:

Date	Date
Mech. Contractor Signature	GC PM/Sys. Engineer Signature

RTU-DX

HCA

RTU-DX

UNIT CONFIGURATION	
1	Exhaust Fan
2	Economizer
3	Pre Filter
4	Preheat hot water Coil
5	Dx Coil
6	Supply Fan
7	Final Filter
8	Compressors
BASIC DESIGN INFORMATION	
9	Unit Design CFM when all VAV terminals are at full cooling
10	Unit Design CFM when all VAV terminals are at minimum
11	Design Minimum Outside Air CFM
PARAMETERS	
12	Outside Air Temperature
13	Outside Air Humidity
14	Return Air Temperature
15	Discharge Air Temperature Setpoint
16	Discharge Air Temperature
17	Duct Static Pressure Setpoint
18	Duct Static Pressure
19	Building Pressure Setpoint
20	Building Pressure
21	Minimum OA Damper Position
22	Return Air Damper Position
23	Exhaust Air Damper Position
24	Supply Fan Speed
25	Exhaust Fan Speed
BAS CONNECTIVITY TEST	
26	Identify the BAS contol system used at the hospital this FSER is associated with.
27	Verify the BAS for the FSED and Hospital are the same.
28	Verify the RTU standalone Micro-processor is connected via BACnet to the central controller

29	Verify the air handling unit, all boxes and other associated mechanical equipment are communicating with the associated hospital BAS system.
DAMPER BINDING TEST	
30	Test Procedure: Command VAV terminals served by this RTU to 100% design cooling CFM
OUTSIDE AIR DAMPERS	
31	Test Procedure: Command OA damper closed
32	Verify OA damper closed tightly
33	Test Procedure: Command OA damper 5% open
34	Verify actuator & blades of OA damper begin to open
35	Test Procedure: If No, open damper in 2% increments
36	Record value when damper motion begins
37	Are values less than 15%
38	If the value at which the damper begins to move is greater than 15%, respan the damper to this percentage and record number.
39	Test Procedure: Command Outside Air damper to 90%
40	Are values less than 15%
41	Test Procedure: Command Outside Air damper to 100%
42	Verify the damper has movement between 90% and 100% open
43	Verify the Outside Air Damper is fully open.
RETURN AIR DAMPER	
44	Test Procedure: Command Return Air damper closed
45	Verify Return damper closed tightly
46	Test Procedure: Command Return damper 5% open
47	Verify actuator & blades of Return damper begin to open
48	Test Procedure: If No, open damper in 2% increments
49	Record value when damper motion begins
50	Are values less than 15%
51	If the value at which the damper begins to move is greater than 15%, respan the damper to this percentage and record number.
52	Test Procedure: Command Return Air damper to 90%
53	Are values less than 15%
54	Test Procedure: Command Return Air damper to 100%
55	Verify the damper has movement between 90% and 100% open
56	Verify the Return Air Damper is fully open.
EXHAUST AIR DAMPER	
57	Test Procedure: Command Exhaust Air damper closed
58	Verify Exhaust damper closed tightly
59	Test Procedure: Command Exhaust damper 5% open
60	Verify actuator & blades of Exhaust damper begin to open
61	Test Procedure: If No, open damper in 2% increments

62	Record value when damper motion begins
63	Are values less than 15%
64	If the value at which the damper begins to move is greater than 15%, respan the damper to this percentage and record number.
65	Test Procedure: Command Exhaust Air damper to 90%
66	Are values less than 15%
67	Test Procedure: Command Exhaust Air damper to 100%
68	Verify the damper has movement between 90% and 100% open
69	Verify the Exhaust Air Damper is fully open.
70	Release all damper overrides
STATIC PRESSURE CONTROLLER	
71	Record location (room Number and Name) of static pressure sensor
72	Is pressure being sensed in area being served by this RTU?
73	Record TAB recommended setpoint necessary to satisfy worse case air terminal
74	List box that determines setpoint
75	Test Procedure: Set static SP to recommended value. Command VAVs to Design Full Cooling CFM.
76	Verify calibration of sensor by comparison to TAB contractors test instrument measuring pressure between same locations as sensor.
77	Record BAS static pressure reading
78	Record TAB static pressure reading
79	Readings are within specified tolerance
80	Test Procedure: Adjust setpoint down 0.4" below current setpoint
81	Record adjusted static pressure setpoint valve
82	Verify supply fan modulates down to adjusted setpoint
83	Reset static SP back to TAB recommended value
STATIC PRESSURE ALARM	
84	Test Procedure: Manually increase the speed of the supply fan so the static pressure sensor is 50% above the operating setpoint.
85	Record operating static pressure
86	Verify BAS alarmed at 50% above static pressure setpoint
87	If NO: Set BAS alarm to alarm at this point
88	Test Procedure: Manually decrease the speed of the supply fan so the static pressure sensor is 50% below the operating setpoint.
89	Record operating static pressure
90	Verify BAS alarmed at 50% below static pressure setpoint
91	If NO: Set BAS alarm to alarm at this point
92	Release Supply Fan VFD to automatic control
BUILDING PRESSURE CONTROLLER	
93	Record location (room Number and Name) of building pressure sensor
94	Record TAB recommended building pressure setpoint
95	Verify calibration of sensor by comparison to TAB contractors test instrument measuring pressure between same locations as

	sensor.
96	Record BAS building pressure reading
97	Record TAB building pressure reading
98	Readings are within specified tolerance
99	Test Procedure: Adjust setpoint down 0.4" below current setpoint
100	Record adjusted building pressure setpoint valve
101	Verify exhaust fan modulates down to adjusted setpoint
102	Reset static SP back to TAB recommended value
103	Test Procedure: Disable the exhaust fan and close return damper.
104	Manually increase the supply fan until the building pressure sensor is +0.02" above the recommended setpoint value. Record value.
105	Verify alarm is sent to the BAS.
106	Manually decrease the supply fan until the building pressure sensor is -0.02" below the recommended setpoint value. Record value.
107	Verify alarm is sent to the BAS.
SENSOR CALIBRATION	
108	Test Procedure: Close minimum OA, economizer OA, and exhaust damper and open return damper 100%. Set OA CFM SP to 0 CFM. Command VAV boxes to full design CFM
109	Test Procedure: Slowly ramp up supply fan speed until return fan is almost unable to maintain a steady 0 CFM SP
110	Verify no air is leaking through the closed OA & relief dampers
111	Test Procedure: Compare sensor readings against TAB contractor test instrument measuring temperature or humidity at same location as sensor (Tolerance - +/- 0.5°F & +/- 5% RH)
112	Return Air Temperature (BAS Reading)
113	Return Air Temperature (TAB Reading)
114	Is the sensor within Tolerance? If not, calibrate sensor and rerun test.
115	Return Air Humidity (BAS Reading)
116	Return Air Humidity (TAB Reading)
117	Is the sensor within Tolerance? If not, calibrate sensor and rerun test.
118	Discharge Air Temperature (BAS Reading)
119	Discharge Air Temperature (TAB Reading)
120	Is the sensor within Tolerance? If not, calibrate sensor and rerun test.
121	Building Pressure Sensor (BAS Reading)
122	Building Pressure Sensor (TAB Reading)
123	Is the sensor within Tolerance? If not, calibrate sensor and rerun test.
124	Outside Air Temperature (BAS Reading)
125	Outside Air Temperature (TAB Reading)
126	Is the sensor within Tolerance? If not, calibrate sensor and rerun test.

127	Outside Air Humidity (BAS Reading)
128	Outside Air Humidity (TAB Reading)
129	Is the sensor within Tolerance? If not, calibrate sensor and rerun test.
HIGH STATIC SAFETY SWITCH ALARM	
130	Record High Static Safety Switch Setting Approved by Design Consultant
131	Test Procedure: With fan running, trip high static safety switch with squeeze bulb & magnahelic gauge. Adjust setting as required to trip at recorded setting above
132	Record High Static Safety Switch Setting after adjustment
133	Verify RTU supply fan, exhaust fan, & associated EFs shut down
134	Verify RTU economizer, minimum OA, & exhaust dampers modulate closed
135	Record actual switch setpoint adjacent to switch on AHU casing with black permanent marker
DIRTY FILTER ALARM FINAL FILTERS	
136	Record Dirty Pressure Drop Setpoint for Final Filter (Consult submittal & filter schedule)
137	Test Procedure: With fan running, trip dirty filter switch with squeeze bulb & magnehelic gauge. Adjust setting as required to trip at recorded setting above
138	Record Dirty Pressure Drop Setpoint after adjustment
139	Verify Dirty Final Filter Alarm was generated at BAS
140	Test Procedure: Reset dirty filter alarm
141	Verify alarm was cleared on BAS
142	Verify dirty filter setpoint is marked on pressure gauge
LOW STATIC SAFETY SWITCH ALARM	
143	Record Low Static Safety Switch Setting Approved by Design Consultant
144	Test Procedure: With fan running, trip low static safety switch with squeeze bulb & magnehelic gauge. Adjust setting as required to trip at recorded setting above
145	Record Low Static Safety Switch Setting after adjustment
146	Verify RTU supply fan, return fan, & associated EFs shut down
147	Verify RTU economizer, minimum OA, & relief dampers modulate closed
148	Verify return damper modulates fully open
149	Record actual switch setpoint adjacent to switch on RTU casing with black permanent marker
DIRTY FILTER ALARM PRE-FILTERS	
150	Record Dirty Pressure Drop Setpoint for Pre-Filter (Consult submittal & filter schedule)
151	Test Procedure: With fan running, trip dirty filter switch with squeeze bulb & magnehelic gauge. Adjust setting as required to trip at recorded setting above
152	Record Dirty Pressure Drop Setpoint after adjustment
153	Verify Dirty Pre-Filter Alarm was generated at BAS
154	Test Procedure: Reset dirty filter alarm

155	Verify alarm clears on BAS
156	Verify dirty filter setpoint is marked on pressure gauge
ECONOMIZER MODE OPERATION	
157	This test should be performed when the OAT is above 58°F if possible.
PRELIMINARY SETUP	
158	Test Procedure: Release VAV/CAV boxes to auto.
159	Test Procedure: Set DAT SP to 55°F
160	Record Actual BAS DAT
161	Record Actual BAS OAT
162	Record Actual BAS RA Enthalpy
163	Record Actual BAS OA Enthalpy
164	Record Low Ambient Compressor Lockout Temperature
165	Record the BAS Economizer Method (1, 2, or 3)
166	Record the Outside Air Enthalpy Limit (22 BTU/lb adj.)
167	Set the BAS Economizer Method to 3
168	Test: Simulate the outside air enthalpy to be 20 BTU/lb.
169	Simulate the return air enthalpy to be 21 BTU/lb
170	Verify the economizer is enabled
171	Verify the compressors are operating.
172	Test: Simulate the outside temperature to be 49 degrees
173	Verify the compressors are commanded off.
174	Release the outside temperature command.
175	Verify the compressors are commanded on after timeout.
176	Set the Outside Air Enthalpy to be 23 BTU/lb
177	Verify the economizer is disabled
178	Release all overrides and return the unit to normal operation
FINAL SETPOINTS	
179	Ensure all test overrides have been released and the unit is operating in normal conditions.
180	Test Procedure: Record the following Setpoints
181	DAT SP
182	RAT SP
183	RAH SP
184	Building static pressure SP
185	Economizer with Mechanical Cooling enable temperature
186	Low Ambient Compressor Lockout (Temperature transition to full economizer)
FINAL READINGS	
187	Test Procedure: Record the following Parameters

188	OAT
189	RAT
190	DAT
191	Duct Static Pressure
192	Building Differential Pressure
193	Minimum OA Damper Position
194	Economizer OA Damper
195	Return Air Damper Position
196	Exhaust Air Damper Position
197	SF VFD Speed
198	RF VFD Speed

24 HOUR UNIT TRENDS

199	Test Procedure: Set up trend log to record the following required points once every 1 minute preferred or a minimum of once every 3 minutes for 24 hours. Data shall be in electronic tabulated form in excel and transmitted to engineer for review. Obtain HCA data formatting template from design engineer and present data in that format in excel spreadsheet
200	OAT
201	DAT
202	DAT SP
203	RAT
204	Any monitored space humidity
205	Minimum OA Damper Position
206	Economizer OA Damper
207	Return Air Damper Position
208	Exhaust Air Damper Position
209	Supply Fan Speed
210	Return Fan Speed
211	Duct Static SP
212	Duct Static
213	Building Differential Pressure SP
214	Building Differential Pressure
215	Record Trend Start Date and Time
216	Record Trend End Date and Time

217	Release all damper overrides

PREHEAT COIL

218	OAT
219	Recirc Pump Status
220	Recirc Pump start date and time
221	2-way control valve modulate to maintain leaving air temp set point
222	Leaving Air Temp

Air Terminal Unit
FPT Report

(Follow the test procedures below. Complete the forms for only boxes noted to have problems during cooling or heating tests. Retain the completed forms from every test.)

HEATING MODE TEST

Initialization: Confirm with design consultant *that the* AHU is operating at the appropriate DAT set point and that the heating water system is operating at the correct supply water set point (usually 180°F). Run this test prior to the Cooling Mode Test. Run this test for 5 hours without any supply fan or return fan shutdowns. Doors to spaces should be closed for this test. Run this test beginning from a zone temp & set point of a 72°F.

STEP ONE - HEATING PERFORMANCE TEST

PROCEDURE: Begin trending all the BAS points listed. After 30 minutes into the test adjust thermostat controller on all the system boxes to maximum space design temperature (i.e. 78°F for the heating mode). The dead band between heating and cooling mode shall be 1°F .

TEST CONDITIONS

Value	Measured	Set	Difference
AHU Discharge Air Temp	°F	°F	°F
AHU CHW Valve Command	% Open		
Supply Chilled Water Sys	°F	°F	°F
Heating Hot Water Supply	°F	°F	°F
Outside Air Temp.	°F		

STEP TWO - HEATING PERFORMANCE TEST

PROCEDURE: In addition to trending the Test Condition points above, trend points at 3 minute intervals and provide an Excel worksheet for each terminal unit. The columns in each work sheet shall be ordered (L to R) *as* follows: date and time in ascending order, zone set point, actual zone temp, terminal unit discharge air temperature, reheat valve command, CFM set point, actual CFM, and damper commanded position. The 5 hour terminal trend data for the Heating Mode Test is to be shaded red. A separate Excel worksheet shall contain the AHU, CHW, HHW and OAT trend data. This form is only to be completed for terminal boxes that do not satisfy the three test conditions listed below during the initial test. Complete the data above and below on this sheet for any box that fails to meet any of the three conditions during the test. Transmit forms & trends to Owner.

Information	Response		Information	Response
BAS Box Identification			Space .- Name/No.	
Manufacturer			Inlet Size	
Model No.			Respective AHU	
Value			**Design**	**Difference**
Box. Damper Position	% open			
BAS Airflow	cfm		cfm	% difference
Box Discharge Air Temp	°F		°F	°F difference (Box) - T(AHU)1
Reheat Valve Position	% open			
Thermostat Setpoint	°F			
Space Temperature	°F		°F	°F difference [T(setpoint) – T(space)]

1. If space temperature cannot be maintained within +/- 1°F of set point; record investigative findings and corrective measures taken.

2. If box cannot control airflow to within +/- 10% of design heating air flow, record investigative findings and corrective measures taken.

3. If box reheat valve is commanded 100% open & discharge air temperature is not 15°F more than AHU DAT, record investigative findings and corrective action taken. If reheat valve is commanded to less than 100% open, raise T-stat set point 5°F above current space temp, verify reheat valve *is* commanded 100% open & box discharge temp is 15°F above AHU DAT.

WITNESSED:

General Contractor

BAS Controls Contractor

Air Terminal Unit
FPT Report

(Follow the test procedures below. Complete the forms for only boxes noted to have problems during

Mechanical Contractor

Test and Balance Contractor

(Follow the test procedures below. Complete the forms for only boxes noted to have problems during cooling or heating tests. Retain the completed forms from every test.)

COOLING MODE TEST

Initialization: Confirm with design consultant that the AHU is operating at the appropriate DAT set point and that the heating water system is operating at design maximum supply water temperature (usually 180°F). Run this test for 5 hours without any supply fan or return fan shutdowns. Doors to spaces should be closed for this test. Run this test immediately after the Heating Mode Test.

STEP ONE - COOLING PERFORMANCE TEST

PROCEDURE: Begin trending all the BAS points listed. After 30 minutes into the test adjust thermostat controller on all the system boxes to minimum space design temperature; (i.e. 68°F for the cooling mode). The offset, or dead band, between heating and cooling mode shall be 1°F.

Value	Measured	Set Point	Difference
AHU Discharge Air Temp	°F	°F	°F
AIR CHW Valve Command	% open		
Supply Chilled Water Sys Temp	°F	°F	°F
Heating Hot Water Supply Temp.	°F	°F	°F
Outside Air Temp.	°F		

STEP TWO - COOLING PERFORMANCE TEST DOCUMENTATION

PROCEDURE: In addition to trending the Test Condition points above, trend points at 3 minute intervals and provide an Excel worksheet for each terminal unit. The columns in each work sheet shall be ordered (L to R) as follows: date and time in ascending order, zone set point, actual zone temp, terminal unit discharge air temperature, reheat valve command, CFM set point, actual CFM, and damper commanded position. The 5 hour terminal trend data for the Cooling Mode Test is to be shaded green. A separate Excel worksheet shall contain the AHU, CHW, HHW and OAT trend data This form is only to be completed for terminal boxes that do not satisfy the three test conditions listed below during the initial test. Complete the data above and below on this sheet for any box that fails to meet any of the three conditions during the test. Transmit forms & trends to Owner.

Information	Response		Information	Response
BAS Box Identification			Space - Name/No.	
Manufacturer			Inlet Size	
Model No.			Respective AHU	

Value	Measured	Design	Difference
Box Damper Position	% open		
BAS Airflow	cfm	cfm	% difference
Box Discharge Air Temp	°F	°F	°F difference [T(Box) - T(A.HU))
Reheat Valve Position	% open		
Thermostat Setpoint	°F		
Space Temperature	°F	°F	°F difference [T(Box) - T(A.HU)

1. If box damper position is 100% and space temperature cannot be maintained within +/- 1°F of set point record investigation and corrective measures taken.

2. If box measured air flow is not within +/- 10% of design cooling air flow, record the investigation and corrective actions taken.

3. If reheat valve is commanded to 0% open & box discharge air temperature is not within + 2°F of AHU, DAT, record the investigative findings and corrective actions taken. If reheat valve is commanded to greater than 0% open, lower T-stat set point 10°F below space temperature and repeat test and record results.

WITNESSED:

General Contractor | BAS Controls Contractor

Mechanical Contractor | Test and Balance Contractor

1.1.A Mechanical controls

1.1.A.a Acceptable Manufacturers: Johnson Controls (JCI) Metasys (Facility Explorer is not acceptable), Schneider Electric EcoStruxture, Distech Apex / Eclypse Controls, Siemens Apogee, and Vykon Controls as follows.

1.1.A.b On new FSERs, the project shall be open for competitive bid between the approved providers listed above, excluding Siemens Apogee Controls. Where a new facility has a parent hospital with existing approved controls, the project should be competitively bid by approved vendors via integration, excluding Siemens BAS.

1.1.A.c For Facilities with a mix of existing systems, the Engineer should consult with FacilitiGroup, Manager of Building Technologies to determine HCA's preferred solution.

1.1.A.d Johnson controls shall remain the primary BAS used on all projects where the existing BAS is a Johnson Controls system.

Kevin Tolbert

Johnson Controls, Inc.

507 E. Michigan St. M-30

Milwaukee, WI 53202

BE-HCA@jci.com

478-952-8740

1.1.B Schneider Electric shall be used on all projects on which the existing BAS is a Schneider, Andover Infinity, Andover Continuum, Inet, Invensys, or TAC system, EcoStruxture, or StruxtureWare.

Jeff Eggleston

Schneider Electric

1650 West Crosby Road

Carrollton, TX 75006

Jeff.eggleston@schneider-electric.com

469-995-1092

1.1.C Siemens Apogee will be a project by project determination made by FacilitiGroup Manager of Building Technologies – Siemens Apogee will only be used when they are existing and have an exceptional record of support and execution with the facility.

1.1.D Distech Apex / Eclypse Controls shall have the integration partner selection provided by Distech Controls and contracted through Distech Controls.

Renne Jacobs

Distech Controls, Apex Product Line

4205 Place de Java

Brossard, Quebec, Canada J4y 0C4

rjacobs@distech-controls.com

913-329-5857

1.1.E Vykon Controls by MSS Solutions shall be used in North Carolina Division **ONLY**.

Philipp Wullimann

VYKON Controls, by MSS Solutions

HCA North Carolina Division **ONLY**

125 Glenn Bridge Road

Arden, NC 28704

Philipp.Wullimann@MSSSolutions.com

828-490-3361

1.1.E.a The use of Johnson Controls as an equal is no longer acceptable and shall not be used in the North Carolina Division for DDC Controls.

1.1.F Alternates: A different vendor on existing hospitals may be considered for continuity and shall require HCA Engineering approval.

1.1.G Warranty for BAS controls shall be for 24 months from completion including commissioning and acceptance.

SECTION 23 09 23B

DIRECT DIGITAL CONTROL/BUILDING AUTOMATION SYSTEM (DDC/BAS)

PART 1 - GENERAL

1.1 DESCRIPTION

A.

B. Direct Digital Control/Building Automation Systems (DDC/BAS) shall be per Specification Sections 23 0923a. All points to be mapped back to the Medical Center's existing front end.

C. The work specified under this section of the specifications includes furnishing, installing, programming, and placing into operation the DDC/BAS systems.

D. The BAS/DDC shall use BACNet/IP protocol capable of communicating over an Ethernet system. It shall be capable of residing on the HCA Enterprise WAN/LAN by having an assigned IP address. BAS/DDC systems are required to permit a remote user with password access, monitor points and issue basic commands over the HCA WAN/LAN using a PC type terminal without the need for proprietary BAS/DDC software. The system front end shall reside on a server not a PC.

E. The DDC/BAS systems shall be furnished and installed under this section of the specifications and shall consist of microprocessor based digital system controllers. The systems shall be complete in every respect, including all auxiliary and accessory items as required, and shall be thoroughly coordinated so as to provide a compatible and completely workable system.

F. Provide a complete control system including electrical interlocks, wiring, conduit, relays, switches, control transformers, and other devices as required to accomplish automatic control of the mechanical systems. Refer to drawings for details.

G. All systems shall be guaranteed against defects of any nature and to operate properly for a period of not less than 12 months after final acceptance of the job by the Owner. During this period, the BAS manufacturer shall service and adjust the systems as required for proper operation, replacing components as required.

H. The contractor shall work in close cooperation with the TAB agency in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor/transmitters.

I. Commissioning of the mechanical and control systems is part of this project. The Cx procedures shall include Prefunctional Performance Testing and final Functional Performance Test. The contractor should refer to Specification Sections 23 0809 and 23 0810, in order to be apprised of, and become familiar with his responsibilities and accountabilities throughout the Cx process.

J. The controls contractor shall furnish the test and balance contractor with appropriate DDC system software available to assist in the TAB process. The contractor shall work in close cooperation with the TAB agency in calibrating all airflow and water flow stations and all duct and pipe mounted differential pressure sensor/transmitters. The controls contractor shall provide a technician for 8 hours to assist/train the TAB technician in the coordination/interface of the BAS with TAB activities.

1.2 SUBMITTALS

A. Submit complete shop drawings, equipment and component brochures, list of control valve CV and pressure drops, list of control dampers, written sequences of operations, diagrams indicating panels, gauges, components, spring ranges, and setpoints, and complete composite wiring diagrams indicating all equipment interlocks for entire control system.

B. At the time of submission to architect/engineer, the contractor shall submit an information only copy of the complete BAS/DDC submittal to HCA Engineering FaciliGroup, One Park Plaza 2-3E, Nashville, TN 37203.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT DESCRIPTION

A. The building automation system shall consist of the following:

1. Stand-alone DDC panels.
2. Stand-alone application specific controllers (ASCs).
3. DDC panel-mounted operator terminal.
4. Web addressable server.

B. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, stand-alone DDC panels, and operator devices.

C. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

D. Stand-alone DDC panels shall be able to access any data from or send control commands and alarm reports directly to any other DDC panel or combination of panels on the network without dependence upon a central processing device. Stand-alone DDC panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.

2.2 NETWORKING/COMMUNICATIONS

A. The design of the BAS shall network operator workstations and stand-alone DDC panels.

B. Local Area Network:

1. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a local area network such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.
2. Dynamic Data Access: All operator devices shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network.
3. General Network Design: Network design shall include the following provisions:
    a. High speed data transfer rates. The minimum transfer rate shall be 100 Mb (Mb/s).
    b. Commonly available, multiple source, networking components and protocols shall be used to allow the BAS to coexist with other networking applications. MAP, ETHERNET, IBM Token Ring and ARCNET are acceptable technologies.
    c. Use of an industry standard IEEE protocol.
    d. Synchronization of the realtime clocks in all DDC panels shall be provided.
    e. Permit at least four simultaneous users to access the system over the LAN, based on password level. Users shall have access to monitor parameters, change set points, set up trends, or start/stop controlled equipment. A remote user shall have this capability without having the system data base loaded on his/her remote computer.
    f. Text/Email feature shall be provided with capability to telephone/email selected facility maintenance personnel to notify them of critical BAS alarms.
4. Connection to Facility's LAN: The BAS shall be connected to the facility's Ethernet LAN to the extent possible to avoid duplication of LAN wiring. Coordinate connection with owner.

a. The BAS shall be connected to the facility LAN and shall permit at least 4 simultaneous users to access the system over the LAN, based on password level, monitor parameters, change set points, set up trends, or start/stop controlled equipment.

b. A remote user shall have this capability without having the system data base loaded on his/her remote computer.

c. Connection by remote Energy Management system shall be accommodated by allowing polling of BAS parameters over open protocols such as Bacnet and Modbus TCP.

2.3 STAND-ALONE DDC PANELS

A. General: Stand-alone DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Each stand-alone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules.

B. Memory: Each DDC panel shall have sufficient memory to support its own operating system and databases.

C. Point Types: Each DDC panel shall support the following types of point inputs and outputs:

1. Digital Inputs for status/alarm contacts
2. Digital Outputs for on/off equipment control
3. Analog Inputs for temperature, pressure, humidity, flow, and position measurements
4. Analog Outputs for valve and damper position control, and capacity control of primary equipment
5. Pulse Inputs for pulsed contact monitoring

D. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, field controllers, sensors, and actuators.

E. Serial Communication Ports: Stand-alone DDC panels shall provide at least two RS-232C serial data communication ports for simultaneous operation of multiple operator I/O devices such as industry standard printers, laptop workstations, PC workstations, and panel mounted or portable DDC panel operator's terminals. Stand-alone DDC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or network terminals.

F. Hardware Override Switches: The operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, on-board hand/off/auto operator override switches for binary control points and gradual switches for analog control type points. These override switches shall be operable whether the panel is powered or not.

G. Hardware Override Monitoring: DDC panels shall monitor the status or position of all overrides and inform the operator that automatic control has been inhibited.

H. Local Status Indicator Lamps: The DDC panel shall provide local status indication for each binary input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device.

I. Integrated On-Line Diagnostics: Each DDC panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment.

J. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standard 587-1980. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

K. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all stand-alone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention.

L. Provide a battery backup (UPS) system to support DDC panel functions for a minimum of 15 minutes upon loss of power. The UPS system shall be provided regardless of connection to facility emergency power system.

2.4 SYSTEM SOFTWARE FEATURES

A. General:

1. All necessary software to form a complete operating system as described in this specification and on drawings shall be provided.
2. The software programs shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

B. Control Software Description:

1. Pre-Tested Control Algorithms:
   a. Two Position Control
   b. Proportional Control
   c. Proportional plus Integral Control
   d. Proportional, Integral, plus Derivative Control
   e. Automatic Control Loop Tuning
2. Equipment Cycling Protection.
3. Heavy Equipment Time Delays.
4. Powerfail Motor Restart.

C. Energy Management Applications: DDC panel shall have the ability to perform any or all of the following energy management routines:

1. Time of Day Scheduling
2. Calendar Based Scheduling
3. Holiday Scheduling
4. Temporary Schedule Overrides
5. Optimal Start/Stop
6. Night Setback/Setup Control
7. Economizer
8. Peak Demand Limiting
9. Temperature Reset

D. Custom Process Programming Capability: DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

E. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform

distributed, independent alarm analysis and filtering to minimize operator interruptions due to noncritical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC workstation or local I/O device, or communications with other panels on the network.

F. Historical Data and Trend Analysis: A variety of historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways:
   1. Continuous Point Histories.
   2. Control Loop Performance Trends.
   3. Extended Sample Period Trends.
   4. Data Storage and Archiving.

G. Runtime Totalization: Stand-alone DDC panels shall automatically accumulate and store runtime hours for binary input and output points.

H. Analog/Pulse Totalization: Stand-alone DDC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

I. Event Totalization: Stand-alone DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off.

2.5 APPLICATION SPECIFIC CONTROLLERS - HVAC APPLICATIONS

A. Each stand-alone DDC controller shall be able to extend its performance and capacity through the use of remote Application Specific Controllers (ASCs).

B. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

C. Each ASC shall have sufficient memory to support its own operating system and data bases.

D. The operator interface to any ASC point data or programs shall be through any network-resident PC workstation or portable operator's terminal connected to any DDC panel in the network.

E. Application specific controllers shall directly support the temporary use of a portable service terminal.

F. Powerfail Protection: All system setpoints, proportional bands, control algorithms, and any other programmable parameters shall be stored such that a power failure of any duration does not necessitate reprogramming the controller.

G. Battery Backup (UPS): UPS shall be provided to support ASC functions for a minimum of 15 minutes upon loss of power. The UPS system shall be provided regardless of connection to facility emergency power system.

H. The modes of operation supported by each ASC shall minimally include, but not be limited to, the following:
   1. Daily/Weekly Schedules
   2. Occupancy Mode
   3. Economy Mode
   4. Temporary override Mode

I. Continuous Zone Temperature Histories: Each ASC shall automatically and continuously maintain a history of the associated zone temperature to allow users to quickly analyze space comfort and equipment performance for the past 24 hours. A minimum of two samples per hour shall be stored.

J. Alarm Management: Each ASC shall perform its own limit and status monitoring and analysis to maximize network performance by reducing unnecessary communications.

K. Application Descriptions:

1. VAV Terminal Unit Controllers:

a. VAV terminal unit controllers shall support, but not be limited to, the control of the following configurations of VAV boxes to address current requirements as described in the Execution portion of this specification, and for future expansion.

1) Single Duct (Cooling Only or Cooling With Reheat)

b. VAV terminal unit controllers shall support the following types of point inputs and outputs:

1) Proportional Cooling Outputs

2) Heating Outputs (Proportional Analog or 1 to 3 Stages)

c. Each VAV terminal unit space temperature sensor shall include setpoint potentiometer, room temperature indication, and communication port for portable operator's terminal. Controller shall be capable of controlling to a discharge temperature that is reset based on the difference between space temperature and space temperature set point changes.

d. VAV box differential pressure transmitter shall be by JCI or Setra, 0 to 1.5" pressure range, +/- 0.0008" w.c. linearity, +/- 0.00075 w.c. repeatability.

2. Unitary Controllers:

a. Unitary controllers shall support, but not be limited to, the following types of systems to address specific applications indicated on the drawings:

1) Unit Ventilators (ASHRAE Cycle I, II, III, or W)

2) Heat Pumps (Air-to-Air, Water-to-Air)

3) Packaged Rooftops

4) Fan Coils (Two-Pipe, Four-Pipe)

b. Unitary controllers shall support the following types of point inputs and outputs:

1) Economizer Switchover Inputs

2) Drybulb

3) Outdoor Air Enthalpy

4) Differential Temperature

5) Differential Enthalpy

6) Binary Input from a separate controller

7) Economizer Outputs

8) Integrated Analog with minimum position

9) Binary output to enable self-contained economizer actuator

10) Heating and Cooling Outputs

11) 1 to 3 Stages

12) Analog Output with two-pipe logic

13) Reversing valve logic for Heat Pumps

14) Fan Output

15) On/Off Logic Control

3. AHU Controllers:
    a. AHU controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally stand-alone fashion.
    b. AHU controllers shall have a library of control routines and program logic to perform the sequence of operation.

2.6 OPERATOR INTERFACE

A. Command Entry/Menu Selection Process: Operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

B. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device.

C. Graphical and Text-Based Displays: Operator workstations shall provide consistent graphical or text-based displays of all system point and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all workstations.

D. Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

E. Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:
    1. Start-up or shutdown selected equipment.
    2. Adjust setpoints.
    3. Add/Modify/Delete time programming.
    4. Enable/Disable process execution.
    5. Lock/Unlock alarm reporting for each point.
    6. Enable/Disable Totalization for each point.
    7. Enable/Disable Trending for each point.
    8. Override PID Loop setpoints.
    9. Enter temporary override schedules.
    10. Define Holiday Schedules.
    11. Change time/date.
    12. Enter/Modify analog alarm limits.
    13. Enter/Modify analog warning limits.
    14. View limits.
    15. Enable/Disable Demand Limiting for each meter.
    16. Enable/Disable Duty Cycle for each load.

F. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the building automation system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

G. Dynamic Color Graphic Displays:

1. Color graphic floor plan displays, and system schematics for each piece of mechanical equipment shall be provided to optimize system performance analysis and speed alarm recognition.
2. The BAS shall include a trend viewing utility that shall have access to all data base points. It shall be possible to display trend data in histogram (X-Y plots) format without exporting the data to another application. Refer to the enclosed sheets at the end of this section for an example of summary sheet displays.

H. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

1. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently add/delete/modify all functions.
2. Programming Description: Definition of operator device characteristics, DDC panels, individual points, applications, and control sequences shall be performed through fill-in-the-blank templates and graphical programming approach.
3. System Definition/Control Sequence Documentation: All portions of system definition shall be self-documenting to provide hardcopy printouts of all configuration and application data. Control process and DDC control loop documentation shall be provided in logical, graphical flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.

2.7 STAND-ALONE DDC PANEL-MOUNTED OPERATOR'S TERMINAL:

A. Each DDC panel (except VAV terminal unit controllers) shall include a local panel-mounted operator's terminal for local command entry, instantaneous and historical data display, setpoint adjustment and program additions and modifications.

1. The DDC panel operator terminal shall provide access to all real or calculated points in the controller to which it is connected or any other controller in the network.
2. Operator access at all DDC panel operator terminals shall be identical to each other, as well as identical to the PC operator workstations. Any password changes shall automatically be downloaded to all controllers on the network.
3. The DDC panel operator terminal shall provide English language prompting to eliminate the need for the user to remember command formats or point names.
4. A multi-function touchpad shall be provided for point and command selection, as well as parameter entry.
5. Context-Sensitive Help.
6. Identification for all real or calculated points shall be consistent for all network devices. Use English language names to access points at the DDC panel operator's terminal.
7. In addition to instantaneous summaries, the DDC panel operator's terminal shall allow a user to view a point history file for system points.

2.8 ELECTRONIC AND ELECTRIC CONTROL COMPONENTS

A. All sensors, pressure transmitters, transducers, etc., shall be selected such that the pressure range midpoint shall coincide with the anticipated normal operating pressure.

B. Electric Thermostats: Thermostats to be manufacturer's best commercial grade thermostat with adjustable setpoint, dials calibrated in degrees F, and digital temperature indication. Select thermostats with suitable range for service intended. Temperature measurement accuracy shall be +/- 0.5 degrees F. Thermostats located in public areas such as corridors or elsewhere as indicated on drawings shall be provided with programming lockout to prevent unauthorized adjustment. Thermostats located where subject to physical damage and/or where identified on drawings shall be provided with tamper resistant cover. Warmer – Cooler setpoint adjustment will not be acceptable.

C. Electronic Sensors/Transmitters: Sensors/transmitters to be 1000 Ohm platinum RTD type with high resistance change vs. temperature or humidity change, accurate to +/- 0.3 degrees F for temperature and +/- 2.0% for humidity at applicable range, and provide 4 to 20 MA or 0 to 5 VDC output signal. Sensors/transmitters to be suitable for room, duct, or well mounting as required by application. Room type to have built-in setpoint potentiometer and digital room temperature or humidity indication. Select for temperature/humidity range of application. Provide appropriate mounting plate and hardware. Temperature sensors used as a part of Energy (BTU) Measurement System shall meet the applicable requirements of that section. Sensors shall have setpoint adjustment through BAS only. Sensors located where subject to physical damage and/or where identified on drawings shall be provided with protective cover. Sensor stability shall be less than 0.1 °F in 5 years. Provide these devices where identified on the contract documents or if not shown on design documents provide at all locations listed within this section.

D. Smoke Detectors: Install duct-mounted smoke detectors at locations indicated on drawings and in accordance with published smoke detector installation requirements. Smoke detectors to be furnished to Division 23 by Division 26.

E. Averaging Temperature Sensors (Mixed Air): Provide single, custom length Freon-filled capillary tube type sensing element. Accuracy shall be +/- 0.3 degrees F. Sensor shall be single element with length of one linear foot for every one square foot of coil face area.

F. Control Panels: Control panels to be constructed of unitized steel or aluminum cabinets. Provide cabinets with hinged, locking door opening to the front. Multiple panels mounted side-by-side to be hinged to the left or on opposite sides to open in the middle. Start-stop switches, hand-off-automatic switches, pilot lights, and temperature indicating devices to be flush-mounted in panel door. All other devices to be internally mounted within panel. Local panels exposed to weather to be weatherproof construction. Panel locations to be approved by Designer and be accessible for operation and maintenance. All devices specified to be mounted on control panel that require electrical connections to be prewired to a dual, numbered terminal strip located inside panel. All lines in panel shall have number I.D. bands. Gauges shall be installed on all pneumatic lines entering or leaving the panel. All devices inside the panel or mounted on panel face shall have an engraved laminated plastic nameplate. Wiring within panel to conform to National Electrical Code, and shall be neatly bundled and laced or enclosed in panduit trough.

G. Control Valves: Two-inch and smaller water service valves to be screw connected chrome plated brass ball type with characterized port to allow equal percentage throttling. Two-and-one-half inch and larger to be flange connected, brass-body ball-type with ductile iron flanges and stainless steel trim. Valve pressure rating to be in accordance with piping and fitting specifications Section 23 21 13. (Minimum 125 psi operating pressure.) Valve actuators to be selected to close valves against pump shutoff head or maximum steam inlet pressure. Provide stainless steel stem with removable composition disc and self adjusting spring-loaded Teflon packing. Two position water valves to be line size or one line size smaller than connecting piping with maximum 1 psi water pressure drop. Modulating water control valves shall have minimum rangeability of 300:1 defined as minimum controllable flow divided by the maximum controllable flow. Output signal of 4-20mA or 0-10 V shall be used to control the position of all modulating valves. Zone type, tri-state, pulse type, or similar non-proportional control valves/actuators are not acceptable.

H. Control Valves for specialized applications – Rotary ball type: Use for chilled water system bypass, steam control valves at HX-1 and HX-2. Valves shall be constructed of a carbon steel body, stainless steel V-notch ball and shaft, low friction bearings and a TFM 1700 ball seat. Valve sizes 1, 1.5 & 2 inches shall be ANSI Class 150/300 multi-rated and have Universal End Connections for use with NPT or ANSI Class 150/300 wafer connections. Valve sizes 3, 4, 6 inch shall have ANSI Class 150 or 300 flanges as required by application. Control valves shall be rated ANSI Class VI leakage rate, 0°F to 400°F temperature range and maximum 250 PSI allowable shutoff pressure. Valves are for use with water, steam and percentage glycol water mixes. Valves have 90 degree rotation, 300:1 rangeability with

equal percentage control characteristic. Valve and linkage shall carry a 3 year warranty from the date of installation. Valve shall be a Valve Solutions Series V segmented ball control valve, Kele or approved equal.

I. Automatic Control Dampers: Ultra low-leak automatic control dampers to be Arrow Pin Lock opposed-blade dampers for modulating control and parallel blades for 2-position control or approved equal. Frames and blades to be minimum 16 gauge extruded aluminum or galvanized steel construction with 4" to 6" deep frame and 8" maximum width blades. Pivot rods to be 1/2" diameter, extruded aluminum or plated steel. Bearings to be corrosion resistant. Install blade linkage hardware in angle or channel frame section out of airstream. All hardware to be corrosion resistant. Seals to be replaceable extruded vinyl or silicone rubber blade seals and flexible metal compression type jamb seals. Dampers to have maximum 4 cfm per square foot leakage at 1" water gauge static pressure and 8 cfm per square foot leakage at 4" water gauge static pressure, verified by independent testing laboratory.

J. Electronic Actuators: Actuators shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. End switches to deactivate the actuator at the end of rotation or magnetic clutch is not acceptable. For power-failure/safety applications, a mechanical, spring return mechanism shall be used. Non-mechanical forms of fail-safe are not acceptable. All spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by changing mounting orientation. Proportional actuators shall accept a 2 to 10 VDC or 4 to 20 mA and provide a 2 to 10 VDC position feedback signal. 24 VAC/DC actuators shall not require more than 15 VA for AC or 8 watts for DC applications. All non-spring return actuators shall have an external manual gear release to aid in installation and allow manual positioning when the actuator is not powered. All actuators shall have an external direction of rotation switch to aid in installation and provide proper control response. Actuators shall be provided with a factory-mounted 3-foot electrical cable and conduit fitting to provide easy hook-up to an electrical junction box. Provide cover mounted control transformer for 120-VAC power supply. The actuators shall be U.L. listed.

K. Volumetric Measuring and Reporting:

1. BAS to read output from JCI RTU Controller. BAS to report supply and exhaust fan CFM read from RTU controller outputs.

L. Room Differential Pressure Alarm System: Room differential pressure devices shall be TSI PresSura or equal by Anemostat or Tekair. Provide a unit outside of each patient isolation room, protective environment room, operating room and, and C-section room. Refer to the architectural floor plans for exact number of rooms. Provide unit with audible and visual alarm, digital display of room pressure differential, through-the-wall pressure sensor and transformer. Provide BacNet interface for device monitoring through the BAS. System accuracy shall be +/- 10% of pressure reading with range of +/- 0.2000” w.c. Output signal shall be: 4-20mA. The device shall be provided with a door switch and field adjustable timer to minimize nuisance alarm indication due to door opening.

M. Hot and Chilled Water Differential Pressure Transmitter: Static pressure measuring stations with +/- 0.25% FS accuracy, suitable for line installation at pressure to 250 psig. Provide 3-valve manifold brass body factory assembled and suitable for pipe or wall mounting. Setra Model 230 – 3V or approved equal. Output signal shall be 4-20mA. Select unidirectional or bidirectional type with transmitter span matched to application. Provide hard wire connection to pump controller rather than network connection.

N. Duct Static Pressure Devices: Static pressure measuring stations with +/- 2% accuracy equal to Paragon Controls PE-5000 or equal by Setra or Air Monitor Group shall be provided. Industrial quality, electronic solid state, 1/2 percent accuracy static pressure transmitters equal to Paragon Controls Model DPT-4001 shall be provided. Transmitter span shall be matched to application. Duct probe shall be 6063-T5 anodized aluminum. Output signal shall be 4-20mA.

O. Transformers: Provide all 24-volt control transformers necessary to convert 120-volt line voltage power to control voltage at control devices.

P. Relays, Hand-Off-Auto Switches: Provide all relays, hand-off-auto switches, and pilot lights necessary to accomplish automatic control of the mechanical systems. See electrical drawings for starters provided integral with hand-off-autos, pilot lights, and auxiliary contacts.

Q. Pressure Switches: Pressure switches shall have contact action and pole configuration as required by application, U.L. listing, and adjustable setpoint.

R. Current Sensing Relays:

1. Acceptable Manufacturer: Hawkeye Model 908, H308 (H540 for small fractional HP motor applications) or approved equivalent.
2. Current sensor shall be induce powered from the monitored load and shall have an adjustable operating range from 2.5 - 135 A, 0.75 – 50 A or 0.25 – 20 A selected for application. Visual indicators (LEDs) shall indicate output status and sensor power. Adjustable trip setpoint to +/- 1%. Current sensor output shall be N.O., solid state, 0.1A @ 30 VAC/DC.
3. The current sensor shall have a sensing range sensitivity selected that will enable BAS to distinguish between small motors operating with and without belts and small pump motors operating with and without water flow.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Components:

1. Provide sensors, transmitters, controllers, actuators, valves, dampers, and related items, necessary to accomplish control sequence shown on drawings. Install all such devices except as noted herein to the contrary.
2. Deliver control valves to the job site to be installed by Mechanical Tradesman under supervision of Control Tradesman.
3. Deliver automatic dampers to the job site to be installed by Mechanical Tradesman under supervision of Control Tradesman.
4. Mechanical Tradesmen to install flow switches, immersion wells, pressure tapping, and all associated shut-off cocks required for control systems.
5. The control equipment and connecting piping shall be installed in a neat and workmanlike manner by trained mechanics in the direct employ of the control manufacturer.
6. All exposed tubing and conduit shall be run parallel to or at right angles to the building structure, and shall be concealed in all finished spaces. Tubing and conduit may be run exposed in mechanical rooms or areas where other piping is exposed.
7. Prepare coordinated composite wiring diagram showing all interlock wiring associated with starters, control panels, and controls.
8. Drawings and Layouts: The controls contractor shall provide to the mechanical contractor complete schematic drawings for the entire control system for submittal to the Designer for approval before work shall begin. Brochures describing each item of control equipment or component shall be included.
9. Provide sequence of operation written so that building engineer can read and understand control scheme.
10. As-built drawings to be framed under Plexiglas and placed in each respective equipment room area.

B. Electrical:

1. Division 23 (Mechanical Tradesman) shall furnish and install low-voltage control wiring, including conduit, conductors, and terminations for same. Division 23 shall also furnish and install control components associated with the low-voltage control systems and shall wire and connect components in accordance with approved wiring diagrams.
2. Division 26 (Electrical Tradesman) shall furnish and install power wiring including conduit, conductors, and terminations to motors, safety switches, starters, relays, valve and damper actuators, and other components requiring power as indicated on the electrical drawings, by the specifications, and in accordance with approved wiring diagrams. Division 26 shall also furnish and install starters as scheduled on the electrical drawings.
3. Division 23 to furnish and install all local area network wiring, including conduit, conductors, and terminations for same. The local area network (LAN) shall be configurable as either a bus or a star, or a combination of the two. The LAN shall use twisted pair, coax, or fiber optic cable, or any combination of the three to meet noise immunity and/or distance requirements. The network design shall provide a high speed data transfer rate for alarm and report generation of no less than 100 Mb (Mb/s).
4. Division 23 to furnish all input and output control wiring, including conduit, conductors, and terminations for same. All input and output control wiring shall be #18 twisted and shielded cable. No input or output point shall be more than 250 feet from its respective panel. All shields to be grounded at the control panel. All shields at the sensors or transducers to be folded back and taped. All cable splices shall have joints soldered and taped including the shield. No mechanical connections will be acceptable. All connections within the panels must be made with connectors of appropriate size and design for the terminals being applied. All cables must be labeled and identified on corresponding termination drawings. A copy of the termination drawing shall be adequately protected and left in its respective panel.
5. Install all control wiring associated with DDC/BAS in minimum 1/2" size EMT. Provide all associated couplings, connectors, and fittings.
6. All wiring shall be in accordance with local regulations and the National Electrical Code.

C. Room Devices:

1. Room devices shall be mounted so that the top of the device is 48" above the floor and aligned with the top of the light switch plates and 8" from the light switch if shown on the drawings adjacent to the light switch.
2. Room device locations shall be coordinated with door swings, light switches, and other wall-mounted items.

D. Pressure/Temperature test ports shall be installed on the entering and leaving side of all heat transfer coils, heat exchangers (HVAC and domestic, both hot and cold fluid), control valves, flow meters, pumps, etc. Installation of P/T ports will facilitate the "Sensor Calibration Check" phase of the functional performance testing (FPT).

E. The contractor shall provide Tee type connections (and associated stop cocks or caps) in the pressure sensor tubing at all differential pressure sensors, including ductwork static pressure, high static pressure, airflow measuring devices, hot and cold water differential pressure, etc., that will allow field test measurements to be taken without interrupting the BAS reading. Providing this type connection will facilitate the sensor calibration check phase of functional performance testing and maintenance, by allowing simultaneous comparison of the BAS reading versus the actual field-measured parameter.

F. Calibrated balancing valves, flow elements and meters shall be installed in strict accordance with the manufacturer's recommendations for orientation, required straight length of upstream and downstream piping, etc., and in no case shall the pressure ports be pointed downward, in order to prevent the accumulation of trash and debris inside the ports. The ports shall be installed in such a manner that allows unobstructed access for the TAB agency to plug into the ports for purposes of measuring and verifying the differential pressure of the valve.

3.2 QUALITY CONTROL

A. Control system to be set up and checked out by factory-trained competent technician skilled in the setting and adjustment of temperature controls used in this project. This mechanic to be experienced in type systems associated with this control system.

B. At time of final observation, Control Contractor to demonstrate the entire sequence of operation for the systems to the Engineer. At this time, Engineer to observe function of entire control system, observe temperature control operations, damper positions, necessary to assure that temperature control system is operating as intended by mechanical design.

C. Final acceptance of system not to occur until sequence of operation check has taken place and certified by Engineer's representative.

D. The Control Tradesman to be responsible for returning to job during the opposite season to verify operation of control system. Engineer to be given notice of this return and to accompany Control Tradesman to observe the sequence of operation.

3.3 INSTRUCTION AND ADJUSTMENT

A. On completion of the job, the controls contractor shall have completely adjusted the entire control system. He shall arrange to instruct the Owner's representative on operation of the control system and supply him with three (3) copies of the control operating and instruction manuals.

B. The Controls Contractor shall obtain from the Owner's representative a signed receipt that he has received the instruction manuals and complete instruction on the operation of the system.

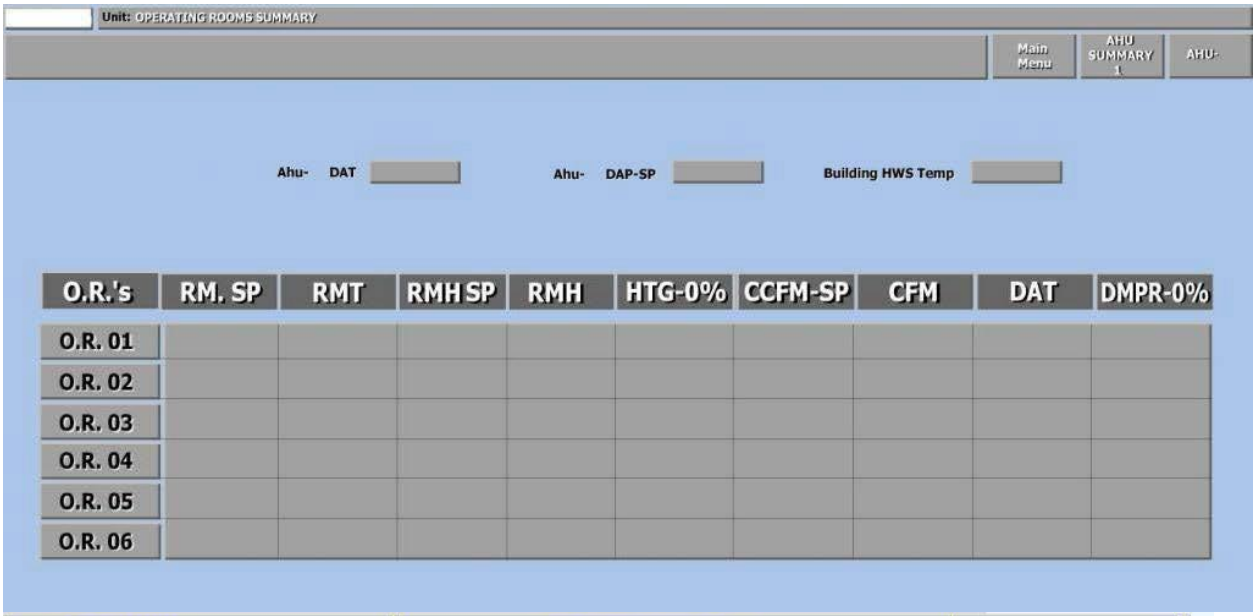
C. Contractor Adjustment: At the completion of the job, the controls contractor must submit to the Architect a letter stating that he has made final calibrations and adjustments to the system and that the Owner's operating personnel have been instructed in its use.

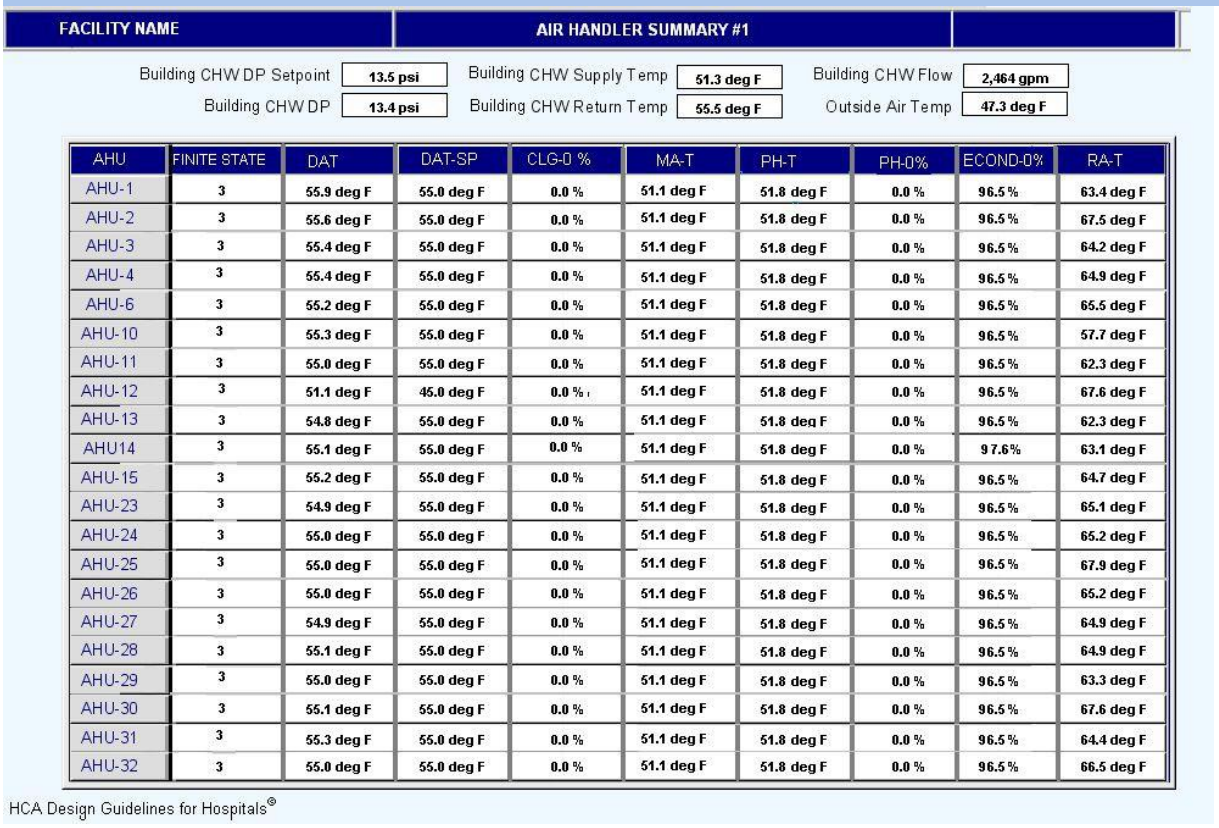
3.4 WARRANTY SERVICE

A. Warranty servicing shall be for a period not less than 12 months after final acceptance of the job by the owner and include the following provisions:

1. Emergency maintenance service on regular working hour basis during warranty.
2. Replacing defective parts and components as required.
3. Servicing by factory trained and employed service representatives of system manufacturer.
4. Maintaining of system programming.

3.5 GRAPHIC DISPLAYS





AHU	FINITE STATE	DAT	DAT-SP	CLG-0 %	MA-T	PH-T	PH-0%	ECOND-0%	RA-T
AHU-1	3	55.9 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	63.4 deg F
AHU-2	3	55.6 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	67.5 deg F
AHU-3	3	55.4 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	64.2 deg F
AHU-4	3	55.4 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	64.9 deg F
AHU-6	3	55.2 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	65.5 deg F
AHU-10	3	55.3 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	57.7 deg F
AHU-11	3	55.0 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	62.3 deg F
AHU-12	3	51.1 deg F	45.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	67.6 deg F
AHU-13	3	54.8 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	62.3 deg F
AHU14	3	55.1 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	97.6%	63.1 deg F
AHU-15	3	55.2 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	64.7 deg F
AHU-23	3	54.9 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	65.1 deg F
AHU-24	3	55.0 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	65.2 deg F
AHU-25	3	55.0 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	67.9 deg F
AHU-26	3	55.0 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	65.2 deg F
AHU-27	3	54.9 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	64.9 deg F
AHU-28	3	55.1 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	64.9 deg F
AHU-29	3	55.0 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	63.3 deg F
AHU-30	3	55.1 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	67.6 deg F
AHU-31	3	55.3 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	64.4 deg F
AHU-32	3	55.0 deg F	55.0 deg F	0.0 %	51.1 deg F	51.8 deg F	0.0 %	96.5 %	66.5 deg F

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FACILITY NAME	AIR HANDLER SUMMARY #2	

Building CHW DP Setpoint	13.5 psi	Building CHW Supply Temp	51.3 deg F	Building CHW Flow	2,464 gpm
Building CHW DP	13.4 psi	Building CHW Return Temp	55.5 deg F	Outside Air Temp	47.3 deg F

AHU	DAP	DAP-SP	SF-0%	SF CFM	DIFF CFM SP	DIFF CFM	RF-0%	RF CFM
AHU-1	1.3 in wc	1.3 in wc	82.6 %	16,592.0 cfm	9,424.0 cfm	9,152.0 cfm	66.9 %	7,440.0 cfm
AHU-2	1.7 in wc	1.7 in wc	76.2 %	14,576.0 cfm	3,550.0 cfm	3,664.0 cfm	65.2 %	11,040.0 cfm
AHU-3	1.3 in wc	1.3 in wc	76.7 %	15,392.0 cfm	6,672.0 cfm	6,664.0 cfm	49.5 %	8,728.0 cfm
AHU-4	1.0 in wc	1.0 in wc	82.4 %	2,462.0 cfm	1,165.0 cfm	1,178.0 cfm	84.6 %	1,293.0 cfm
AHU-6	1.7 in wc	1.7 in wc	78.6 %	5,564.0 cfm	1,600.0 cfm	1,502.0 cfm	63.6 %	4,004.0 cfm
AHU-10	1.5 in wc	1.5 in wc	82.8 %	2,288.0 cfm	1,400.0 cfm	1,406.5 cfm	28.2 %	903.5 cfm
AHU-11	1.2 in wc	1.2 in wc	76.3 %	3,702.0 cfm	1,285.0 cfm	1,276.0 cfm	56.9 %	2,422.0 cfm
AHU-12	2.8 in wc	84.6 %	2.8 in wc	3,066.0 cfm	780.0 cfm	834.0 :fm	99.9 %	2,232.0 cfm
AHU-13	1.0 in wc	1.0 in wc	77.3 %	10,760.0 cfm	8,400.0 cfm	8,426.0 cfm	9.7 %	2,334.0 cfm
AHU14	1.5 in wc	1.5 in wc	66.3 %	2,582.0 cfm	772.5 cfm	767.0 :fm	69.4 %	1,829.0 cfm
AHU-15	1.7 in wc	1.7 in wc	76.4 %	2,720.0 cfm	857.5 cfm	856.0 :fm	49.3 %	1,864.0 cfm
AHU-23	1.0 in wc	1.0 in wc	66.9 %	9,984.0 cfm	4,548.0 cfm	4,500.0 cfm	38.3 %	5,272.0 cfm
AHU-24	1.3 in wc	1.3 in wc	70.1 %	10,872.0 cfm	4,172.0 cfm	4,244.0 cfm	46.3 %	6,628.0 cfm
AHU-25	1.3 in wc	1.3 in wc	65.0 %	11,736.0 cfm	4,000.0 cfm	3,956.0 cfm	64.1 %	7,864.0 cfm
AHU-26	1.2 in wc	1.2 in wc	67.9 %	10,840.0 cfm	3,500.0 cfm	3,524.0 cfm	61.9 %	7,364.0 cfm
AHU-27	1.3 in wc	1.3 in wc	67.1 %	10,576.0 cfm	4,500.0 cfm	4,380.0 cfm	40.2 %	6,196.0 cfm
AHU-28	1.3 in wc	1.3 in wc	66.0 %	11,352.0 cfm	4,128.0 cfm	4,200.0 cfm	50.8 %	7,152.0 cfm
AHU-29	1.2 in wc	1.2 in wc	67.6 %	9,696.0 cfm	4,500.0 cfm	4,520.0 cfm	34.4 %	5,176.0 cfm
AHU-30	1.2 in wc	1.2 in wc	68.8 %	12,560.0 cfm	4,128.0 cfm	3,992.0 cfm	56.1 %	8,568.0 cfm
AHU-31	1.2 in wc	1.2 in wc	64.9 %	10,496.0 cfm	4,548.0 cfm	4,460.0 cfm	41.2 %	6,012.0 cfm
AHU-32	1.2 in wc	1.2 in wc	72.6 %	12,104.0 cfm	4,172.0 cfm	3,940.0 cfm	56.1 %	7,964.0 cfm

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FACILITY NAME	AIR HANDLER SUMMARY #3	

Building CHW DP Setpoint	13.5 psi	Building CHW Supply Temp	51.3 deg F	Building CHW Flow	2,464 gpm
Building CHW DP	13.4 psi	Building CHW Return Temp	55.5 deg F	Outside Air Temp	47.3 deg F

AHU	DAT	DAT-SP	HumV-0%	RA-T	RAH-%	HiLim-H
AHU-1	55.9 deg F	55.0 deg F	23.0 %	63.4 deg F	40.0 %	60.0 %
AHU-2	55.6 deg F	55.0 deg F	20.4 %	67.5 deg F	40.0 %	60.0 %
AHU-3	55.4 deg F	55.0 deg F	20.1 %	64.2 deg F	40.0 %	60.0 %
AHU-4	55.4 deg F	55.0 deg F	41.7 %	64.9 deg F	40.0 %	60.0 %
AHU-6	55.2 deg F	55.0 deg F	43.9 %	65.5 deg F	40.0 %	70.0 %
AHU-10	55.3 deg F	55.0 deg F	8.4 %	57.7 deg F	50.0 %	80.0 %
AHU-11	55.0 deg F	55.0 deg F	24.9 %	62.3 deg F	40.0 %	60.0 %
AHU-12	51.1 deg F	45.0 deg F	100.0 %	67.6 deg F	30.0 %	70.0 %
AHU-13	54.8 deg F	55.0 deg F	7.2 %	53.7 deg F	50.0 %	0.0 %
AHU14	55.1 deg F	55.0 deg F	35.3 %	63.1 deg F	25.2 %	70.0 %
AHU-15	55.2 deg F	55.0 deg F	38.2 %	64.7 deg F	40.0 %	60.0 %
AHU-23	54.9 deg F	55.0 deg F	6.9 %	65.1 deg F	50.0 %	60.0 %
AHU-24	55.0 deg F	55.0 deg F	16.6 %	65.2 deg F	50.0 %	60.0 %
AHU-25	55.0 deg F	55.0 deg F	16.0 %	67.9 deg F	50.0 %	60.0 %
AHU-26	55.0 deg F	55.0 deg F	20.1 %	65.2 deg F	50.0 %	60.0 %
AHU-27	54.9 deg F	55.0 deg F	13.2 %	64.9 deg F	50.0 %	60.0 %
AHU-28	55.1 deg F	55.0 deg F	5.7 %	64.9 deg F	50.0 %	60.0 %
AHU-29	55.0 deg F	55.0 deg F	11.0 %	63.3 deg F	50.0 %	60.0 %
AHU-30	55.1 deg F	55.0 deg F	10.0 %	67.6 deg F	50.0 %	60.0 %
AHU-31	55.3 deg F	55.0 deg F	23.3 %	64.4 deg F	40.0 %	60.0 %
AHU-32	55.0 deg F	55.0 deg F	26.0 %	66.5 deg F	40.0 %	60.0 %

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END OF SECTION

SECTION 23 21 13

HYDRONIC PIPING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Submit pipe, valves, and fittings and have approved before starting installation. Pipe, valves, and fittings to be new, and marked clearly with manufacturers' name, weight, and classification or working pressure.

B. Piping to run approximately as shown on drawings or as structural and architectural conditions permit.

C. Provide seismic analysis and bracing of all piping systems in accordance with Section 23 05 47 - Seismic Restraint of Mechanical Equipment and Suspended Utilities.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

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

1. Ferguson Enterprises
   Contact: Bettina Dawson
   office (615) 316-1920
   email: HCA@Ferguson.com

2.2 COPPER PIPES

A. Type "L" hard-drawn seamless copper tubing, ASTM B-88:

1. HVAC hot water piping 2-1/8" O.D. and smaller. Piping dimensions on drawings for piping 2-1/8" and smaller are outside diameter. (O.D.).

B. VIEGA PROPRESS COUPLINGS AND FITTINGS (OR APPROVED SUBSTITUTIONS):

1. As a deductive alternate, the contractor may submit cost savings to use Viega ProPress couplings and fittings for connection of chilled water and heating hot water piping for sizes up to and including 2 inch pipes.
2. Copper shall conform to ASME B16.51. ProPress fittings 1/2-inch thru 2-inch for use with ASTM B88 type L copper tube. ProPress fittings shall have an EPDM sealing element and Smart Connect (SC) feature.
3. Tube ends shall be cut on a right angle (square) to the tube. Tube ends shall be reamed and chamfered, all grease, oil or dirt shall be removed from the tube end with a clean rag. Visually examine the fitting sealing element to ensure there is no damage, and it is properly seated into the fitting. Insert tube fully into the fitting. Make a mark with a felt tip pen on the tube wall at the face of the fitting. Always examine the tube to ensure it is fully inserted into the fitting prior to pressing the joint. ProPress fittings ½-inch thru 2-inch shall be installed using Rigid ProPress Tools. ProPress fittings shall be installed according to the most current edition of the Viega installation guidelines. Installers shall attend a Viega ProPress installation training class.
4. After ProPress fittings have been installed a "step test" shall be followed. Pressurize the system with air, or dry nitrogen between 5 psi and 45 psi, or with water between 15 psi and 85 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, walk the system and check for un-pressed fittings. When you identify the un-pressed fitting/s ensure the tube is fully inserted into the fitting, and the tube is properly marked prior to pressing the joint. After appropriate repairs have been made, retest the system per local code, or specification requirements.
5. Pricing for the deductive alternate shall include the manufacturer's and contractor's 5 year parts, labor, and consequential damages warranty due to a defect in either labor, workmanship, or parts. The warranty cost should be reflected in the deduct price.

C. Type "DWV" hard-drawn seamless copper tubing: Contractor's option for above-ground moisture condensate drain piping.

D. Copper Pipe Fittings:

1. Provide sweat fittings, ASTM B-62, dimensions conforming to ANSI B16.22, wrought copper, with sweep patterns for copper tubing.
2. Dielectric connection: Provide Epco Sales, dielectric couplers at junction of steel pipe and equipment with copper piping systems. Use of steel or cast iron fittings in copper piping systems prohibited.
3. Fittings for drainage piping to be drainage pattern type.

E. Unions to be brass ground joint, 250-pound working pressure.

F. Nipples used in conjunction with copper pipe to be brass.

2.3 VALVES

A. Valves are specified by Stockham model numbers to establish quality levels unless otherwise noted. Crane, Milwaukee, Hammond, Nibco, Stockham, Centerline, Apollo, Kitz, or Watts are considered equal manufacturers. Valves in piping systems with mechanical grooved joints to be Victaulic or approved equal. Provide clamp lock hand lever operators on valves less than 8 inches. Provide hand wheel and closed housing worm gear on valves 8 inches and larger unless indicated otherwise below. Provide chain operators for all equipment room and powerhouse valves 4 inch and larger which are located over 6 feet 6 inches above the finish floor.

B. Gate Valves:

1. Gate valves for 2-1/2" and larger steel piping systems to be Class 125, cast iron body, bronze mounted, flanged ends, Stockham Figure G623. Valves to have solid wedge disc, outside stem and yoke with rising stem, and bolted bonnet.
2. Gate valves for 2" and smaller steel piping systems to be Class 125, bronze body, screwed ends, Stockham Figure B105. Valve to have solid disc, rising stem, and union bonnet.
3. Gate valves for copper piping systems to be Class 125, bronze body, solder ends, Stockham Figure B109. Valve to have either solid or split wedge disc, inside screw, rising stem, and screwed bonnet.

C. Globe Valves:

1. Globe valves 2-1/2" and larger to be Class 125, cast iron body, bronze mounted, flanged ends, Stockham Figure G512. Valves to have renewable seat and disc, outside stem and yoke with rising stem, and bolted bonnet.
2. Globe valves 2" and smaller to be Class 150, bronze body, screwed ends, Stockham Figure B29. Valve to be plug type with renewable seat and disc, rising stem, and union bonnet.

D. Ball Valves:

1. Ball valves for copper water piping systems 2-1/8" O.D. and smaller to be equal to Apollo "3" Figure 82-200, solder ends, and for 2-5/8" thru 3-1/8" O.D. to be equal to Apollo Figure 70-100, threaded ends. Valves to have bronze body, chromium plated bronze ball, Teflon seats, stuffing box ring and seals, and quarter turn on-off. Provide memory stops for valves used for balancing service. Valves to be rated for 400-psi WOG at 200 degrees F. Install threaded end valves with brass adapters.
2. Ball valves for PVC piping systems 2" and smaller to be equal to Celanese Piping System Chemtrol TU series, Schedule 80 PVC with Teflon seats and vitron seals. Valves for pipe 3" and larger to be Celanese Piping System Chemtrol DE series, Schedule 80 PVC with Teflon seats and vitron seals. Valves to be rated for 150 psi at 75 degrees F.

E. Butterfly Valves:

1. Butterfly valves for steel water piping systems to be Crane Monarch Figure 24N, Centerline Series LT, or approved equal industrial quality lug type with threaded holes. Valves to provide bubble-tight shut-off at 150 psi working pressure and 200 degrees F. Valves to have ductile iron body, "EPT" seats and stem seals, 316 stainless steel or bronze disc, 316 or 416 stainless steel stems. Valves 4" and larger to have weatherproofed sealed gear operator consisting of fully enclosed worm, worm gear, and worm shaft with handwheel to provide necessary torque for close-off and infinite throttling positions. Valves 3" and smaller to have 10 position lever lock handle suitable for on-off and manual throttling service. All operators to have valve position indicator and memory stop.

F. Check Valves:

1. Check valves for copper water piping systems to be swing type, Class 125, bronze body, screwed ends, Stockham Figure B309.

2.4 STRAINERS

A. Provide cleanable "Y" type strainers in pump suction lines. Strainers to have iron body with screwed bronze or bolted iron cap. Strainer baskets to be brass. Water strainers to be Monel 20 mesh screen. Strainers to be line size complete with blow-down hose bibbs. When Suction Diffusers are specified for end suction pumps, strainers are not required. Strainers to be as follows:

1. Screwed 125# - Crane 988-1/2.
2. Flanged 125# - Crane 989-1/2.
3. Solder joint 250# - Muessco 353-1/2.
4. Grooved 300# - Victaulic Series 732 / W732

2.5 HANGERS

A. Seismic application: The use of single-sided or friction type C-clamps with retention straps for hanging pipe is expressly prohibited on the project.

B. Non-insulated steel piping 1/2" thru 24" with no longitudinal movement to be Grinnell Figure 260, MSS SP-69 Type 1, adjustable clevis hanger.

C. Insulated steel piping 1/2" thru 24", galvanized piping 1/2" thru 24", copper piping 1/2" O.D. thru 4" O.D., with no longitudinal movement to be Grinnell Figure 260, MSS SP-69 Type 1, adjustable clevis hanger with Figure 167, MSS SP-69 TYPE 40, galvanized steel insulation protection shield sized for maximum 10' span on 4 psi compressive strength insulation.

D. Non-insulated cast iron soil pipe thru 8" to be Grinnell Figure 104, MSS SP-69 TYPE 6, adjustable swivel ring, split ring type, and pipe 10" thru 15" Grinnell Figure 260, MSS SP-69 TYPE 1, adjustable clevis hanger.

E. Non-insulated copper tubing 1/2" O.D. thru 4" O.D. with no longitudinal movement to be Grinnell Figure CT-99C, MSS SP-69 TYPE 9, plastic coated adjustable tubing ring hanger.

F. Insulated steel piping 1" thru 30" with longitudinal movement to be Grinnell Figure 171, MSS SP-69 TYPE 41, pipe roll complete with Figure 160, MSS SP-69 TYPE 39A or 39B, pipe insulation protection saddle sized for proper pipe size and insulation thickness.

G. Insulated copper piping 1/2" O.D. thru 2-1/8" O.D. with longitudinal movement to be Grinnell Figure 171, MSS SP-69 TYPE 41, pipe roll complete with Figure 167, MSS SP-69 TYPE 40, galvanized steel insulation protection shield sized for maximum 10' span on 4 psi compressive strength insulation.

H. Support copper pipe risers by Grinnell Figure CT-121C, MSS SP-69 TYPE 8, plastic coated riser clamps at floor penetrations.

I. Support steel pipe risers by Grinnell Figure 261, MSS SP-69 TYPE 8, riser clamps at floor slab penetrations.

J. Support three or more parallel lines by trapeze hangers utilizing Unistrut channel or equal in bottom mounting arrangement with rod hanging support.

K. Adequately size hangers on insulated piping for insulation to pass continuously through hangers. Insulated piping to be supported outside insulation covering.

L. Provide concrete inserts, Grinnell Figure 282, MSS SP-69 TYPE 18, universal concrete insert, for attaching hangers to building structure. Inserts to be adequately sized and correctly positioned to support piping, valves, etc., when full of water and system is in operation.

M. Attention is called to pipe spring isolation specified to be furnished by this Contractor.

N. Support all piping by heavy steel, adjustable hangers, or brackets suitably fastened to structural portion of building. Place hangers in accordance with following tables:

COPPER TUBING SUPPORTS	
SIZE (IN.)	DISTANCE BETWEEN SUPPORTS (FT.)
5/8	6
7/8 - 1-1/8	8
1-3/8 - 2-1/8	10
2-5/8 - 5-1/8	12
6-1/8 - 8-1/8	14

O. Perforated metal, strap iron, or band iron hangers are not permitted. Offsets in hangers are not allowed. Pipe risers to be supported at regular intervals in pipe shafts within the limits of good practice.

P. See Insulation Section for requirements at pipe hangers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install piping not to interfere with opening of doors or other moving parts. Do not install piping near or directly over any portion of electrical equipment.

B. Provide chromium-plated escutcheon plates for exposed uninsulated pipes projecting through floors or walls in finished spaces. Mechanical rooms and janitor closets are not considered "finished" spaces.

C. Hang piping so equipment, flanges, and connections do not bear weight of piping.

D. Adequately support vertical lines at their bases or by a suitable hanger placed in horizontal line near riser or by a base fitting set on pedestal.

E. Pipes not to be hung or supported by pumps. No torque to be applied to pumps by connecting pipes. After final pipe adjustments and initial operation of the pumps, this Contractor to recheck alignment of pumps and realign as required.

F. Run piping in straight lines; riser lines to be plumb with such offsets only as indicated or necessary. No sagging of lines permitted.

G. Unless otherwise shown on drawings, lines to be installed to drain to sumps or sewer.

H. Ream pipe after cutting to full bore. Remove foreign matter from inside of pipe before installing. Keep installed piping free from dirt and scale and protect open ends from foreign matter. Use temporary plugs or other approved methods of open end closure.

I. Threads to be right-hand, pipe standard, clean cut, full depth, and tapered. Joints to be made tight without caulking. Approved pipe joint lubricant to be used, applied in thin layer to the male thread only.

J. Install copper fittings with suitable flux and 95/5 solder. Type K copper pipe to be joined by means of suitable flux and silver or phos-copper.

K. Piping to have sufficient number of flanges or unions for convenient installation and removal of piping and equipment.

L. Remake or replace defective, leaking, or otherwise unsatisfactory joints or material. Peening, caulking, or doping of piping is not permitted.

M. Install piping to prevent stresses and strains to piping and hangers from expansion or contraction. Provision for proper loops, offsets, or expansion joints to be responsibility of Contractor. Make provision for servicing and removal of equipment without dismantling piping.

N. Grooved joints shall be installed in accordance with the manufacturer's published installation instructions. The coupling manufacturer's factory trained representative shall provide documented on-site training for the contractor's field personnel in the use of grooving tool and installation of grooved joint products.

3.2 FIRE-RATED PARTITIONS

A. Provide permanent firestop system at all piping penetrations of fire-rated walls and floors. Review details on drawing as well as this specification for permissible firestop systems. The firestop system shall have been tested and approved in accordance with ASTM E119 and U.L. 1479 (ASTM E814) and classified for up to 2 hours fire rating. Firestop system shall be type detailed on drawings or intumescent type capable of expanding up to 8 times its original volume. Firestop system to be 3M, Hilti, Nelson, Johns Manville, or Specified Technologies. Firestop system shall be installed in strict accordance with published U.L. approved installation instructions. Piping to pass through the fire-rated partition insulated or non-insulated as specified and detailed. Submit U.L. approved installation drawing for each type of penetration prior to construction.

3.3 NON-RATED PARTITIONS

A. Piping to pass through the walls insulated or non-insulated as specified. Wall should be finished to fit neatly around the piping. Firestopping is not required at non-rated partitions.

3.4 PIPE SLEEVES

A. Pipe sleeves shall be provided at non-rated partitions and floor penetrations. Pipe sleeves to be Schedule 40 or 18 gage steel. Sleeves to extend 1-1/2" in excess of partition depth on each side. Sleeves penetrating floors in wet areas, including all mechanical rooms, shall extend a minimum of 1 inch above the floor.

1. Piping requiring sleeves:

a. Heating hot water

3.5 PIPING IN TRANSFORMER, ELECTRICAL, AND ELEVATOR EQUIPMENT ROOMS

A. Refer to drawings. No water piping permitted in transformer, electrical, or elevator equipment rooms.

3.6 VALVE ACCESS

A. Locate all shutoff and control valves for easy access and operation. Where valves must necessarily be located in enclosed spaces, they shall be provided with access panels of sufficient size for operation. Furnish these access panels to proper trades for installation.

3.7 AIR VENTING

A. Provide manual air vents at high points of vertical risers and at each water coil to eliminate air from HVAC water systems.

3.8 WATER DRAINING

A. Provide 3/4" hose end gate valves at low points and bottom of each riser to drain HVAC water systems.

END OF SECTION

SECTION 23 21 20

HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Expansion tank.

B. Tangential air separator.

C. P.T. test plugs.

D. Pressure gauges.

E. Digital thermometers.

F. Thermometer test wells.

G. Relief valves.

H. Flow balancing valve.

I. Flow measuring meter.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Bell and Gossett ITT, Dieterich Standard, Flow Design, Gerand, Mueller, Peterson Engineering, Taco, Thrush, John Wood Industrial Products, Weiss Instruments, Inc.

2.2 EQUIPMENT

A. Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in top of tank for tank fitting. Tanks shall be factory tested with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
3. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.

B. Tangential Air Separator:

1. Provide an external air separation unit consisting of a steel tank, strainer, and collector tube.
2. Unit to have flanged tangential inlet and outlet connections.
3. Design internal perforated stainless air collector tube to direct released air into compression tank.
4. Removable stainless steel system strainer to have 3/16 inch diameter perforations and free area of not less than five times cross-sectional area of connecting pipe.
5. Construct unit in accordance with ASME Boiler and Pressure Vessel Code and stamp for 125 psig working pressure at 350 degrees F.
6. Unit shall be stamped with ASME "U" symbol.
7. Provide blowdown connection on bottom of unit to facilitate routine cleaning of unit.
8. Unit to prevent accumulation of air in hydraulic heating and/or cooling system and prevent noises caused by entrained air in piping.
9. Separator to be Bell & Gossett ITT Rolairtrol, or approved equal.

C. P.T. Test Plugs:
   1. Provide 1/4 inch solid brass pressure/temperature test plugs at each BAS temperature sensor and at the entering and leaving connections of coils, chillers, hot water boilers, and heat exchangers.
   2. Nordel self-closing valve to be rated for 275 degrees F. service.
   3. Plugs to be manufactured by Flow Design, Peterson Engineering, SISCO, or approved equal.

D. Pressure Gauges:
   1. Provide 3-1/2 inch dial, glycerin-filled pressure gauges across chillers (cooler and condenser), pumps, and AHU coils.
   2. Gauges to be equal to Trerice Model No. 800LF with glycerin liquid fill, nylon, steel, or aluminum case, acrylic plastic window, brass movement, phosphor bronze bourdon tube, and brass socket.
   3. Accuracy to be guaranteed within one-half percent in powerhouse and mechanical rooms, other gauges shall be 2% over middle half of scale range and 3% for remainder.
   4. Select scale range of gauges to indicate design pressure near midpoint of scale.
   5. Provide each gauge with 1/4 inch size, brass construction needle valve equal to Trerice Model No. 735-2.
   6. Provide each gauge with impulse dampener equal to Trerice Model No. 870.

E. Digital Thermometers:
   1. Provide solar digital vari-angle Weiss Instruments, Inc., Model DVU-35 (no substitutions) with adjustable angle (rear, front, and side) thermometers across chiller coolers and condensers, entering and leaving heat exchanges hot water boilers and AHU coils.
   2. Each thermometer to be self-powered and within 1% accuracy. Stem assembly to be industrial glass.

F. Thermometer Wells:
   1. Provide Trerice or equal stainless steel thermometer wells for water temperature sensors and at other locations shown on drawings.
   2. Test wells to be stainless steel with 2-1/2 inch extension neck and screw plug cap with chain and shall be filled with light clear oil.

G. Relief Valves:
   1. Provide relief valves for each hydronic system as shown on drawings.
   2. Valve to be constructed to ASME code requirements, tested by National Board, and labeled with ASME symbol.
   3. Valve body to be bronze construction.
   4. Valves to be diaphragm type operating with slow opening and closing feature.
   5. Valve to seat against face of EPDM rubber.
   6. Set differential between opening and closing pressure to prevent water flash and water hammer.
   7. Valve to include manual lever for testing valve.

H. Flow Balancing Valve:

1. Balancing/shut-off valve to be ball type with bronze/brass body, chromium plated bronze ball, Teflon seats, blowout proof stem with Teflon packing and nut, and full size quarter turn handle with grip and memory stop.
2. The flow measuring element shall be a low loss/high signal Venturi type of one to ten rangeability equipped with dual Schrader type pressure test ports and caps for connection to a portable differential pressure meter.
3. Meter connections to have built-in check valves.
4. Valves to provide for leak tight shutoff service at full rated working pressure.
5. Sizes 1/2" through 2" to be threaded ends with brass adapters; sizes 2-1/2" and larger to be flanged.
6. Valves and Venturis to be rated for 125 psig working pressure at 250 degrees F.
7. Combination flow measuring, balancing, and shutoff valves to be Flow Design Accusetter or approved equal Venturi type.

I. Flow Measuring Meter:

1. Provide portable flow measuring meter capable of indicating pressure differential across previously specified flow balancing valves and flow measuring stations.
2. Unit to be complete with hoses, shutoff and vent valves, and carrying case.
3. Flow measuring meter to be made by manufacturer of associated flow balancing/measuring devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install hydronic specialties in strict accordance with manufacturers' published installation instructions.

B. Provide 1/2" manual air vents at top of pipe risers and other locations where air can be trapped or collected.

C. Provide 3/4" hose end gate valve drains at bottom of pipe risers and other locations to drain water systems.

D. Pipe relief valve outlets from hydronic systems to nearest floor drain.

E. Support pump inlet and strainer fittings with floor mounted pipe and flange supports.

F. Locate thermometers and pressure gauges no higher than 7 feet above finished floor elevation.

END OF SECTION

SECTION 23 21 25
IN-LINE, HORIZONTALLY MOUNTED PUMPS

PART 1 - GENERAL

1.1 Pump(s) to be non-overloading, single-stage, in-line, close-coupled, bronze fitted, vertical splitcase, centrifugal type pumps driven by VFD.

1.2 Pumps to be Bell & Gossett Series e-90 or approved equal.

PART 2 - PRODUCTS

2.1 PUMP

A. Volute to be cast iron, 175 psig working pressure, and include suction and discharge nozzles of equal size.

B. Impeller to be brass of enclosed type, hydraulically and dynamically balanced, and keyed to shaft and secured by a suitable locking cap screw.

C. Shaft to be steel, replaceable shaft sleeve to be copper. Shaft sleeve to completely cover wetted area under mechanical seal.

D. Standard mechanical seal, carbon seal ring and Remite (or equal) seat to be provided to seal off liquid cavity.

E. Pump to be designed so pump internals can be serviced without disturbing connecting pipe.

2.2 MOTOR

A. See separate Section 23 05 13.

2.3 NAMEPLATE

A. Each pump/motor assembly to be provided with stainless steel nameplate securely fastened to casing. Nameplate to provide data necessary for equipment identification and replacement.

2.4 TESTS

A. The pump is to be factory-tested for the specified operating condition, thoroughly cleaned, and painted with one coat of machinery enamel prior to shipment.

PART 3 - EXECUTION

3.1 Install pipe supports on each side of pump to prevent undue strain on piping system.

3.2 Include set of installation instructions with pump at shipment**.**

END OF SECTION

SECTION 23 23 00

REFRIGERANT PIPING SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Refrigeration piping, valves and fittings to connect remote condensers, split system air conditioning systems.

1.2 SAFETY CODE

A. Comply with the requirements of ANSI B9.1, Code for Refrigerant Systems.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Piping: Type "L" ACR hard copper, ASTM B280.

B. Fittings: Wrought copper.

C. Solder: Silver solder, or phos-copper solder having a melting point of 1125 degrees F. or higher.

2.2 EQUIPMENT

A. Service Valves: Henry valves or equal. Provide packed type receiver, purge, and gauge valves with valve stem seal cap ports.

1. Valves up to 5/8" O.D.: Henry Figure 516 or equal, diaphragm type.
2. Valves larger than 5/8" O.D.: Henry Figure 203 or equal.

B. Solenoid Valves: Manufactured by Sporlan Co., or equal, suitable for the type of refrigerant used, and of a type permitting manual lifting of stem for emergency operation. Size valves for pressure drop of 3 pounds at design flow.

C. Refrigerant Filter Dehydrator: Sporlan Co. Filter-Drier or equal sealed core type of size recommended by manufacturer for maximum design tonnage. For systems 20 nominal tons and larger, provide replaceable core filter driers.

D. Moisture Indicator: Sporlan Co. See-All type SA-125 or equal.

E. Pipe Supports:

1. Pipes subject to vibration: Isolation type brackets.
2. Pipes not subject to vibration: Grinnell No. CT-95 or equal.
3. Riser clamps: Grinnell CT-121 or equal.

F. Escutcheons: Chrome plated escutcheons sized for pipe.

G. Sleeves: Provide sleeves as specified in Section 23 21 13.

H. Insulation: Insulate piping as specified in Section 23 07 10.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Make solder joints with carbon dioxide or nitrogen passing through joints being soldered. Ensure a clean, tight system. Pull a clean rag through each piece of tubing after cutting or reaming.

B. Install pipe and hangers in accordance with hanger manufacturer's printed instructions.

C. Provide escutcheons at all visible wall penetrations in finished areas.

3.2 LEAK TESTING

A. Test for leaks by use of carbon dioxide or nitrogen and a liquid soapsuds solution. Correct leaks found.

B. Evacuate system to 20" vacuum and charge with refrigerant until a pressure of 15 psig is reached. Then test for leaks using a Halide leak detector. Correct leaks found.

C. Pressurize system, with carbon dioxide or nitrogen, to 300 psig on the high side, and 200 psig on the low side, and test for leaks. Correct leaks found.

3.3 SYSTEM DEHYDRATION

A. Dehydrate system by "Double Dehydration" method.

B. Use a suitable vacuum pump. Evacuate system to a vacuum of 0.2" Hg absolute and operate pump for eight hours when that pressure is reached.

C. After eight hours, admit dry nitrogen directly to the system, and then evacuate system to a vacuum of 0.2" Hg absolute and operate pump for four hours.

3.4 CHARGING SYSTEM

A. When system dehydration is complete and all leaks are corrected, charge system with refrigerant.

END OF SECTION

SECTION 23 29 23

VARIABLE FREQUENCY MOTOR CONTROLLER

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish complete variable frequency motor controllers (VFMC or VFD) as specified herein for the fans designated. All standard and optional features shall be included within the VFD enclosure unless otherwise specified.

B. All VFD's provided to be of the same manufacturer.

1.2 QUALITY ASSURANCE

A. To ensure quality and minimize infantile failures at the job site, the VFD shall be burned in at an ambient of 40 degrees Celsius minimum for at least 120 hours. The VFD shall be operating a dynamometer and the load and speed shall be cycled during the test. All optional and special features shall be functionally tested at the factory for proper operation.

1.3 WARRANTY

A. The VFD shall be warranted by the manufacturer for a period of 24 months from date of start-up. The warranty shall include parts, labor, travel costs, and living expenses incurred by the manufacturer to provide factory authorized on-site service.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. VFD to be as manufactured by ABB, Danfoss-Graham, York/Toshiba, Square D/Schneider or Yaskawa. No substitutions.

B. VFD's motor transfer circuit shall include three contacts for bypass switching from line to VFD and vice versa.

C. VFD's for all motors up to and including 50 hp shall be 6-pulse drives. VFD's for all motors greater than 50 hp shall be 18-pulse drives.

D. Total harmonic distortion shall not exceed 5% at VFD terminals.

E. Provide VFDs with RFI/EMI filters.

F. VFDs serving fans and pumps (e.g. AHU's, chilled water, & cooling towers) shall have the ability to lock out critical speeds.

G. The VFD shall convert 3-phase, 60-Hz utility power to adjustable voltage and frequency, 3-phase, AC power for stepless motor speed control from 5% to 100% of the motor's Hz speed. Input voltage shall be as indicated on the equipment schedules on drawings.

H. Convertor Section: Full wave diode bridge rectifier.

I. Invertor Section: Transistorized sine coded pulse width modulated (PWM) type for stepless motor speed control.

J. Silicon-controlled rectifiers (SCRS) or GTOs shall not be used in the circuitry.

K. The VFD maximum output current rating shall be 110 percent of the motor nameplate full load current.

L. The VFD and options shall be tested to ANSI/UL Standard 508. The complete drive including all options shall be listed by a nationally recognized testing agency such as U.L. or ETL.

M. The VFD and options shall comply with the applicable requirements of the latest standards of ANSI, IEEE, and the National Electrical Code. The VFDs full load amp rating shall meet or exceed NEC Table 430-150.

N. Power line noise shall be limited to a voltage distortion of 3 percent and line notch depth of 10 percent or 16,400 volt microseconds whichever is less as defined in IEEE Standard 519, Guide for Harmonic Control and Reactive Compensation of Static Power Converters. Provide line reactors sized to limit line notching to 10 percent or 16,400 volt microseconds whichever is less.

O. The VFD shall not emit either conducted or radiated RFI in excess of the limitations set forth in the FCC Rules and Regulations, Part 15, Subpart J, for class A computing devices. The VFD shall have an FCC compliance label. Provide RFI filters if required.

P. The increase in audible motor noise with the VFD operating shall not exceed 3 decibels.

2.2 BASIC FEATURES

A. The VFD shall include the following basic features:

1. The VFD shall be factory mounted in RTU. See Section 237513.
2. The following operator controls shall be located on the front of the enclosure:
    a. Hand/Off/Auto selector switch to start and stop the motor. In the auto position, the drive will start/stop from a remote contact closure.
    b. Auto/Manual selector switch. In the auto position, motor speed is determined by the follower signal. In the manual position, motor speed is determined by the manual speed potentiometer.
    c. Manual speed potentiometer.
    d. Power on pilot light to indicate that the AFC is being supplied by the power line.
    e. Fault pilot light to indicate that the AFC has tripped on a fault condition.
    f. Digital meter to indicate percent speed and percent load.
3. Two sets of form C, dry contacts to indicate when the VFD is in the run mode.
4. One set of form C, dry contacts to indicate when the VFD is in the fault mode.
5. When input power returns to normal following a fault trip for under-voltage, over-voltage, or phase loss, the VFD shall automatically restart. The VFD shall not automatically restart following fault trips due to overload or over-current.
6. The VFD shall include a door interlocked, padlockable, input power disconnect switch.
7. Speed Control: The output frequency may be adjusted in proportion to any one of the following:
    a. 0-10 VDC Analog Signal.
    b. 0-5 VDC Analog Signal.
    c. 4-20 MA DC Analog Signal.
8. Coordinate with controls supplier for exact input signal and type to provide proper input follower (i.e., grounded or floating).
9. Provide open protocol BACnet MS-TP, LONtalk, Johnson N2, etc. interface card to connect to Building Automation System. Coordinate with controls system provider for preferred interface language.

2.3 PROTECTIVE FEATURES

A. The VFD shall include the following protective features:

1. Current limiting semiconductor fuses for the power input.
2. Separate overload relay for each motor controlled.
3. Protection against input power under-voltage, over-voltage, and phase loss.
4. Protection against output current overload and over-current.
5. Protection against over-temperature within the VFD enclosure.

6. Protection against over-voltage on the DC bus.
7. In the event of a power loss, shutdown without component failure. Upon return of power, automatically return drive to normal operation, if the start is in the "ON" condition, being able to restart into a rotating motor regaining positive speed control without shutdown or component failure.
8. In the event of a phase-to-phase short circuit, shutdown safely without component failure.
9. In the event that an input or output power contactor is opened or closed while the drive is activated, no damage to the VFD shall result.
10. Any disconnect switches between the VFD and the motor shall include an auxiliary contact interlocked to the VFD fault trip circuit. In the event that a disconnect switch is opened while the drive is running, the drive shall shut down.
11. DC bus discharge circuit for protection of service personnel.
12. Insensitive to incoming power phase sequence.

2.4 ADJUSTMENTS

A. The VFD shall include the following adjustments available via potentiometers inside the enclosure:
   1. Maximum speed, adjustable 50-100% base speed.
   2. Minimum speed, adjustable 0-50% base speed.
   3. Acceleration time, adjustable 2-60 seconds.
   4. Deceleration time, adjustable 2-60 seconds with override circuit to prevent nuisance trips if deceleration time is set too short.
   5. Current limit, adjustable 0-110%.

2.5 SERVICE CONDITIONS

A. The VFD shall be designed to operate within the following service conditions:
   1. Ambient temperature, 0-40 degrees C.
   2. 0-95% relative humidity, non-condensing.
   3. Elevation to 3300 feet without derating.
   4. AC line voltage variation, -5% to 10% of nominal.

2.6 SPECIAL FEATURES

A. The following special features shall be included in the VFD enclosure. The unit shall maintain its U.L. or ETL listing.
   1. A motor starter shall be included in the bypass circuitry for constant speed motor control when the VFD is taken out of service. Manual bypass shall provide all the circuitry necessary to transfer the motor from the VFD to the power line, or from the line to the controller while the motor is at zero speed. The bypass circuitry shall be mounted in a separate section of the VFD enclosure. Two motor contactors, electrically interlocked, shall be utilized. One contactor is to be between the controller and the motor. The other contactor is to be between the bypass power line and the motor providing across-the-line starting for motors 50 hp and less, and part-winding or “soft start” starting for motors greater than 50 hp. Motor overload protection is to be provided in both the controller mode and the bypass mode. The bypass section door shall include a "drive/line" switch, "on/off-reset" switch, and a "load transferred to line" pilot light.
   2. The VFD shall include a main fused disconnect switch or circuit breaker to provide a means of disconnecting all power to both the bypass circuitry and the controller. The disconnect switch or circuit breaker shall be door interlocked and padlockable. The fuses or circuit breaker shall be sized to provide short circuit protection for the motor when in the bypass mode per the NEC.

3. A second disconnect switch, circuit breaker, or contactors shall be provided to disconnect input power to the controller but not the bypass circuitry. This disconnect will allow troubleshooting and testing of the VFD, both energized and de-energized while operating in the bypass mode.
4. Plug-in test meter shall provide a quick means for monitoring the different signals within the VFD for start-up and troubleshooting. Where the meter is capable of operating with different horsepower VFDs, only one meter needs to be supplied.
5. A critical frequency avoidance circuit shall be provided to avoid operation at speeds which cause excessive vibration in the driven equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The manufacturer of the VFD equipment shall provide a competent, factory trained service technician to supervise the installation, start-up and testing of the VFD.

B. Install VFDs in locations shown on the drawings in strict accordance with the manufacturer's published installation instructions.

C. Contractor shall provide such materials and assistance as required by the manufacturer's representative.

D. Division 26 shall provide necessary electrical connections.

E. Contractor shall provide coordination of the necessary controls not provided by the VFD manufacturer.

3.2 START-UP, TESTING, DEMONSTRATION

A. The manufacturer's factory-trained service technician, assisted by contractor, shall verify correct installation, start-up equipment, and test it as a unit and a part of the system it serves. Verify by adjustments, tests, etc., that the equipment is functioning as specified. Provide three copies of test data to the Owner. As a minimum, check the following items:

1. Motor voltage and frequency.
2. Control input and automatic start/stop.
3. Calibration and adjustment for minimum and maximum speed setpoints and acceleration and deceleration rates.
4. Wire terminations.

B. VFD manufacturer shall provide a minimum of 4 hours instruction to Owner to demonstrate the operation of the system. Provide three copies of operation and maintenance manual to Owner at completion of instructions.

C. A copy of the variable frequency drives certified startup sheets for all AHUs shall be provided to the construction manager / Cx team for record purposes within one week of start-up.

END OF SECTION

SECTION 23 31 10

SHEET METAL DUCTWORK - LOW PRESSURE

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Low pressure ductwork refers to systems operating at 2.00" w.g. total static pressure with velocities up to 2000 FPM. It is the intent of this specification to provide an installed duct system which will supply the air quantities indicated by the plans and have the lowest possible friction loss with the least possible leakage loss. Friction loss for each system shall not exceed that which is indicated in the A.C. unit schedule as external static pressure or in the fan schedule as static pressure and shall include the losses of all accessories. Friction losses shall be minimized by reduction in the number of offsets and elbows by pre-planning the duct system installation and coordination with other trades to prevent interferences. Access to all accessories requiring maintenance, service and inspection shall be maintained. Radius elbows are preferred for all turns to minimize friction, noise and vibration; and, especially, for sections having large volume or higher velocities and sections which may have turbulences.

B. The contractor shall provide and/or construct all materials, ductwork, joints, transitions, splitters, dampers, access doors, etc., as set forth in these specifications necessary to install the Low Pressure Sheet Metal Ductwork required by the Mechanical Drawings.

C. Low pressure ductwork shall be constructed to meet the following pressure class:

1. Supply ductwork downstream of terminal units: 1.0" pressure class.
2. Supply and return duct connections to fan coil units or single zone air systems (ESP ≤1.0"): 1.0" pressure class.
3. Supply and return duct connections to fan coil units or single zone air systems (ESP >1.0", ≤2.0"): 2.0" pressure class.
4. Exhaust and return ductwork (Fan ESP ≤2.0"): 2.0" pressure class.
5. Return duct within 100 feet of a fan: 3.0” pressure class.

1.2 QUALITY CONTROL AND REGULATORY STANDARDS

A. SMACNA Manual: Sheet Metal Tradesman is to have access on the construction site to the Latest Edition of SMACNA "HVAC Duct Construction Standards”, (Metal and Flexible). The Manual is referred to in specifications for required construction methods and details. Contractor shall comply with provisions of the SMACNA Manual and more stringent requirements of this specification.

B. Quality control involves not only the general performance requirements for all air ducts, but also quality workmanship which includes layout preplanning so that offsets, rises, falls, elbows, fittings, etc., are minimized or eliminated. General performance requirements for all ducts include:

1. Dimensional stability (shape deformation and strength).
2. Containment of the air being conveyed (leakage control).
3. Vibration (fatigue and appearance).
4. Noise (generation, transmission or attenuation).
5. Exposure (to damage, weather, temperature extremes, flexure cycles, wind, corrosive atmospheres, biological contamination, flow interruption or reversal, underground or other encasement conditions, combustion, or other in-service conditions).
6. Support (alignment and position retention).
7. Seismic restraint is applicable. Refer to specification section 23 05 47.
8. Thermal conductivity (heat gain or loss and condensation control).

C. Provide galvanized duct materials which meet applicable requirements of SMACNA manual and local and state codes, whichever is the most stringent.Support ductwork in accordance with applicable requirements of SMACNA manual, local and state codes, and details on plans, whichever is the most stringent.

D. Emboss fittings with material gauge, manufacturer, and type material.

E. Materials used as sealers, liners, pre-insulated jackets and flexible ducts shall comply with a flame spread rating of 25 or less and a smoke developed rating of not over 50.

F. Joint sealer shall meet the requirements of UL181A or UL181B as applicable.

G. Duct sealant classification: Seal all transverse joints, longitudinal joints and duct wall penetrations in accordance with SMACNA Class A. The sealant used to seal the longitudinal joints of low pressure ductwork must be visible or the joints shall require resealing in the field.

1.3 SUBMITTALS AND SHOP DRAWINGS

A. Submit material/product data to designer for approval ONLY when it deviates from products specified in Part 2 herein.

B. Shop Drawings: Contractor to submit to owner for approval complete sheet metal shop drawings of all ductwork, including equipment rooms, shafts, and especially congested areas and areas with possible conflicts. No installation shall proceed without owner stamped approval of shop drawings. Submittal to reflect space requirements coordinated with other trades such as Electrical, Plumbing, Mechanical and Structural. Prior to submission to owner, shop drawings to have stamped approval of all major trades which occupy ceiling space (HVAC, plumbing, piping, sprinkler, and electrical), to substantiate adequate coordination as to space, accessibility and to ensure no conflict exists between contractors.

C. The General Contractor shall be responsible for coordination between trades and shall stamp and sign the duct drawings to substantiate that the coordination has been accomplished. Non-critical piping and conduit shall give way to ducts.

PART 2 - PRODUCTS

2.1 MATERIAL

A. Sheet Metal, Angles, Bar Slips, Hangers, and Straps: Galvanized steel.

B. Screws: Cadmium plated.

C. Joint Sealer: Hardcast Iron Grip 601 or equal, Single Stage Sealant Process.

2.2 FABRICATION

A. Provide a rectangular or round duct where required on drawings of prime quality galvanized steel sheets, thickness and reinforcement as required by the Latest Edition of SMACNA, or local and state codes, whichever is more stringent. When fabricating low pressure ductwork, largest duct dimension governs the entire duct and complete joint. **Ductwork to be no lighter than 24 gauge.** Contractor may substitute heavier gauge at n o additional cost.

B. Duct dimensions shown on drawings indicate inside clear dimensions.

C. In addition to the requirements above, add supplemental bracing as necessary to prevent sagging, drumming, and vibration.

D. Round prefabricated slip joint duct may be used on exhaust and return duct 12" and smaller and for runout duct to boxes, diffusers, registers, and grilles.

1. Secure duct sections and fittings with sheet metal screws.
2. Make connections of round duct to rectangular duct using "spin-in" collars with manual volume damper.
3. Transverse and longitudinal slip joints shall be sealed with approved sealer.

E. Provide transverse joints of "s" and drive construction at least every eight feet on duct whose larger side is less than 18". Seal all transverse joints with joint sealant material.

F. Provide transverse joints, or equivalent supplemental angle reinforcing on 4 foot centers on

duct whose larger side is greater than 18". At the contractor's option, duct mate or equal joint system may be substituted for "s" and drive construction. Seal all transverse joints with joint sealant material.

G. Longitudinal seams shall be Pittsburg Lock or grooved seams closed tightly and evenly. Button punch snap lock longitudinal seam construction shall not be allowed. Seal longitudinal joints which prove to leak with joint sealant material.

H. Cross break ductwork over 10" dimension, either side.

I. Do not exceed 20 degree angle of slope for increase-in-area transitions.

J. Do not exceed 20 degree angle of slope for decrease-in-area transitions.

K. Do not exceed 30 degrees on the entering side or 45 degrees on the leaving side for angle of transitions at connections to equipment without the use of approved vanes. 20 degree angle is preferred and should be used space permitting.

L. Provide Ells fabricated to one of the following specifications in order of preference (SMACNA Figures 4-2 through 4-4 and Figure 4-9 and Chart 4-1):

1. Unvaned elbow with the throat radius equal to 3/4 of the width of the duct and with a full heel radius.
2. Six inch throat radius with full radius, single thickness vanes and full heel radius. Maximum unsupported length of vanes shall be 36". Vanes shall be securely fastened to runners. All vanes shall be secure and stable in installed operating position. Construct vane edges to project tangents parallel to duct sides.
3. Square elbows with single thickness turning vanes. Maximum unsupported length of vanes shall be 36". Vanes shall be securely fastened to runners. All vanes shall be secure and stable in installed operating position. Construct vane edges to project tangents parallel to duct sides.
4. Radius elbows are the preferred fitting. Square elbows are to be used only when available space prevents the use of radius elbows.

M. Provide offsets as necessary in accordance with SMACNA Figure 4-7.

N. Make branch connections and tees in one of the following manners:

1. Converging radius elbow with MVD. (SMACNA Figure 4-5).
2. 45-degree entry with MVD. (SMACNA Figure 4-6).
3. Round spin-in fitting with MVD.

O. Space duct joints to avoid cutting them for branch take offs and outlet collars.

PART 3 - EXECUTION

3.1 INSTALLATION, APPLICATION, ERECTION

A. Support ductwork on each side of the duct with suitable sheared strips of galvanized metal or 1" x 1/8" galvanized steel band iron hangers.

B. Attach hangers to the ductwork using sheet metal screws.

C. Secure hangers to concrete structure with approved anchor shields and to steel structure by means of C-clamps.

D. Space hangers approximately eight feet along the duct except as noted below.

E. For ducts 60" and larger and heavy sections, such as welded duct and sound absorbers, space hangers at approximately four foot intervals.

F. Obstructions shall not be located within ducts.

G. Do not exceed 45 degrees for easement transition angle.

H. All ductwork, including supply, return and exhaust shall have circumferential joints, longitudinal joints and duct wall penetrations in accordance with SMACNA Class A. The sealant used to seal the longitudinal joints of low pressure ductwork must be visible or the joints shall require resealing in the field.

I. Insulation: Where drawings and insulating specifications indicate that ducts are to be insulated make provisions for neat insulation finish around damper operating quadrants, splitter adjusting clamps, access doors, and similar operating devices. Metal collar equivalent in depth to insulation thickness and of suitable size to which insulation may be finished to be mounted on duct.

J. Counterflashing: Counterflash all ducts where they pierce the roof.

K. Pitot Ports: Pitot ports for measuring airflow to be located in each main duct at the downstream end of the straightest run of the main and before the first branch take-off. Pitot ports to be formed by drilling 7/16" holes in the duct, lined up perpendicular to airflow on maximum 8" centers and at least three to a duct, evenly spaced. Holes to be plugged with plastic plugs. Provide access to these for future rebalancing.

3.2 CLEANING

A. Clean ductwork thoroughly to assure all foreign matter, dirt, etc. is removed.

END OF SECTION

SECTION 23 31 11

SHEET METAL DUCTWORK - MEDIUM PRESSURE

PART 1 - GENERAL

1.1 WORK INCLUDED

A. The contractor shall provide and/or construct all materials, ductwork, joints, transformations, fittings, access doors, etc. as set forth in these specifications necessary to install the medium pressure sheet metal ductwork required by the drawings.

B. Medium pressure - sheet metal ductwork with air velocity greater than 2000 feet per minute and static pressure 6" or less, but greater than 2".

C. It is the intent of this specification to provide an installed duct system which will supply the air quantities indicated by the plans and have the lowest possible friction loss with the least possible leakage loss. Leakage shall not exceed one percent of the respective system capacity. Friction loss for each system shall not exceed that which is indicated in the A.C. unit schedule as external static pressure or in the fan schedule as static pressure and shall include the losses of all accessories. Friction losses shall be minimized by reduction in the number of offsets and elbows by pre-planning the duct system installation and coordination with other trades to prevent interferences. Access to all accessories requiring maintenance, service, and inspection shall be maintained. Radius elbows are preferred for all turns to minimize friction, noise and vibration; and, especially, for sections having large volume or higher velocities, and sections which may have turbulences.

D. Medium pressure ductwork is required from the outlet of AHU to each variable volume terminal box and shall be constructed to meet a 6" pressure class minimum or higher as required to meet air handling unit design external static pressure.

1.2 QUALITY CONTROL AND REGULATORY STANDARDS

A. SMACNA Manual: Sheet metal tradesman to have access, on the construction site, to "HVAC Duct Construction Standards, Metal and Flexible, Latest Edition". The Manual is referred to in the specifications for required construction methods and details. The Contractor shall comply with applicable provisions of the SMACNA Manual and the more stringent requirements of this specification.

B. Quality control involves not only the general performance requirements for all air ducts; but also, quality workmanship, which includes layout preplanning so that offsets, rises, falls, elbows, fittings, etc., are minimized or eliminated. General performance requirements for all ducts include:

1. Dimensional stability (shape deformation and strength).
2. Containment of the air being conveyed (leakage control). (See Part 3 of this specification for leakage testing.)
3. Vibration (fatigue and appearance).
4. Noise (generation, transmission or attenuation).
5. Exposure (to damage, weather, temperature extremes, flexure cycles, wind, corrosive atmospheres, biological contamination, flow interruption or reversal, underground or other encasement conditions, combustion, or other in-service conditions).
6. Support (alignment and position retention).
7. Seismic restraint, if applicable. Refer to Specification Section 23 05 47.
8. Thermal conductivity (heat gain or loss and condensation control).

C. Provide galvanized duct materials which meet requirements of SMACNA manual and local and state codes, whichever is the most stringent.

D. Support duct in accordance with SMACNA manual, local and state codes, and details on plans, whichever is the most stringent.

E. Emboss fittings and duct sections with material gauge, manufacturer, and type material.

F. Materials used as sealers, liners, pre-insulated jackets and flexible ducts shall comply with a flame spread rating of 25 or less and a smoke developed rating of 50 or less.

G. Joint sealer shall meet the requirements of UL181A or UL181B as applicable.

H. Duct sealant classification: Seal all transverse joints, longitudinal joints and duct wall penetrations in accordance with SMACNA Class A.

1.3 SUBMITTALS AND SHOP DRAWINGS

A. Submit material/product data to owner for approval.

B. Shop Drawings: The Contractor is to submit to Owner for approval complete sheet metal shop drawings of all ductwork, including equipment rooms, shafts, and especially, congested areas and areas with possible conflicts. No installation shall proceed without owner stamped approval of shop drawings. Submittal to reflect space requirements coordinated with other trades such as Electrical, Plumbing, Mechanical, and Structural. Prior to submission to Owner, shop drawings to have stamped approval of major trades which occupy ceiling space (HVAC, plumbing, piping, sprinkler, and electrical), to substantiate adequate coordination as to space and accessibility and to ensure no conflict exists between contractors.

C. The General Contractor shall be responsible for coordination between trades and shall stamp and sign the duct drawings to substantiate that the coordination has been accomplished. Noncritical piping, low pressure ducts, and conduit shall give way to medium pressure ducts.

PART 2 - PRODUCTS

2.1 MATERIAL

A. Sheet Metal, Angles, Bar Slips, Hangers and Straps: Galvanized steel.

B. Screws: Cadmium plated.

C. Joint Sealer: Hardcast Iron Grip 601 or Equal Single-Stage Sealant Process.

2.2 GENERAL FABRICATION REQUIREMENTS

A. Medium-pressure duct and fittings to be manufactured by a company who has had as its principal business the manufacture of spiral duct and welded fittings for at least five years.

B. Medium-pressure fittings to be manufactured by same manufacturer of ductwork to assure tight fit of all ductwork and components.

C. Supplier of medium-pressure ductwork to provide to Designer certified copies of test data made by independent United States laboratory covering all duct and fittings as manufactured by supplier.

D. Duct test data to cover leakage rate, bursting strength, collapsing strength, seam strength, and friction loss. Friction loss test data to cover both duct and assembled coupling joints. Fitting test data to cover friction loss tests of all fittings shown on drawings.

E. Installation manuals to be included by the Contractor with submittals. Manuals to provide detailed instructions on assembly, joint sealing, erection, reinforcement of flat-oval duct, and system pressure testing for leaks.

2.3 SPECIFIC FABRICATION REQUIREMENTS

A. Round Duct and Fittings:

1. Round duct to be manufactured using galvanized steel meeting ASTM A-525. Construction shall be in accordance with SMACNA manual and manufacturer's standards.

2. Round duct is to have appropriate seams made to eliminate leakage based on pressures for which the system has been designed. Longitudinal seam duct to have fusion welded butt seam.

3. Fittings and couplings shall have the minimum gauges specified by SMACNA Manual. Fittings to have continuous welds along all seams.
4. Divided flow fittings (90 degree and 45 degree branches, wyes, crosses, etc.) to be manufactured as a separate fitting, not as a tap collar or saddle tap welded into spiral duct sections. Entrances to be free of weld buildup, burrs, or irregularities.
5. Elbows in diameters 3" thru 8" to be stamped elbows. Other elbows to be gored construction with all seams continuously welded. Elbows to be fabricated to center line radius of 1.5 times the cross-sectional diameter. Two-piece mitered elbows shall not be used unless specifically shown on plans.
6. Spun bellmouth connections to be used at each round take-off from medium pressure plenum.
7. Galvanized areas damaged by welding to be coated with corrosion resistant aluminum paint.

2.4 COUPLINGS FOR ROUND MEDIUM-PRESSURE DUCT

A. Diameters up to 60":
1. Duct-to-Duct joints to be sleeve couplings, reinforced by rolled beads.
2. Duct-to-fitting joints to be slip-fit of projecting collar fitting into duct.
3. Insertion length of sleeve coupling and fitting collar to be 2" minimum.

B. Flat-Oval Duct and Fittings:
1. Provide flat-oval duct and fittings where indicated on drawings by symbol accompanying minor and major axis dimensions.
2. Provide spiral-seam, flat-oval duct manufactured from galvanized steel in the following U.S. Standard gauges:

FLAT OVAL DUCT CONSTRUCTION, SPIRAL SEAM	
MAXIMUM WIDTH (IN.)	**GAUGE**
0 - 24	24
25 - 48	22
49 - 70	20
70 and up	18

3. Provide reinforcement and bracing in accordance with SMACNA manual and published details of spiral flat-oval duct manufacturer for size and pressure conditions applicable.
4. Matching flat-oval fittings to be manufactured from galvanized steel with continuous weld seams in the following U.S. Standard gauges:

FLAT OVAL FITTING CONSTRUCTION	
MAXIMUM WIDTH (IN.)	**GAUGE**
0 - 36	20
37 - 60	18
61 and up	16

5. Construct flat-oval duct for sizes not available in spiral construction to the following minimum gauges:

FLAT OVAL DUCT CONSTRUCTION, LONGITUDINAL SEAM	
MAXIMUM WIDTH (IN.)	**GAUGE**
0 - 36	20
37 - 60	18
61 and up	16

6. Flat-oval duct not of spiral construction to be adequately braced on 4' centers by reinforced couplings or angle ring flanges to limit amplitude of wall vibration to plus or minus 0.008" and maximum wall deflection to 0.52" at 6" static pressure. Provide angle flanges when maximum width exceeds 41" or when maximum height exceeds 26".
7. Spun bellmouth connection shall be used at each flat oval duct connection to medium pressure plenum.

C. Rectangular Ductwork:

1. Reinforce rectangular duct with angles or internal tie rods. Joints to be double "S" slip up to 60" in width and companion angle flanged joint above 60" in width. Sheet metal gauges for medium pressure duct shall be as required by the latest SMACNA manual.
2. Fabricate elbows using one of the following methods:
   a. Radius elbows are the preferred fitting. Square elbows are to be used only when available space prevents the use of radius elbows.
   b. Six inch throat radius with full radius, single thickness vanes and full heel radius. Maximum unsupported length of vanes shall be 36". Vanes shall be secure and stable in installed operating position. Construct vane edges to project tangents parallel to duct sides.
   c. Unvaned elbow with the throat radius equal to 3/4 of the width of the duct and a full heel radius.
   d. Square elbows with H-E-P: High Efficiency Profile turning vanes as manufactured by Aero/Dyne Company. Turning vanes shall be double thickness airfoil design with smoothly-rounded entry nose and extended trailing edge. Turning vane assemblies shall be fabricated with side rails and installed on design centers across the full diagonal dimension of the elbow. Vanes are to be installed in strict accordance with manufacturers' recommendations.
3. Contractor may request round or oval duct be substituted for any rectangular duct shown. Size substitutions to be based on equivalent airflow resistance.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Support round ducts from building structure with galvanized steel hangers as recommended in SMACNA manual. Secure hangers to masonry portion of building by means of inserts or other acceptable anchors. Secure hangers to steel structure members by means of C-clamps. Vertical risers and other duct runs where methods of support specified above are not applicable, to be supported by angle brackets as shown in SMACNA manual.

B. Support rectangular and flat oval ducts by 1" x 1/8" galvanized band iron or 3/8" galvanized rod hangers attached to reinforcing angles and spaced same as reinforcing angles. Secure hangers to concrete beam or slab by inserts, anchor shield and bolt, toggle bolt, or expansion bolt.

C. Attach hangers to ductwork using sheet metal screws.

D. Space hangers approximately 8' along the duct for ducts under 60". For ducts 60" and larger and heavier sections, such as welded duct, space hangers at approximately 4' intervals.

E. Hangers and bracing used with ductwork to be galvanized.

F. Obstructions shall not be located within ducts.

G. Provide smooth insulation finish around dampers, access doors, and similar operating devices. Provide metal collar equivalent in depth to insulation thickness.

H. Provide pitot ports for measuring airflows in each main supply duct downstream of straightest run of main and before first branch takeoff. Form pitot ports by drilling 7/16" holes in the duct, lined up perpendicular to airflow on maximum of 8" centers. Provide minimum of 3 per duct evenly spaced. Plug holes with plastic plugs. Provide access to pitot ports for future re-balancing.

I. Seal duct joints as follows:

1. Apply sealer to male end of couplings and fittings. After joint is slipped together, place sheet metal screws 3" on center, 1/2" from joint bead. Apply sealer to the outside of the joint extending 1" on each side of the joint bead and covering screw heads.
2. Duct sealer to be specifically formulated for the sealing of high-pressure duct systems. Submit sealer specifications for approval. Flame spread rating of sealer to be less than 25, smoke development rating of sealer to be less than 50. Apply joint material in strict accordance with manufacturers' published installation instructions.
3. Flanged joints to be sealed with neoprene rubber gaskets.

3.2 LEAKAGE TESTING OF INSTALLED SYSTEMS

A. Test medium pressure ductwork as follows:

1. Follow procedure published by United Sheet Metal Division of United McGill Corporation entitled "System Pressure Testing for Leaks" using prescribed test kit containing test blower, two U-tube manometer, and calibrated orifice tube.
2. Medium pressure duct to be pressure tested from the AHU to the terminal boxes.
3. Installed medium-pressure duct system to be pressurized to 50% over design operating pressure to 6" w.g. maximum. Air leakage at test pressure to be measured by a calibrated orifice type flow meter. Total allowable leakage of system shall not exceed 1/2 of 1% of system air handling capacity. If system is tested in sections, leakage rates to be added to give performance of whole system.
4. Leakage concentrated at one point may result in objectionable noise even if system passes leakage rate criteria; correct to satisfaction of Designer.
5. Orifice flow measurement device to be individually calibrated against a primary standard and calibrated curve permanently attached to orifice tube assembly.
6. Leak testing shall be observed by the General Contractor's on-site quality control representative. The contractor shall have on site at all times the duct leak test training video distributed by the Owner. Maintain on site a set of prints to identify, in different colors, the duct sections isolated for each test, as well as the date of the leak test and final leakage rate recorded for each duct section.

END OF SECTION

SECTION 23 33 10
SHEET METAL SPECIALTIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Specialties to be submitted and approved before starting installation.

B. Items to be installed approximately as shown on drawings taking into account differences in mechanical equipment submitted and that shown on contract documents. Each item to be installed so that it is readily accessible for maintenance, repair, and/or setting and balancing.

C. Diffusers, registers, and grilles to have ratings certified by Air Diffusion Council and tested per ADC Equipment Test Code 1062R2 and ASHRAE Standard 36B-63.

D. Refer to drawings for diffuser, register, and grille sizes and number of airflow directions.

PART 2 - PRODUCTS

2.1 FIRE DAMPERS

A. Fire dampers to be U.L. listed in accordance with UL-555. Fire dampers to be held in an open position with a 165 degree F fusible link and arranged to lock in position on closure.

B. Fire dampers for rectangular duct to be type "B" and for round duct to be Type "C". Fire dampers located behind sidewall registers and grilles and others specifically indicated on drawings to be Type "A". Fire dampers to be multi-leaf type with spring closing for horizontal mounting and weighted-gravity closing for vertical mounting. Dampers to be steel construction with rust resistant finish and provided with a factory-installed mounting sleeve suitable for structure. Mount per manufacturer's published U.L. approved installation instructions.

C. See Architectural drawings for hour-rating of walls and/or floors. Dampers to be compatible with hour ratings.

2.2 COMBINATION SMOKE/FIRE DAMPERS

A. Combination smoke/fire dampers to be U.L. listed both as 1-1/2 hour fire damper under UL-555 and as smoke damper under UL-555S as Minimum Leakage Category II and Elevated Temperature Category B (350 degrees F).

B. Dampers to be steel construction with rust resistant finish and provided with 165 degree F fusible link and factory-installed mounting sleeve suitable for structure. Mount damper per manufacturer's published U.L. approved installation instructions.

C. Damper operator to be electric type compatible with electrical characteristics used for smoke detection and/or fire alarm system.

D. Dampers to be Ruskin Model FSD35 with crimped type blades for low-pressure duct systems and Ruskin Model FSD60 with airfoil blades for medium and high-pressure duct systems.

2.3 DAMPERS

A. Automatic Control Dampers: All automatic control dampers to be furnished by Control Subcontractor and installed by this Contractor (except unit mounted dampers).

1. Automatic control dampers to be low-leak, galvanized steel or aluminum construction parallel blade type, Ruskin Model CD36, Arrow Series 395, or approved equal.

2. Dampers to be complete with minimum 4" deep, 16-gauge hat-shaped channel frame, minimum 16 gauge blades on maximum 6" centers, 1/2" diameter shafts, and corrosion resistant bearings.

3. Dampers to have extruded vinyl blade seals and stainless steel or aluminum flexible metal compression type jamb seals to limit leakage to a maximum of 1/2% (maximum of 5.4 cfm/sq. ft. leakage for 48" x 48" size damper) when tested in accordance with AMCA Standard 500.

4. Motor actuator to be oil immersed gear train, 120-volt line voltage type with spring return to closed position on power interruption. Provide Honeywell Model M445/845, Barber-Colman MA-5210/5330 or approved equal complete with damper linkages.

B. Manual Volume Dampers (MVD): Manual volume dampers to be hand-operated type dampers constructed of galvanized steel, minimum 22-gauge for duct widths 18" and less, minimum 16-gauge for duct widths greater than 18". Dampers for ducts to 12" height and 12" diameter to be single blade carried on a 3/8" round steel rod mounted inside of duct without frame and fitted with locking type quadrant and brass end bearing plate accurately drilled and secured to duct. Dampers for ducts greater than 12" height to be multi-blade type, 12" maximum blade width up to 30" blade length and 10" maximum blade width over 30" blade length. Blades to be mounted on frame with brass sleeve bearings interconnected for operation from one locking type hand quadrant. Round pivot rods to have section faced flat to receive locking setscrew in locking quadrant. Refer to SMACNA manual Figures 2-14 and 2-15.

1. For manual damper locations above a rigid or non-accessible ceiling or where damper access is limited, a remote damper operator shall be used. Damper operator to be self-locking worm gear designed for 3/8” damper shaft. Shaft extension to be 3/8” square rod with coupler. Remote operator to be provided with wrench operated shaft adjustment, position indication and lock nut. Where straight shaft extension cannot be used due to accessibility, a flexible cable operator with compatible damper operator and regulator may be utilized. Damper operator, shaft and regulator shall be designed for minimum 35 in-lb torque. Remote operator in non-sterile areas to be ceiling mounted with removable cover plate or mounted above access door. Sterile area installations such as surgery rooms or elsewhere as indicated on drawings shall use bracket mount installation above access door. Where multiple operators are routed to single or multiple access locations, provide markings to identify the associated air device for future use. The damper operator, shaft extension and ceiling termination/regulator shall be manufactured by Young Regulator, Inc. or approved equal.
2. Ductwork manual volume damper (MVD) handles in externally wrapped ductwork shall be supplied with a stand-off bracket and locking quadrant to ensure that the handle can be adjusted without disturbing the insulation vapor barrier.

C. Backdraft Dampers (BDD): Backdraft dampers to be Ruskin Model CBD6 or approved equal low-leak counterbalanced backdraft dampers. Dampers to be heavy-duty type suitable for air velocities to 2500 fpm with all extruded aluminum construction, minimum 0.81" thick frame, and minimum .050" thick blades on maximum 4" centers. Provide blades with vinyl edge seals. Provide dampers with aluminum linkage and corrosion resistant type bearings. Provide dampers with adjustable counterbalances on blades to assist closing.

2.4 SQUARE CEILING DIFFUSERS

A. Provide Titus TDC or approved equal round or square neck, louvered face ceiling diffusers at all locations designated by schedule on drawings. Diffusers to be all steel construction. Frame to be flush mount for diffusers in "hard" ceilings and lay-in T-bar mount for diffusers in lay-in ceilings. Finish to be baked-on, off-white enamel.

2.5 SQUARE CEILING DIFFUSERS

A. Provide Titus Omni or approved equal round neck, square steel panel face ceiling diffusers at all locations designated by schedule on drawings. Diffusers to be steel or aluminum construction. Frame to be flush mount for diffusers in "hard" ceilings and lay-in T-bar mount for diffusers in lay-in ceilings. Finish to be baked-on, off-white enamel.

2.6 LINEAR BAR DIFFUSERS

A. Provide Titus CT-540 or approved equal linear bar diffuser at all locations designated by "LSD" on drawings. Linear bar diffuser to be extruded aluminum construction with 0 degree deflection, 1/4" wide fixed bars spaced 1/2" apart. Diffuser to be complete with maximum 3/4" flanged border, and concealed fastening. Finish to be baked-on, off-white enamel.

2.7 LAMINAR FLOW DIFFUSERS

A. Provide Titus “TLF” or approved equal laminar flow, steel, perforated face ceiling diffuser at all locations designated by schedule on drawings. Diffuser to have round neck, balancing deflector ring, 3/32” diameter holes on 1/4” centers in a 60 degree staggered pattern, retainer cable and suitable for either surface-mounted or laid-in T-bar ceiling system. Finish to be baked-on, off-white enamel.

2.8 SIDEWALL RETURN REGISTERS

A. Provide Titus 33-RL heavy duty registers at all locations designated on drawings. Registers to be minimum 16-gauge steel construction complete with minimum 38 degree deflection fixed blades spaced 1/2". Finish to be baked-on, off-white enamel.

2.9 CEILING RETURN & EXHAUST REGISTERS

A. Provide Titus Model 50-F or approved equal at locations designated by schedule on drawings. Registers to be complete with 1/2" cube egg-crate aluminum grid. Finish to be baked-on, off-white enamel. Border to be flush mounted frame style.

2.10 AIR LOUVERS

A. Stationary air louvers to be extruded aluminum construction, fixed drainable blade type as manufactured by Ruskin, Arrow, American Warming and Ventilating, Dowco, or approved equal. Louvers to be constructed of minimum 0.081" thick frame and blades. Louver depth to be 6" with equal blade spacings. Blade construction to provide built-in rainstops. Finish shall be Kynar 70% PVDF paint finish with color selected by Architect. Manufacturer will submit metal color chip to Architect as part of the submittal approval. Louver shall be rated at: 1,250 fpm beginning water penetration (at maximum 0.1 oz. per square foot), minimum 55% free area, 0.15" S.P. resistance at 1,000 fpm. Provide 1/2" mesh expanded aluminum screen with removable frame mounted on inside face of louver. Provide minimum 10 year finish warranty.

2.11 FLEXIBLE CONNECTORS

A. Install UL listed flexible duct connectors between duct and fan/equipment connections. Flexible duct connectors to be made of 28-ounce, heavy glass fabric double coated with neoprene.

2.12 FLEXIBLE DUCT

A. Flexmaster Type 1M Acoustical Attenuating or Approved equal. Submit acoustical performance of any alternate product for prior approval.
   1. Characteristics of flexible duct:
      a. Approved as UL-181 Class 1 air duct.
      b. Flame spread rating less than 25 and smoke developed rating less than 50.
      c. Rated for 6" w.g. positive pressure, 4" w.g. negative pressure, and 5000 fpm air velocity.
      d. Tear and puncture resistant reinforced CPE inner liner mechanically locked together with a corrosive resistant galvanized steel helix.
      e. Insulated with minimum 1/2" thick fiberglass insulation with vapor barrier jacket.

B. Seal off the insulation jacket at its ends and at joints with mastic, Hardcast, or similar material. Replace flexible duct if jacket is punctured.

C. Flexible duct is NOT to be used for runouts where it must pass through walls or through smoke or fire partitions. Flexible duct is not to be used in exposed application. Flexible duct lengths shall not exceed 6 feet at each connection.

D. No bends shall be made in flexible duct with the center line radius less than one and one-half duct diameter and only one bend may occur per 6 foot length of duct material.

2.13 DUCT ACCESS DOORS

A. Duct access doors to be provided for access to all coils, fire, fire/smoke, and smoke dampers, automatic and backdraft dampers, duct smoke detectors, static pressure and air volume sensing devices, and other equipment installed in ducts and at other points indicated on drawings.

B. Access door construction and airtightness must be suitable for the duct pressure class used (low, medium, or high).

C. Access doors to be double-panel, galvanized steel construction with minimum 1" rigid insulation between panels. Access doors in exhaust duct and unlined return duct may be uninsulated single panel, galvanized steel construction. Doors to mount in rigid frame constructed of formed galvanized steel. Angle iron bracing to be used as required to provide rigid assembly. Doors to hinge on one side with door latch on opposite side.

D. Access doors in ductwork shall fully comply with Figure 2-12 and 2-13 of SMACNA manual. Casing access doors shall fully comply with Figure 6-11 and 6-12 of SMACNA manual.

E. Doors to close against gasket seal.

F. Ductwork and/or equipment access doors shall be required at all motorized dampers, fire/smoke dampers, smoke detectors, airflow monitoring stations, duct-mounted temperature/pressure sensors and/or transmitters, vaned elbows, duct-mounted heat transfer coils, sound attenuators and any other mechanical and/or control device requiring inspection, maintenance or test access. In addition, 24" x 24" access doors should be utilized wherever possible to facilitate adequate access for maintenance and/or testing.

G. Access doors for fire dampers, fire/smoke dampers, and smoke dampers shall be permanently identified on the exterior by a label having letters not less than 0.5 inches in height reading: “Fire Damper” “Fire/Smoke Damper” or “Smoke Damper” as required by 2015 International Mechanical Code.

2.14 DUCT MOUNTED SMOKE DETECTOR

A. Duct mounted smoke detectors shall be furnished by Division 26. Coordinate power and control wiring. Installation of smoke detector shall by Division 23.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation to be in accordance with manufacturers’ published installation instructions as well as applicable sections of SMACNA manual.

B. Provide all screws, bolts, nuts, and inserts required for attaching sheet metal specialty items to ducts, walls, floors and ceilings.

END OF SECTION

SECTION 23 33 20

ACOUSTICAL BARRIER WRAP

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide barrier wrap equal to Kinetics Model KNM-100ALQ materials at locations indicated on the drawings or as otherwise directed.

B. Provide wrap for vertical supply and return drops from RTU on roof and the first 6 feet of each tap from drops.

PART 2 - PRODUCTS

2.1 BARRIER WRAP

A. Barrier wrap to be a single composite material consisting of a mass loaded limp, flexible, vinyl sheet noise barrier bonded to reinforced aluminum foil on exterior and 1" quilted fiberglass decoupling layer on interior.

B. The barrier wrap to be nominal 1 lb/sq ft density and to have a minimum 28 STC rating as a free hanging barrier when tested according to ASTM E-90-90.

OCTAVE BAND TRANSMISSION LOSS (dB)					
125	250	500	1K	2K	4K
13	16	24	33	43	49

C. The barrier wrap to have maximum flame spread rating of 10 and smoke developed index of 40 when tested in accordance with ASTM E-84.

D. The composite material to have the following minimum insertion loss when adhered to 20 gauge sheet metal duct when tested according to ASTM E-222-90.

OCTAVE BAND INSERTION LOSS (dB)					
125	250	500	1K	2K	4K
6	7	18	24	27	28

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wrap barrier around sheet metal completely covering the area indicated. Quilted fiberglass is to be placed against the sheet metal to decouple the outer limp barrier material from the metal. Securely fasten wrap with proper adhesive, kinetics acrylic based tape and/or bands.

B. All joints are to be sealed with a 6" minimum overlap of limp barrier material similar to that used in the composite to form a continuous air tight barrier around the duct. This to be adhered with 100% coverage of adhesive.

C. Seal all joints where the barrier wrap abuts the building construction with non-setting acoustical sealant such as DAP Acoustical Sealant or approved equal.

END OF SECTION

SECTION 23 34 20
CENTRIFUGAL EXHAUST FANS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Certify fan performance in accordance with AMCA Certified Air and Sound Rating Criteria.

B. Fans shall be UL or ETL listed.

1.2 REQUIREMENTS

A. Select fans such that fan BHP does not exceed motor nameplate horsepower at scheduled conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Greenheck, Acme, Cook, or approved substitute.

2.2 EQUIPMENT

A. Non-overloading, backward inclined, aluminum centrifugal fan wheel.

B. Variable pitch V-belt drive or direct drive as scheduled.

C. Roof as scheduled.

D. Removable heavy gauge aluminum fan housing enclosing motor outside airstream.

E. Permanently lubricated, ball bearing fan motor.

F. Isolate fan motor, wheel, and drive from base with rubber vibration isolators.

G. Electrical junction box.

2.3 ACCESSORIES

A. Gravity backdraft damper.

B. Birdscreen around fan discharge.

C. Disconnect switch on single-phase fans.

D. Prefabricated, 1" thick fiberglass insulated, minimum 18-gauge aluminum or galvanized steel construction, minimum 12" high roof curb. Coordinate required curb base type with roof construction, pitch, and flashing requirements. See architectural drawings.

E. Solid state variable speed controller when scheduled on drawings.

F. Sparkproof construction with explosionproof motor when scheduled on drawings.

G. See fan schedule on drawings for other required accessories.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans in accordance with manufacturers' published instructions.

B. Secure fans to curbs with stainless steel screws.

C. Connect ducts to fans to allow for straight and smooth airflow.

D. Provide flexible connections between fans and ducts.

E. Install fans level.

F. Check fan alignment and balance. Correct improperly aligned or vibrating fans.

G. Final installation to be free of leaks.

H. Ensure fans are interlocked with appropriate systems and/or controls.

END OF SECTION

SECTION 23 34 40
BELTED VENT SETS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This section includes requirements for single width backward inclined, airfoil type belted vent sets.

B. Provide fan capacity, direction of rotation, and discharge direction as shown on drawings.

1.2 PERFORMANCE

A. Certify fan performance in accordance with AMCA Certified Air and Sound Rating Criteria Standard 210, 300, and 301.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Twin City, Greenheck, Cook, or approved equal.

2.2 EQUIPMENT REQUIREMENTS

A. Belted vent sets shall be a completely packaged unit including fan assembly, motor, adjustable belt drive, and adjustable motor base.

B. Wheels and Housings: Wheel diameters and discharge areas shall be sized in accordance with AMCA Standards.

C. Housing Construction: Heavy gage continuously welded steel. Housings shall be suitably braced to prevent vibration and pulsation. Housings shall be field rotatable to different discharge positions. Inlets shall be fully streamlined. Provide inlet and discharge flanges.

D. Painting: Factory applied, corrosion-resistant paint.

E. Shaft: Solid hot rolled steel, ground accurately for a smooth bearing fit.

F. Provide heavy duty, anti-friction, self-aligning ball or roller type bearings. Position bearing supports to directly oppose drive belt tensions and transmit loads to the fan base. Bearings to have a minimum L10 life of 40,000 hours.

G. Mount motor on an adjustable slide rail base.

H. Provide steel fan base.

I. Motor horsepowers and outlet velocities shall not exceed that scheduled on drawings.

J. Fans shall be statically and dynamically balanced at the factory.

K. Provide fans with OSHA approved expanded metal beltguards with tach hole for checking fan shaft speed.

L. Provide fans which all use same type grease.

M. Provide fan housing drain.

N. Provide housing access door.

O. Fans for outdoor mounting to be completely weatherproofed, with a fan motor and drive weather cover, and complete epoxy coating.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans in locations shown on drawings in accordance with manufacturers' published installation instructions.

B. Connect fans to ductwork by means of flexible connections.

A. Exhaust fans serving airborne infection isolation (AII) emergency department waiting rooms shall discharge a minimum of 10'-0" above the finished roof. Refer to details on the drawings.

3.2 TEST AND ACCEPTANCE

A. Start-up and checkout fan for proper motor phasing, alignment, and vibration free operation. Correct improperly aligned fans. Change unmatched belts.

B. Demonstrate system operation to Owner's maintenance personnel and instruct them in operational and maintenance requirements.

C. Verify that, where applicable, fans are interlocked with other fans as required by control drawings.

END OF SECTION

SECTION 23 34 50
SQUARE CENTRIFUGAL IN-LINE FANS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Certify fan performance in accordance with AMCA Certified Air and Sound Rating Criteria.

B. Fans shall be UL or ETL listed.

1.2 REQUIREMENTS

A. Select fans such that fan BHP does not exceed motor nameplate horsepower at scheduled conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Greenheck, Acme, Cook, or approved substitute.

2.2 EQUIPMENT

A. Non-overloading, backward inclined, aluminum centrifugal fan wheel.

B. Variable pitch V-belt drive or direct drive as scheduled.

C. Heavy gauge aluminum or galvanized steel housing with duct connection at fan inlet and outlet and removable access panels to access all interior components without removing ductwork or wiring.

D. Permanently lubricated, ball bearing fan motor.

E. Electrical junction box.

2.3 ACCESSORIES

A. Gravity backdraft damper.

B. Disconnect switch on single-phase fans.

C. Belt guard/motor cover.

D. Solid state variable speed controller when scheduled on drawings.

E. Rubber vibration isolators when scheduled on drawings.

F. See fan schedule on drawings for other required accessories.

G. Provide spark proof fan for med gas bottle storage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans in accordance with manufacturers' published instructions.

B. Connect ducts to fans to allow for straight and smooth airflow.

C. Provide flexible connections between fans and ducts.

D. Install fans level.

E. Check fan alignment and balance. Correct improperly aligned or vibrating fans.

F. Final installation to be free of leaks.

G. Ensure fans are interlocked with appropriate systems and/or controls.

END OF SECTION

SECTION 23 36 10
VARIABLE VOLUME AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Variable volume air terminal units to be pressure independent, single duct, DDC control type with hot water, reheat coil pre-assembled unit with factory installed piping and controls and shall be pre-commissioned.

B. Air terminal unit airflow and sound performance ratings to be certified in accordance with AHRI Standard 880.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

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

1. Johnson Controls, Inc.
   VAV Box Model VRU
2. Siemens
   VAV Box Model ZCU

2.2 EQUIPMENT REQUIREMENTS

A. Provide terminal units with minimum 22-gauge welded galvanized steel housing, slip and drive duct connection, hanger holes or brackets, and 1/2-inch-thick internal glass fiber insulation with a non-ablating, cleanable, sound attenuating liner. Insulation to be UL listed and meet NFPA-90A and UL-181 requirements.

B. Terminal units to be pressure independent. Terminal unit airflow to be monitored by an integral, multiple point, averaging airflow sensing ring or cross to maintain constant airflow within 5 percent of rated cfm down to 25 percent of nominal cfm, independent of changes in system static pressure. Sampling points to be evenly spaced across the air terminal box inlet for better readings. Factory set, field adjustable settings for terminal unit maximum and minimum airflows to be provided in accordance with schedule on drawings. Integral flow taps and calibration chart to be provided for each terminal unit.

C. Internal resistance of terminal unit shall not exceed that scheduled on drawings when handling maximum scheduled air volumes.

D. Terminal unit leakage rate to be maximum 1 percent of nominal cfm at 0.50" w.g. inlet static pressure.

E. Maximum room N.C. due to discharge or radiated sound shall not exceed NC-35 when terminals are either in throttled or full open position with inlet static pressure ranging from 0.5 to 2" w.g. Correction of noise excesses not to constitute additional charges.

F. Terminal units to be complete with factory installed, direct digital control actuator for connection to DDC controls provided by controls contractor.

G. Provide factory mounted hot water reheat coils for terminal units scheduled on drawings in accordance with Section 23 82 16 Heating Coils. Minimum tube thickness of 0.016”.

H. Provide a discharge air temperature on each terminal unit. Temperature measurement to be 1000 Ohm RTD, 2-wire sensing element with +/- 0.3°F accuracy and a stability of less than 0.1°F in five years.

I. Access Door: Provide insulated single wall access door to access terminal interior. Door should be 4-cam lock door with a piano hinge.

J. Piping Components

1. Box should be delivered pre-piped and pre-pressurized. Lines to be 1'-0" long and minimum of 3/4" in diameter.
2. Supply: Ball valve with stainless steel screen as a strainer with hose connection for drain and full-size handle. Valve to have bronze body, chromium plated bronze ball, Teflon seats, stuffing box ring and seals, and quarter turn on-off.
3. Return: Shutoff valve, air vent, PT (Pressure Temperature) test plug, and union. Valve to be ball type with bronze/brass body, chromium plated bronze ball, Teflon seats, blowout proof stem with Teflon packing and nut, and full-size quarter turn handle with grip and memory stop.
4. Auto control valve: Chrome plated brass ball type with characterized port to allow equal percentage throttling. Stainless steel step with removable composition disc and self-adjusting spring-loaded Teflon packing. Valves shall have fully modulating electronic actuators. Actuators shall be proportional and accept a 0 - 10 vdc or 0 - 20 ma. Zone type, tri-state, pulse-type, or similar non-proportional control valves/actuators are not acceptable. Control valve to have unions on both sides of the valve.

K. Shipping: All components to be adequately protected during shipping, pipes to be plugged to keep debris from getting into the pipe and fittings, pipe ends to be prevented from damage during shipping.

L. Warranty: 1-year parts and labor warranty for all the parts of the pre-assembled air terminal box unit, except for the controls contractor's scope of work.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install terminal units in strict accordance with manufacturers' published installation instructions.

B. Terminal units to be supported directly from unit to structure with appropriate supports.

END OF SECTION

SECTION 23 41 10
AIR FILTERS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install filters as scheduled on drawings with appropriate draft gauge(s).

1.2 QUALITY ASSURANCE

A. All filters to meet NFPA 90A requirements for flammability.

B. Filters with a 90% efficiency and less shall be tested in accordance with ASHRAE Standard 52.

C. Filters with a 95% efficiency and higher shall be rated under the D.O.P. test requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. American Air Filter, Flanders, CamFilFarr, TriDim, and 3M.

2.2 MANOMETER

A. Provide a Dwyer magnehelic gauge across each filter bank.

B. Mark gauge to indicate design clean and dirty loading conditions.

2.3 MEDIUM-EFFICIENCY DISPOSABLE FILTERS

A. Provide medium efficiency, disposable, pleated media filters at locations shown on drawings.

B. Each filter shall consist of a non-woven cotton media, media support grid, and enclosing frame.

C. Filter shall be listed by UL as Class II.

D. Provide MERV 11 (60% efficiency) per ASHRAE Test Standard 52.

E. 2-Inch Thick Media: Effective filter media area shall not be less than 4.6 square feet of media per square foot of face area.

2.4 HIGH-EFFICIENCY CARTRIDGE FILTERS

A. Provide MERV 14 (90% efficiency) per ASHRAE Standard 52 to locations shown on drawings.

B. 12-Inch Thick high-efficiency cartridge type filter.

C. Filters to have average velocity through media of not more than 25 fpm.

D. Filters to be selected in accordance with schedule for face velocity in order to produce efficiency and not exceed initial and final resistance as indicated on drawings.

2.5 HOLDING FRAMES

A. Frames to be constructed of 16-gauge galvanized steel.

B. Designed to provide a positive seal against leakage of unfiltered air.

C. Pre-drilled for convenient assembly into banks.

D. Integral spring type latches for holding filter against sponge rubber gaskets.

E. Install frames to provide service from the dirty air side.

F. The Cx authority shall inspect the filter arrangement for tight fit and absolute minimal bypass leakage around frame assembly and it shall be the responsibility of the contractor to correct any deficiencies prior to acceptance by the Owner.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide filters and housings of size and capacities scheduled on drawings.

B. Mount filters and housings at locations shown on drawings.

C. Provide one complete change of filter media for each air handling unit, delivered to job site and turned over to Owner at final inspection.

D. Install filters in accordance with manufacturers' published installation instructions.

E. Install draft gauge(s) outside of air stream for each bank of filters.

F. Protect heating coils, cooling coils, and ductwork with filter media during construction.

G. Upon completion of ductwork and fan system, thoroughly clean systems and install specified filter media prior to placing system in operation.

H. The installing contractor shall be responsible for providing a new set of clean filters during initial system startup and at the start of TAB fieldwork for all air handling units. In addition, temporary filter media shall be removed and final unit filters shall be installed prior to final unit setup by the TAB agency (i.e., prior to final unit traverse).

END OF SECTION

SECTION 23 51 23
PREFABRICATED GAS VENT SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install factory-fabricated, UL listed, double wall, positive pressure vent piping and fittings for Category II, III, or IV appliances.

B. Furnish and install factory-fabricated, UL listed, single wall, positive pressure combustion air intake piping and fittings.

1.2 QUALITY ASSURANCE

A. Where applicable, products furnished under this section shall conform to the requirements of NFPA 54 and NFPA 211, and shall comply with UL 1738, ULC S636 Standard for Venting Systems for Category II, III, and IV Gas-Burning Appliances, and all other applicable standards.

B. All flue-gas carrying components of the vent system shall be obtained through one source.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Dura Vent.
B. Heatfab.
C. Metal-Fab Inc.
D. Approved equal.

2.2 POSITIVE PRESSURE VENT

A. Vent shall be factory-built special gas type, double wall, engineered and designed for use on Category I, II, III, and IV appliances, or as specified by the equipment manufacturer.

B. Maximum continuous flue gas temperature not to exceed 480°F (249°C) for gas burning appliances.

C. Vent shall be constructed with an inner conduit constructed of AL29-4C® or 29-4 (S44735) superferritic stainless steel with a minimum thickness of .015” for diameters 3”-8”, .019” for diameters 10”-16”.

D. Vent shall be listed for an internal static pressure of 15” w.g. and tested to 37” w.g.

E. All inner wall conduit components shall be manufactured from AL29-4C® or 29-4 (S44735). The joint closure system shall be an inner wall mechanical locking design. Joints shall not use screws or fasteners that penetrate the inner conduit.

F. Vent shall be constructed with a factory installed gasket used to seal the joint for diameters 4”–16”.

G. Inner wall joints shall be designed with a male and female overlapping metal-metal connection to maintain condensate on the AL29-4C stainless steel.

H. The outer wall casing shall be constructed of stainless steel.

I. Inner conduit and outer wall casing shall be constructed with an air space between them and in such a fashion that prevents cross-alloy contamination.

J. Tees and elbows shall provide a pressure drop less than 15 feet equivalent horizontal vent.

K. Fittings that increase or decrease vent diameter shall be asymmetric in construction with a flat wall that maintains a straight line with adjoining parts to facilitate the unobstructed flow of all condensate.

L. All parts shall be compatible with other single wall and double wall products of the same manufacturer.

2.3 COMBUSTION AIR INTAKE PIPING

A. Combustion air intake piping shall be factory-built special gas type, single wall, as specified by the equipment manufacturer.

B. Conduit shall be constructed of AL29-4C® or 29-4 (S44735) superferritic stainless steel with a minimum thickness of .025 for diameters 18”-24”, and .035 for 26” and greater.

C. All conduit components shall be manufactured from AL29-4C®. The closure system shall be a Mechanical Locking Strap design. Joints shall not use screws or fasteners that penetrate the inner conduit.

D. Joints to be sealed with factory supplied sealant.

E. Joints shall be designed with a male and female overlapping metal-metal connection to maintain condensate on the AL29-4C stainless steel. Proper ¼” per foot pitch must be maintained at all times and condensate should flow back toward the appliance to the required number of drains.

F. All parts shall be compatible with other single wall and double wall products of the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all components in strict accordance with manufacturers’ published installation instructions.

B. Provide all supports, roof or wall penetrations, terminations, appliance connections, and drain fittings required to install a complete vent system.

C. Protect incomplete vent installations by attaching temporary closures over open ends of sections.

D. Clean all vent and breechings of dust and debris prior to final connection to appliances.

END OF SECTION

SECTION 23 52 16
BOILER, CONDENSING HIGH EFFICIENCY

PART 1 - GENERAL

1.1 INCLUDED WORK

A. Furnish labor, materials, tools, equipment, and services for boilers as specified herein, sized and located in accordance with mechanical drawings.

1.2 RELATED WORK

A. Section 23 05 47: Seismic Bracing of Mechanical Equipment and Suspended Utilities

B. Section 23 09 23: Direct Digital Control / Building Automation System (DDC/BAS)

C. Section 23 21 13: Hydronic Piping

D. Section 23 21 20: Hydronic Specialties

E. Section 23 51 23: Prefabricated Gas Vent System

1.3 QUALITY ASSURANCE

A. Design, construct, and factory test boiler in accordance with ASME Code for Boilers and Pressure Vessels, Section 1, Power Boilers, and state and local boiler codes.

B. Boiler shall receive authorized boiler inspection and bear ASME Stamp, and be UL 795 listed or ANSI Z21.13/CSA Certified.

C. Fire test boiler at factory with the specified fuel(s) to check operation and function of controls. Provide source and field quality control test reports to owner.

D. Gas train assembly shall meet the requirements of Industrial Risk Insurers (IRI) or Factory Mutual (FM).

E. Boiler shall be provided with a minimum 10 year warranty (or manufacturer standard whichever is greater) against failure due to condensate corrosion, thermal stress, mechanical defects or workmanship.

1.4 SUBMITTALS

A. Submit product data for Designer's approval as required by Section 23 01 00.

1.5 DOCUMENTS

A. Provide the following documents to be delivered upon completion of work:

1. Certificates/Permits
    a. ASME Certificate
    b. National Board of Pressure Vessels Inspectors Certificate
    c. Guarantee
    d. Construction and Operating Permits (where required by state or local regulations) from Air Pollution Control Authorities.
    e. Certificate of Acceptance or Boiler Operating Permit from State Boiler Inspector.
2. Operation and Maintenance Data:
    a. Boiler Emergency Manual
    b. Boiler Operation Manual
    c. Boiler Maintenance Manual

1.6 PERMITS

A. Contractor shall obtain construction and operating permits from local Air Pollution Control Authorities and boiler and/or insurance inspectors.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acceptable manufacturers are:

1. Aerco.
2. Lochinvar.
3. Cleaver Brooks
4. Approved Equal.

B. Boilers submitted as alternate to that scheduled on the drawings must be of a size to fit in the space allowed. Boilers are to be provided with a minimum of 3'-0" clear to all sides unless boiler is UL listed to be mounted as a single module with additional units.

C. Boilers submitted must contain the following information: performance data, dimensions and clearances for service, operating characteristics, furnished specialties and accessories, efficiency curves @ 100%, 50% and 7% firing rates and water temperatures ranging from 60F to 160F, pressure drop curve from boiler minimum flow to max flow, and vent requirements.

D. If boiler submitted is an alternate manufacturer or model from the basis of design, contractor and manufacturer are responsible for submitting a coordinated package with all modifications required for the alternate model to work within the as designed system. This will include piping modifications, pump modifications, vent modifications, control modifications, and electrical circuiting requirements. Specific attention is to be given to flow rates of the boiler and any requirements for constant volume boiler flow with variable volume secondary or building flow.

2.2 BOILERS – GENERAL CONSTRUCTION

A. Condensing high efficiency heating water boiler, complete with all controls and accessories ready to operate on natural gas as primary fuel, and propane as back up fuel.

B. Capacity and working pressure: As scheduled on drawings. Boiler shall be factory fabricated, factory-assembled and factory-tested, fully condensing boiler with heat exchanger sealed pressure-tight, built on a steel base, including insulated jacket, flue-gas vent, combustion air intake connection, water supply, return, and condensate drain connections and controls.

C. The boiler shall be manufactured in accordance with ASME Boiler and Pressure Vessels Code. The pressure vessel shall have flanged 150 pound ANSI rated water connections sized for the appropriate flow of the boiler. Pressure vessel shall be constructed of carbon steel or stainless steel.

D. The heat exchanger shall be stamped with the appropriate ASME working pressure not less than 160 psi and manufactured of stainless steel. Pressure vessel/heat exchanger shall be of welded construction. Access to the heat exchanger shall available for inspection and removal.

E. Burner and Modulating air/fuel valve shall be capable of turn down scheduled on the drawings without the loss of combustion efficiency or staging of gas valves. A VFD controlled blower shall be used to ensure the optimum mixing of air and fuel.

F. Exhaust manifold shall be corrosion resistant cast aluminum or 316 Stainless Steel. Manifold to have gravity drain for condensate.

G. Blower to include VFD control and operate during the burner firing sequence and pre-purge the combustion chamber. Blower motors shall not operate in the service factor of the motor.

H. Ignition shall be via regulated staged spark ignition with 100 percent main valve shut off and electric flame supervision.

I. The boiler shall be completed with a metal jacket consisting of a rust resistant alloy steel casing with a two coats hard enamel finish. Jacket shall be readily removable by section.

J. Provide electrical voltage as scheduled on the drawings. Provide factory installed and wired all require controllers, switches, devices and wiring with single point power connection. All wired in conformance with applicable provisions of the National Electric Code.

K. Ceramic fibers that may be potentially carcinogenic to humans are unacceptable as a combustion liner.

2.3 BOILER CONTROLS AND SAFTEY CIRCUITS

A. Control panel shall be UL listed and include LED display. Controls shall annunciate boiler and sensor status and include extensive self diagnostic capabilities the incorporate separate status and fault messages. Combustion safeguard/flame monitoring system shall use spark ignition and a rectification type flame sensor. Controller is to automatically restart after a loss of power in the same mode as before interruption.

B. Controls shall incorporate the following self governing modes where it receives and external control signal to eliminate nuisance faults due to over temperature, improper external signal or loss of external signal. 1) Set point High Limit 2) Set point Low Limit 3)Failsafe Mode

C. Boiler control system shall include the following:

1. System Start Temp
2. Pump Delay timer
3. Auxiliary start delay timer
4. Auxiliary temperature sensor
5. Analog output feature to enable simple monitoring of temperature set point, outlet temperature or fire rate
6. Remote interlock circuit
7. Delayed interlock circuit
8. Fault Relay for remote fault alarm
9. Supply temperature reset based on outdoor ambient temperature

D. Boiler shall include and electric, single seated combination safety shut off valve/regulator with proof of closure switch in its gas train. Each boiler shall incorporate dual over-temperature protection with manual reset, in accordance with ASME Section IV and CSD-1

E. Boiler shall include an oxygen monitoring system that will measure the oxygen content of the exhaust gasses in real-time. Output of monitor shall be available through display.

F. The control system for the combination natural gas and propane firing system shall be IRI or FM approved.

G. Safety provisions in the control circuit shall cause the burner to shut off and prohibit restart until normal condition in the event of the following:

1. High Discharge Temp
2. High Internal pressure
3. Low Water Flow
4. High Water Flow
5. Forced draft fan failure or loss of pressure
6. Ignition pilot flame failure
7. Main flame failure
8. Low fuel pressure

H. In the event of a pilot or main flame failure, the burner shall automatically shut off and cannot begin operation until it is manually reset.

I. Modulating fire control shall provide low fire start and step modulation up to needed capacity firing rate.

2.4 BOILER BURNER

A. Combination type burner shall be an integral part of the boiler, and shall be approved for operation with natural gas and propane.

B. The burner shall be capable of scheduled turn down modulating capacity control without loss of combustion efficiency or staging of gas valves.

C. The burner shall be a metal-fiber mesh cover a stainless steel body with spark ignition and flame rectification. All burner material exposed to combustion to be stainless steel.

D. Modulating burner air and fuel valve to be controlled by a single linkage. Linkage shall not require field adjustment.

E. Ignition shall be a via regulated staged spark ignition with 100 % main valve shut off and electronic flame supervision.

F. Burner to be capable of limiting excess oxygen in flue gas to less than 7%.

2.5 BOILER VENTING

A. The exhaust vent must be UL Listed for use with Category II, III and IV appliances and compatible with operating temperatures up to 230 F. positive pressure, condensing flue gas service. Refer to section 23 51 23 Prefabricated Vent System.

B. Provide exhaust vent flue size as shown on the drawings.

C. Combustion-Air Intake: Boilers shall be capable of drawing combustion air from the outdoors via a sealed combustion duct work constructed of metal between the boiler and building exterior.

D. Follow all requirements for maximum length and slope of manufacturer's venting guide for installation

2.6 GAS PIPING

A. Provide all necessary gas piping properly valved between main and connection to burner and pilot.

B. Gas pilot train shall include a three-way two-position plug cock to facilitate the use of propane as a standby pilot fuel. See drawings for propane tank size, location, and piping.

C. Size in accordance with national, state, and local ordinances and codes, and NFPA recommendations.

D. Gas cocks: Lubricated plug cocks with operating handles.

E. Gas burner piping assembly, including pilot, shall meet requirements of IRI or FM.

2.7 ASSEMBLY AND TESTING

A. Boiler, control panel and all components to be factory assembled and tested.

B. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions and carbon monoxide in flue gas and demonstrate submitted combustion efficiency. Perform hydrostatic test.

C. Test and Inspect factory assembled boilers, before shipping according to ASME Boiler and Pressure Vessel Code. Provide testing documentation and results to owner as part of owner engineering manuals.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Boilers are to be installed per submitted and approved shop drawings. Refer to specification section 23 01 00 for requirements.

B. Install boilers in accordance with NFPA, ASME, local codes, and manufacturer's instructions, and Factory Mutual requirements. All boilers are to be installed with a minimum 3'-0" clear in all dimensions.

C. Coordinate size and location of concrete bases. Provide minimum 6” base extending a minimum of 6” beyond the anchor attachments for all seismic rated anchors. Refer to seismic bracing sub contractor anchorage drawings for requirements, specification section 23 05 47. Cast anchor-bolt inserts into bases. Coordinate concrete, reinforcement and formwork requirements with division 3.

D. Boilers and accessories shall be installed and piped per manufacturer's recommendations and under his supervision. Drain valves on boiler shell and condensate neutralization receivers shall be piped to the nearest drain, full size of the connection. Relief valves and vents shall be piped to outside the building using either the connection size. Relief lines turning up through the roof shall be provided with gooseneck fittings to prevent water entry. Pipe gas vent connections on gas controls to outside of the building.

E. Boilers shall receive factory start-up supervision tests to check construction, operation, and function of controls and to ensure proper preparation for use. (See the following paragraphs.)

3.2 DUTIES OF SERVICE REPRESENTATIVE

A. Boiler and burner manufacturers’ factory trained service representative(s) to perform services described below:

1. Instruct designated maintenance personnel in operation and maintenance of equipment.
2. Test operation of safety valves.
3. Adjust firing equipment. Representative shall have the test equipment, tools, and instruments necessary to accomplish this work.
4. Conduct boiler performance demonstration; demonstrate firing on both fuel sources.

B. Provide option for separate (additional) boiler operating training, if required.

3.3 START-UP

A. Leak Test: Perform hydrostatic test.

B. Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

C. Test and adjust controls and safety’s. Replace damaged and malfunctioning controls and equipment. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.

D. Set field-adjustable switches and circuit-breaker trip ranges as required.

3.4 OPERATING DEMONSTRATION

A. Demonstrate to Owner the operation of the system over entire range, using both primary fuel and back up fuels.

B. Demonstrate to Owner the operation and maintenance of total system as a unit - boiler, circulating pumps and condensate neutralization system. Demonstration is to be videotaped for owner records.

END OF SECTION

SECTION 23 75 13
ROOFTOP AIR HANDLING UNIT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide rooftop units as shown on schedule and located on drawings. Units to be manufactured by AAON.

B. Related Sections
   1. Section 23 05 48 Vibration Isolation – Roof curb requirements.
   2. Section 23 41 10 Filters – Filter requirements.

1.2 SUBMITTALS

A. Shop Drawings: Shop drawing submittals shall include, but not limited to, the following: drawings indicating components, dimensions, weights, required clearances, location, type and size of field connections, and power and control wiring connections.

B. Product Data: Product data shall include dimensions, weights, capacities, ratings, fan performance, motor electrical characteristics, and gauges and finishes of materials.

C. Documentation:
   1. Fan curves with specified operating point clearly plotted shall be provided.
   2. Product data of filter media, filter performance data, filter assembly, and filter frames shall be provided.
   3. Electrical requirements for power supply wiring, including wiring diagrams for interlock and control wiring shall be supplied. Factory and field-installed wiring shall be clearly indicated.

PART 2 - PRODUCTS

2.1 UNIT CONSTRUCTION

A. The unit shall include an integral design base rail with lifting points clearly marked and visible on the base rail and a 1-1/4 inch female pipe thread (FPT) connection for condensate drainage. The unit base shall be designed with a recessed curb mounting location. The recessed curb mounting surface shall provide a continuous surface for field application of curb gasketing to create a weather-tight seal between the curb and unit.

B. Unit casing shall have double wall insulation with injected foam. Insulation application shall meet NFPA 90 requirements. Insulation system shall be resistant to mold growth in accordance with UL 181 and ASTM C1338 standardized test methods.

C. Exterior painted surfaces shall be designed to withstand a minimum of 750 salt spray hours when tested in accordance with ASTM B-117.

D. All necessary tags and decals to aid in the service and/or indicating caution areas shall be provided. Electrical ladder wiring diagrams shall be attached to the control panel access door.

E. Installation and maintenance manuals shall be supplied with each unit.

2.2 ACCESS DOORS

A. Double wall access doors shall be provided in the fan, discharge coil, filter, and inlet sections.

B. Doors shall be double wall construction with a solid liner and a minimum thickness of 1 inch.

C. Doors shall be attached to the unit with stainless steel hinges. A minimum of three 5/16-inch hex-drive, 90° opening standard finger pull latches shall be provided.

D. Panels and doors shall be completely gasketed with a closed-cell, neoprene gasket.

E. Door tiebacks shall be provided for all doors to secure them while servicing.

F. Doors that provide access to positive pressure segments shall include a safety latch. The safety latch shall relieve pressure if inadvertently opened during unit operation.

2.3 COOLING COIL SECTION

A. Direct expansion coils to be multi-row type fabricated from seamless copper tubing mechanically bonded to aluminum fins. Coils to be factory leak tested with air at 450 psig. Coil circuiting to be fed with adjustable thermal expansion valve (one per refrigerant circuit) with external equalizer.

B. Main coil drain pan to be insulated double-sloped stainless steel construction drain pan with condensate connection through the base rail of the unit. Pan shall be sloped to provide positive drainage of condensate. Coil sections with stacked coils to have an intermediate drain pan with condensate drop tubes to main drain pan.

2.4 SUPPLY FAN SECTION WITH VFD

A. The fan section shall be equipped with dual SWSI airfoil plenum wheels. Plenum fans shall be direct drive. Dual SWSI supply fans shall be connected to a single VFD. An access door shall be provided on the opposite side of the control panel for fan/motor access.

B. Fan motors shall be NEMA design ball-bearing types with electrical characteristics and horsepower as specified. Motors shall be nominal 1800 RPM, ODP type.

C. Fan and fan motor shall be internally mounted and isolated on a full width isolator support channel using 1-inch springs.

D. The VFD shall include an integral DC line reactor to reduce harmonic distortion in the incoming and outgoing power feeds. If a DC line reactor is not provided, an AC line reactor shall be provided.

E. All VFDs shall be factory tested and matched with each unit.

F. Shaft grounding rings on motors shall be provided to prevent electrical bearing fluting damage by safely diverting harmful shaft voltages and bearing currents to ground, increasing motor longevity.

G. Supply Airflow Measurement capability shall be provided. Supply fan airflow shall be viewable on the control panel and communicable across the BAS.

2.5 FILTER SECTION

A. Provide side access filter section with galvanized steel filter racks as integral part of unit. Provide final filter section prior to unit discharge.

B. Minimum filter area to be as specified on unit schedule but not to exceed 500 fpm filter face velocity.

C. Filter sections to have full sized, hinged, latched, double wall access doors on both sides of unit for filter service.

D. Refer to Section 23 41 10 Filters, for filter specification.

E. Provide 30 percent medium efficiency (ASHRAE Standard 52), 2" thick pleated disposable type cartridge filters equal to Farr 30/30.

F. Provide 90 percent high efficiency (ASHRAE Standard 52), 12" thick pleated, disposable type cartridge filters equal to Farr Riga-Flo.

G. Provide one complete set of replacement filters to Owner at job completion.

2.6 RELIEF FAN WITH VFD

A. Relief fan to be a SWSI direct drive plenum fan statically and dynamically balanced for quiet operation.

B. An access door shall be provided on at least one side of the unit for fan/motor access.

C. All VFDs shall be factory tested and matched with each unit.

D. Fan motors shall be National Electrical Manufacturers Association (NEMA) design ball-bearing types with electrical characteristics and horsepower as specified. Shaft grounding rings on motors shall be provided to prevent electrical bearing fluting damage by safely diverting harmful shaft voltages and bearing currents to ground, increasing the motor longevity. Motors shall be nominal 1200 RPM open drip-proof (ODP) type. The motor shall be

located within the unit on an adjustable base.

E. Fan and fan motor shall be internally mounted and isolated on a full width isolator support channel using1-inch springs The fan shall be connected to the fan cabinet using a flexible connection to insure vibration-free operation.

F. Provide safety grate over return air opening.

2.7 ECONOMIZER SECTION

A. The economizer segment shall be designed to use outside air for cooling, ventilation, and shall provide a means of exhausting air from the air handling unit. The segment shall consist of parallel-acting low leak dampers. The outside air (OA) and exhaust air (EA) dampers shall be sized for 100% of nominal unit airflow. The EA damper assembly shall have rain hood attached to the cabinet to prevent windblown precipitation from entering the unit.

B. OA inlet openings shall be covered by a rain hood attached to the cabinet to prevent windblown precipitation from entering the unit. The OA hood shall contain a removable and cleanable filter with an efficiency rating of 50% based on ASHRAE 52. Damper blades shall be fabricated from a minimum of 16-gauge galvanized steel. Damper shafts shall be fabricated from solid steel and mounted in the frame with bronze bearings.

2.8 DISCHARGE AIR PLENUM

A. Double wall discharge plenum with double wall access door to plenum.

B. The discharge air temperature (DAT) sensor shall be in the DA plenum and located such that it accurately measures the supply air temperature

2.9 CONDENSER SECTION

A. Condenser fans shall be propeller type with aluminum blades, directly driven by permanently lubricated three phase motor.

B. Microchannel condenser coils shall be constructed of parallel flow aluminum alloy tubes metallurgically brazed to enhanced aluminum alloy fins. Condenser cleaning hatches shall be provided for access to condenser coil without the removal of condenser fans. All coils shall be pressure-tested at a minimum of 650 psig.

C. Discharge and suction and liquid shut-off valves shall be included to provide a means of isolating the refrigerant charge in the system so that the refrigeration system shall be serviced without removing the charge in the unit.

D. Sight Glasses shall be accessible without having to open air handler section access doors or remove panels.

E. Units shall use hermetic scroll compressors, piped, and charged with oil and R-410A refrigerant. Each compressor shall be protected from over-temperature and over-current conditions. Compressors shall be vibration-isolated from the unit and installed in an easily accessible area of the unit. All compressor-to-pipe connections shall be brazed to minimize potential for leaks. Unit shall be designed to minimize leaving air temperature changes when varying capacity. Steps of capacity control shall not exceed 23% of unit capacity when modulating from minimum to maximum. Hot gas bypass operation shall not be used to meet maximum modulation steps of control. Variable speed drive compressors shall be used if unit is not capable of meeting the maximum modulation percentage of step capacity.

F. Liquid line filter driers shall be provided as a standard on the unit.

G. The condenser section shall be enclosed by a wire grill condenser enclosure on the three exposed sides.

H. Condenser Safety tie-off shall be supplied on condenser roof. Safety tie-off shall allow for service technician to attach personal fall protection device during repair/inspection of condenser fans and motors.

2.10 CONTROLS

A. Unit shall be factory configured, installed, wired, and tested with a rooftop unit controller housed in a rain and dust-tight, powder painted, steel cabinet behind hinged, latched, and gasket-sealed door. VFD control keypads shall be in the control cabinet for accessibility and

servicing while the unit is operating.

B. A duplex ground fault circuit interrupt (GFCI) receptacle shall be factory-mounted in a weatherproof enclosure and wired for a 15-amp load. Unit powered convenience outlet shall include transformer to step down to 115V.

C. Control shall include automatic start, stop, operating, and protection sequences across the range of scheduled conditions and transients. The rooftop unit controller shall provide automatic control of compressor start/stop, energy saver delay and anti-recycle timers, condenser fans, and unit alarms. Automatic reset to normal operation after power failure. Software shall be stored in nonvolatile memory with programmed setpoints retained in super capacitor-backed real time clock (RTC) memory for a minimum of 5 years.

D. Unit shall be supplied with the Smart Equipment Control system. All units shall be factory commissioned, configured, and run tested.

E. The display shall be organic light-emitting diode (OLED) with green characters on black background providing high visibility. The display shall provide a minimum of 175 characters in total with 35 characters x 5 lines. The OLED display shall be a 256 × 64 dot matrix. The display shall show animated text, symbols, and descriptions down to -40.0°F (-40.0°C) without noticeable degradation of contrast or display response time. Numeric data shall be provided in imperial or metric units. A sealed, membrane style keypad with 20 keys shall be used to navigate the controller and enter data. Specific keys shall be individually assigned to allow quick selections. The software on the user interface (UI) shall be upgradable in the field.

F. The following display information shall be available based on selected unit options:
   1. Unit summary with serial, model number, language, unit status, and enable. Controller hardware, firmware, and network inputs.
   2. Sensor information for all devices connected to the unit, and setpoints.
   3. Commissioning menu shall have options to view key parameters such as occupancy, cooling, heating, economizer, ERW, morning warm-up, staggered start, safety setup, low ambient and demand control ventilation (DCV).
   4. Start-up, air balancing and commissioning wizard shall be provided for field technicians to complete unit configuration and start-up.
   5. Occupied, unoccupied, coast modes.
   6. Date, time, time zone, schedules.
   7. Cooling enable, status, setpoints, stages, compressor capacity, runtime, anti-short cycle time, rapid start, and morning cool down.
   8. Heating mode, enable, status, stages, capacity, runtime, setpoints, valve commands, and morning warm up.
   9. Supply fan, return/exhaust fan status, command, air proving switch, VFD speed, runtime, and faults.
   10. Condenser fan staged and modulating command, low ambient.
   11. Economizer mode, damper position, airflow, fresh air, and alarms for economizer FDD.
   12. HGRH status, enable, humidification setpoint, and valve command.
   13. Energy recovery wheel status, command, output, temperature.
   14. Smoke control modes, sensor inputs, smoke detector shutdown.
   15. Unit alarms such as safety switch, phase monitor, compressor safety, filter differential pressure, carbon-dioxide (CO2), low pressure, high pressure, freezestat, UV light, and condensate switch. Alarms mode with up to 5 current alarms and 25 previous alarms with time and date.

G. Upon start-up of the unit controller, it shall run through a self-diagnostic check to verify proper operation and sequence loading. The rooftop unit controller shall continually monitor all input and output points to maintain proper operation. The unit shall continue to operate in a trouble mode or shut down as necessary to prevent an unsafe condition for the building occupants or to prevent damage to the equipment. In the event of a unit shutdown or alarm, the operating conditions, date, and time shall be stored in the shutdown history to facilitate service and troubleshooting. A minimum of 10 error histories shall be recorded.

H. Staging of the multiple fixed speed compressors shall be used to control refrigeration capacity. Upon entering cooling mode from other modes, the unit controller shall estimate the

cooling requirement and match it closely to the capacity to reduce the time required to satisfy the cooling requirements. After the initial calculation, the unit controller shall add or reduce stage as necessary to establish a balance between the unit capacity and the space cooling load.

I. The smoke control sequences shall be available through BAS communication and hard-wired connections using Customer Terminal Board. The smoke control sequences shall be used whenever the smoke control binary inputs are turned ON to remove, exhaust, or ventilate smoke, fumes, or other airborne contaminates from the occupied space. The unit controller shall include purge, pressurization, and evacuation sequences of operations. Smoke control inputs shall be assigned a higher priority over smoke detector and shall override a smoke detector shutdown.

2.11 BAS COMMUNICATIONS

A. The unit shall have BACnet MS/TP, Modbus, N2 communication protocol integral to the unit controller. The controller shall be certified for BACnet communication protocol by BACnet Testing Laboratory (BTL) to meet the requirements of the advanced application control profile. A control points list, BACnet interoperability building blocks (BIBBs), and protocol implementation conformance statement (PICS) shall be provided by the manufacturer to facilitate communications programming with the BAS.
   1. Customer Terminal Board - A Customer Terminal board shall be supplied on all units requiring smoke control sequences.
   2. Metasys® communication interface - The building automation system (BAS) shall provide the owner with a simple user experience and configurable controls. The system shall consist of Smart Equipment technology and must be capable to interface with Metasys systems.

2.12 ROOF CURB

A. Refer to Section 23 05 48 Vibration Isolation for roof curb requirements.

2.13 ELECTRICAL

A. Unit to be wired and tested at factory before shipment. Wiring to comply with NEC requirements and conform with applicable UL standards. Wiring to be number coded per electrical wiring diagrams. Electrical components to be labeled according to electrical diagram and be UL recognized where applicable. Each unit to have 115-volt control circuit transformer separate 115-volt power source connection, 115-volt receptacle and plenum lights. All wiring shall be in rigid conduit or EMT and shall be securely fastened to unit interior wall.

B. Fan motors to be individually fused. Fan motors to have contactors and external overload protection. Main control panel to be weatherproof construction with a dead front cover over the main power circuit controls.

C. Terminal block to be provided for main power connection. Provide terminal board for low-voltage control wiring.

D. Non-Fused Disconnect Switch: Provide disconnect switch on each unit to cut power to entire unit before control panel door can be opened.

E. Provide factory wiring between fan motors, lights, and power box. Power box to include motor starters, disconnect, hand-off-auto switch, pilot light, control power transformer, convenience 120-volt outlet and light switch. All electrical components except vapor-tight lights to be mounted in a NEMA 1 enclosure adjacent to the access door. A light switch, fuse and 120-volt convenience outlet shall be mounted on the power box cover.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Each unit to be installed level and in strict accordance with manufacturers' published installation instructions. Contractor to be responsible to insure no roof leaks around unit curb, curb to unit interface, cabinet leaks, condensate leaks, etc. Roof curb(s) to incorporate roof structural slope so unit will be level.

B. Duct connections to units to allow for straight and smooth airflow. No turns to be installed at fan discharge in opposite direction to fan wheel rotation. Connections to unit to be made with U.L. approved flame resistant, self-extinguishing, water and airtight, heavy glass fiber woven material impregnated with synthetic elastomer; Duro-Dyne "Durolon", Ventfabrics "Ventlon", or approved equal.

C. Piping connections to unit coils to be supported independently of coils with adequate flexibility to prevent undue stress at coil header connections.

D. Drain lines to be run full size from drain pan connection and include a trap to permit condensate to drain freely.

E. Service valves to be installed on both supply and return lines to coils. Install at location so valves can be shut off, section of pipe removed, and coil removed by sliding out. This does not apply to direct expansion coils.

F. Unit manufacturer to provide with equipment bid, 8 hours of training to Owner or Owner's representative in maintenance and proper operation of equipment furnished.

END OF SECTION

SECTION 23 81 26

SINGLE CONDENSER / MULTI-ZONE HEAT PUMP

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Air-cooled, split system multi-zone air conditioning units to be by Carrier, Mitsubishi, LG, Sanyo, Daikin or approved equal.

B. Manufacturers both listed above and proposed alternates to review the allowable space for the indoor units considering service access, filters access and refrigerant and condensate piping to ensure adequate clearance exists for their units prior to submitting bid. Contractor shall not be allowed an extra should the low bidder prove to have unacceptable clearance.

C. Manufacturer to submit for approval all evaporator and condensing unit matches showing a balance diagram indicating refrigerant suction pressure and proposed refrigerant line sizes. Under no circumstances shall an evaporator/condensing unit match be selected less than 36 degrees F. Attention to be given to units where significant lengths (heights) exist between evaporator and condensing unit locations.

PART 2 - PRODUCTS

2.1 CONDENSING UNITS

A. Units to have capacity scheduled on drawings and be complete with the following:

1. Capacitor start and relay.
2. Indoor fan relay.
3. Liquid line filter dryer.
4. Short cycling prevention (Solid State).
5. Solid brass service valves.
6. Crankcase heaters.
7. High and low refrigerant pressure switches.
8. Current and thermal compressor overloads.
9. Winter start and condensing pressure control to allow operation in ambient to 40 degrees F.
10. Fully weatherproof casing, galvanized steel, zinc phosphatized, and finished with enamel. Provide with screened or louvered coil guards.
11. Control transformer.
12. Five-year compressor warranty.
13. Automatic changeover thermostat.
14. Condensing unit to be capable of serving multiple indoor evaporator units.
15. Provide manufacturer's refrigerant piping manifold for multiple indoor evaporator connections.

2.2 EVAPORATOR UNIT

A. Units to be capacity matched with condensing units and complete with following:

1. Forward curved, double inlet supply fan mounted on motor shaft, dynamically and statically balanced. Fan motor to be multi-speed, factory lubricated, have internal overload protection, and be resiliently mounted.
2. Cooling coil of nonferrous tubing with mechanically bonded aluminum plate fins with all joints brazed. Coil to have factory installed refrigerant metering device, refrigerant mechanical joint line fittings, and condensate pan.

3. Factory installed electric heater. All heaters to be equipped with thermal overload device, current overload for heaters 10 kw and required heating and cooling system controls including 60-va control circuit 24-volt transformer. Low voltage connection to be point-to- point on terminal board.
4. Factory insulated unit enclosure constructed of cold-rolled steel, bonderized and finished with baked enamel. Front access panels to provide access to all components. Filter rack to accept 1 inch thick filters.
5. Unit to be provided with 2" pleated 30% efficient disposable filters of standard size.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install evaporator and condensing unit to allow space for service, maintenance, and airflow requirements.

B. Provide flexible duct to evaporator connection.

C. Install in compliance with manufacturers' recommendations.

END OF SECTION

SECTION 23 82 16
HEATING COILS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Hot Water Coils.

1.2 CERTIFICATION

A. Certify coil capacities, pressure drops, and selection procedures in accordance with AHRI Standard 410.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Coils shall be the product of a manufacturer regularly engaged in production of coils who issues complete catalog data on such products.

2.2 CONSTRUCTION

A. Tubes: Copper.

B. Fins: Aluminum or copper.

C. Headers: Heavy gauge cast iron or steel.

D. Casing: Minimum 16-gauge galvanized steel.

E. Testing: Proof test and leak test each coil at minimum 300 psig and 200 psig air pressure respectively with coil submerged in water.

2.3 HOT WATER COILS

A. Design for minimum 200 psig at 220 degrees F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount coil in accordance with SMACNA standards including a maximum transition angle of 30 degrees on the entering air side of coil and 45 degrees on leaving air side. Transitions on both entering and leaving side to be 20 degrees if space permits. Provide air-tight seal between coil and duct or unit casing.

B. Provide access door on entering air side of coil for cleaning and inspection purposes.

C. See drawings for required piping connections to hot water coils.

D. Externally insulate coil casing including return bends with 1" thick, blanket-type fiberglass insulation to prevent condensation.

E. Hot water reheat coils required for variable volume boxes to be furnished factory mounted to boxes by terminal box manufacturer.

END OF SECTION