SECTION 230500 - HEATING AND AIR CONDITIONING

230501 GENERAL

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. The Heating and Air Conditioning Contractor shall cooperate with the contractors of other trades and shall install his work as fast as the progress of the balance of the work will permit.

C. See Section 013000 for requirements for Coordination Drawings.

D. The Heating and Air Conditioning Contractor shall install all work and fired and unfired pressure vessels and their safety devices in accordance with the requirements of the latest edition of the North Carolina State Boiler Inspection Law Rules and Regulations and the North Carolina State Building Code. Codes to be a part of these specifications: North Carolina State Building Code, National Fire Protection Association Codes Section 54, 70, 90A, 91 and other applicable sections.

E. Permits and Inspection Fees: The Heating and Air Conditioning Contractor shall secure all necessary required permits and inspections for this work. Charges for permits will be by the Owner. Inspection by local authorities will be required.

F. The drawings accompanying these specifications indicate diagrammatically the general location of the ducts, piping, and equipment and do not show all offsets, supports, fittings, bolts, connections, etc., required for a complete system. While the drawings are to be followed as closely as possible, if it is found necessary to change the location of same to accommodate the conditions at the building, such changes shall be made without additional cost to the Owner, and as directed by the Engineer. Any detail which is omitted, and which is necessary for the proper operation of any system included under the contract, shall be supplied and installed by the Heating and Air Conditioning Contractor without extra cost to the Owner. All pipes and ducts shall be run as high as possible to maintain ceiling and head clearance. All equipment shall be installed in such a manner as to allow proper maintenance access.

G. Equipment and Materials shall be delivered to the site and stored in original containers, suitably sheltered from the elements, but readily accessible for inspection by the Engineer until installed. All items subject to moisture damage shall be stored in dry spaces.

H. Conditions shall be checked at the building before placing orders for apparatus and such apparatus shall be of such dimensions as to fit the spaces allotted. The Heating and Air Conditioning Contractor shall not scale mechanical plans, but rather refer to architectural plans for dimensions.

I. By signing the Contractor's Proposal, it is understood and agreed that the Heating and Air Conditioning Contractor has, by careful examination, satisfied himself with the quantity, quality, and location of all excavation materials to be encountered in his contract. No additional payment will be approved for well pointing or any other existing conditions encountered. Refer to Division 31 of these specifications for site work requirements.

J. All debris resulting from heating and air conditioning work shall be removed from the premises daily or as directed by the Engineer. Trash and rubbish shall not be allowed to accumulate either within or outside the building. Materials and debris, which in the opinion of the Engineer cannot practicably be removed from the site the same day, may be temporarily stacked or stored in a designated location on the site as directed by the Engineer.

K. Guards shall be provided for all moving equipment, motor couplings, pump shafts, belt drives and similar exposed reciprocating or rotating components.

L. All HVAC and refrigeration equipment shall be labeled in accordance with Section 301 of the North Carolina Mechanical Code and as required by the Authority having jurisdiction. Labeling shall be a permanent factory-applied nameplate affixed to the equipment on which shall appear in legible lettering, the manufacturer's name or trademark, the model, serial number, and the seal or mark of the testing agency.

230502 SCOPE

A. The Heating and Air Conditioning Contractor shall provide labor and materials required for a complete system ready for operation as shown on the drawings and hereinafter specified. This includes all equipment, ductwork, necessary plumbing, and all other services necessary whether they are specifically mentioned herein or not. The entire installation shall be installed in a first-class, neat, professional manner to the satisfaction of the Engineer and shall conform to all applicable codes and laws.

230503 SHOP DRAWINGS AND SUBMITTAL DATA

A. The Heating and Air Conditioning Contractor shall submit within 10 days after award of the contract a list of materials and the manufacturer to be used on this project. He shall submit within thirty days after award of the contract at least five copies of submittal data in written form for the Engineer's use in approving materials and equipment. One copy will be returned. If the Heating and Air Conditioning Contractor desires the return of more than one copy, additional copies shall be provided to the Engineer at the time of the original submission. It is requested that all submittal data be sent to the Engineer at one time. Unless special consideration is given, none of the submittal data will be checked until it has all been received by the Engineer. Where called for, the Heating and Air Conditioning Contractor shall submit five sets of shop drawings showing the detailed arrangement or connections that are shown schematically on the drawings. Data certified for the specified project and indicated manufacturer, type, or size, capacity, etc., shall be submitted for the following equipment items:

1. Packaged Gas/Electric Air Conditioning Units
2. Dedicated Outside Air Units
3. Power Ventilators and Louvered Penthouses
4. Diffusers, Grilles and Registers
5. Heaters
6. Controls with Complete Diagram
7. Fire, Manual, and Motorized Dampers
8. Access Doors
9. Spiral Ductwork
10. Insulation
11. Duct Sealant
12. UL Pipe Penetration Details
13. Seismic Restraints
14. Testing and Balancing

230504 APPROVED EQUAL EQUIPMENT, ETC.

A. Manufacturers listed are to establish a standard of quality and not intended to limit the selection to these manufacturers. All materials and equipment which are essential and have not been specified or shown shall be new and of the highest grade and quality, free from defect or other imperfections. It should be understood that where the word "provide" is used, it is intended that the Heating and Air Conditioning Contractor shall purchase and install all materials required. Approval of equipment will not relieve the Contractor of compliance with the specifications even if such approval is made in writing, unless the attention of the Engineer is called to the non-complying features by letter accompanying the submittal data. Approval of submittal data by the Engineer shall not be construed as a complete check of approval of detailed dimensions, weights, gauges, and similar details with the proposed articles. The conformance

with the necessary coordination between the various other contractors and suppliers shall be solely the responsibility of the Heating and Air Conditioning Contractor.

230505 PACKAGED GAS/ELECTRIC AIR CONDITIONING UNITS

A. Units shall have cooling performance rated in accordance with AHRI standards. Unit shall be factory assembled, piped, internally wired, fully charged with R-410A and 100% run tested to check full operation, fan and blower rotation and control sequence before leaving the factory. Wiring internal to the unit shall be numbered for simplified identification. Unit shall be UL listed and labeled, classified in accordance to UL 1995/CAN/CSA No. 236-M90 for Central Cooling Air Conditioners.

B. Units shall have the following characteristics:

1. DX cooling, natural gas heat.
2. Downflow airflow.
3. Dual compressors where indicated on the drawings.
4. High pressure control.
5. Factory installed 0-100% outside air dry bulb economizer with barometric relief where indicated on the drawings.
6. Factory installed hot gas reheat - dehumidification control.
7. Gas heating section, multi-stage where indicated on the drawings.
8. MERV 8 filters.
9. Microprocessor controls with Reliatel or equal controller inside unit.
10. Programmable space temperature and relative humidity sensors with link to unit controller
11. Phase monitor.

C. Unit casing shall be such that all components are mounted in a weather resistant steel cabinet with a painted enamel finished exterior. Service panels shall be provided for unit controls, indoor coils and fans with a water and air tight seal. Indoor air section shall be completely insulated with fire resistant, permanent, odorless, foil faced glass fiber material.

D. Compressors shall be hermetically sealed, direct drive, scroll type with internal over current and over temperature protection, crankcase heaters, and high pressure control. Cooling shall be multi-stage where indicated on the drawings. See GUARANTEE 230529 for description of compressor warranty requirements.

E. Condenser coils shall have tubes mechanically bonded to aluminum fins. Evaporator coils and hot gas reheat coils shall be copper tubes mechanically bonded to high performance aluminum plate fins. All coils shall be leak tested to 200 psig and pressure tested to 450 psig. Provide guards on units to fully protect condenser coils from vandalism.

F. Units shall have forward curve, centrifugal indoor fans with permanently lubricated motor bearings. Motors shall be EISA 2007 NEMA premium efficiency with 1.15 service factor and shall be Model J ball bearing with minimum NEMA design “B” for 40°C ambient. Efficiency rating shall be stamped on motor nameplate. Motors shall have thermal overload protection. Motor/blower assemblies shall be isolated from the unit via rubber mounts. Where available from factory, motors shall be direct drive ECM type. Belt drive fans shall have adjustable variable pitch selected at a minimum service factor of 1.2. Heating and Air Conditioning Contractor shall provide one new set of drive belts installed in units at final inspection and provide a spare drive belt set for each unit. Belt set shall be secured inside each unit. After final assembly, the entire unit shall be given final vibration test.

G. The outdoor fan shall be direct-drive statically and dynamically balanced, draw through in the vertical discharge position. The fan motors shall be permanently lubricated and have built-in thermal overload protection.

H. Units shall be completely factory wired with necessary controls and terminal block for power wiring. Units shall have a single point through base power entry with HACR circuit breaker. Unit protection shall include phase monitoring.

I. Heating section shall be indirect fired heat exchanger, multi-stage where indicated on the drawings, with stainless steel heat exchanger and burner, and forced draft combustion via direct spark ignition. Gas connection to unit shall be through roof curb base. Heat exchanger shall have factory 10-year warranty.

J. Filters shall be disposable 2" thick MERV 8. Contractor shall supply three complete sets of filters – including filters as necessary for use during construction.

K. Unit's dampers shall have metal compressible jamb seals and extruded vinyl blade edge seals. Units shall have motorized outside air intake and return air dampers to open and provide the specified outside air. Where indicated on the drawings, units shall have outside air economizers capable of providing 100% outside air even if additional mechanical cooling is required to meet the cooling load of the building. Barometric dampers shall provide means to relieve excessive outdoor air during economizer operation to prevent over pressurizing the building. Outside air intake and relief air openings shall have rain hoods with bird screens.

L. Condensate drain pan shall be insulated positively sloped of durable, long-lasting and corrosion resistant construction.

M. Curbs shall be vibration isolation type custom made from 12 gauge or heavier as required galvanized steel with welded one-piece construction and 1-1/2" thick rigid insulation. Curb height shall be a minimum of 14" high above finished roof height. Secure curb to roof structure and unit to curb per manufacturer's recommendations for site's wind zone loading. Coordinate sizes as necessary.

N. Startup and testing shall be by factory authorized service representative.

O. Units shall be Trane, Carrier, York or approved equal.

230506 DEDICATED OUTSIDE AIR UNITS

A. Units shall be factory manufactured, assembled, tested, single package type for dedicated 100 percent outside air roof mounting application with airflow in the horizontal direction. Duct connections shall be directly to the unit casing. Unit shall be factory assembled, piped, internally wired, fully charged with R-410A and 100% run tested to check full operation, fan and blower rotation, and control sequence before leaving the factory. Wiring internal to the unit shall be numbered for simplified identification. Units shall be UL or ETL listed and labeled.

B. See GUARANTEE 230529 for description of compressor warranty requirements.

C. Unit shall be constructed for outdoor installation:

1. Base shall be minimum 10 gauge galvanized steel rails with 16 gage integral floor pan insulated with 1/2" closed-cell neoprene liner. Base shall have a minimum 4" overhang over the top of a roof curb to prevent water infiltration and raised rib joint floor seams. Only penetrations through the floor of the unit within the perimeter of the curb shall be except for duct openings and utility chases. Penetrations through the floor shall have a ½" raised rib around each opening.
2. Casing shall be constructed with minimum 2-inch, foam-injected, thermally broken, double-wall panels. Interior side of panel shall be 22 gauge G-90 galvanized steel. Exterior side of panel shall be 22 gauge painted steel rated for 1000 hours in accordance with ASTM B117 and ASTM D1654. Insulation shall be 2 lb/ft3 foam insulation with an average R-value of 6 per inch and show "no growth" per ASTM G21 biocide testing. No insulation shall be exposed to the air stream.

3. Access doors shall be provided for access to all components requiring regular maintenance or inspection. Access doors shall be hinged with a minimum of two quarter-turn compression latches with adjustable catches, shall have construction identical to unit casing, and shall be sealed with a full-perimeter gasket constructed of Mylar-encased low-density foam. Door hinges shall be stainless steel.
4. Weather hood with bird screen shall be provided on outside air inlet. Hoods shall have high performance moisture eliminators.
5. Roof shall be pitched with a minimum ½" roof overhang around the perimeter of the unit.
6. Exhaust outlet shall be gravity backdraft damper with bird screen.

D. Fan assemblies shall be direct-drive plenum type without the use of belts or adjustable sheaves with manufacturer provided variable frequency drive for each fan section. Variable frequency drives shall be mounted, wired, programmed by the manufacturer, and located in an enclosed compartment outside of the supply or exhaust air stream. Fan wheel shall be tested in accordance to AMCA 210. Fan motors shall be EISA 2007 NEMA premium efficiency inverter duty squirrel cage, drip proof with 1.15 service factor and shall be Model J ball bearing with minimum NEMA MG 1, Part 31, design "B" for 40°C ambient. Efficiency rating shall be stamped on motor nameplate. Where motors are greater than 10 hp, provide shaft grounding rings.

E. Motorized dampers shall have 16 gage galvanized steel hat-channel frame with flexible stainless steel compression-type jamb seals, 16 gage galvanized steel v-grooved blades with extruded vinyl blade edge seals, and synthetic sleeve-type axle bearings. Damper leakage shall be no more than 3 cfm/sq.ft. at 1 in.wg static pressure. Modulating spring-return actuators shall be provided by the factory, installed on the damper, and wired to the control center.

F. Filters:

1. Outdoor air intake hood shall have 1" filter rack with 1" aluminum framed filter media.
2. Outdoor air filter section shall have 2" filter rack.
3. Return air filter section shall have 2" filter rack.
4. Air filters shall be 2" thick UL Class 1 pleated panels with Minimum Efficiency Reporting Value of MERV 8 per ASHRAE Standard 52.2-1999. Contractor shall supply three complete sets of filters – including filters as necessary for use during construction. Provide factory supplied fixed filter blockoffs to prevent air bypass around filters.

G. Cooling – Air Cooled DX:

1. Unit shall be provided with factory piped, charged, and tested packaged air-cooled direct expansion refrigeration system including microprocessor-based head pressure control logic for active head pressure control, and adjustable superheat thermal expansion valves (TXV).
2. Evaporator coil shall be rated in accordance to AHRI standards and pressure tested for 250 psi working pressure, shall be a minimum of 4 rows deep with 16 gage galvanized steel casing, 1/2" diameter 0.016" thick seamless copper tubes, and 0.0060" thick aluminum fins. Refrigeration systems with more than one circuit shall have interlaced evaporator coils.
3. Drain pan shall be constructed of a minimum of 18 gage 201 stainless steel with double-slope and 8" extension past the evaporator coil.
4. Modulating hot-gas reheat coil shall be separated from the evaporator coil by a minimum of 6" in the direction of airflow to prevent the re-evaporation of condensate, provide room for coil cleaning, and allow control system to monitor evaporator coil leaving air temperature. Coil shall be rated in accordance to ARI standards and pressure tested for 250 psi working pressure with 16 gage galvanized steel casing, 3/8" diameter 0.016" thick seamless copper tubes, and 0.0060" thick aluminum fins. Hot-gas reheat shall be controlled through a factory-supplied modulating control valve.
5. Compressors shall be hermetic scroll type with suction and discharge service valves, reverse rotation protection, oil level adjustment, oil filter, rotary dirt trap, short cycling control, high and low pressure limits, and crankcase heaters. Compressors shall be installed in an isolated compartment

separate from supply airflow, return airflow, microprocessor controller, non-fused disconnect, compressor relays, fan motor VFD, and all other electrical components inside the unit on manufacturer's recommended rubber vibration isolators. Lead refrigeration circuit shall utilize Digital Scroll™ compressor capable of 10:1 turndown.

6. Condenser coils shall be 16 gauge galvanized steel casing, 3/8" diameter 0.016" thick seamless copper tubes, and 0.0060" thick aluminum fins. Provide guards on units to fully protect condenser coils from vandalism.
7. Evaporator coils, hot gas reheat coils, and condenser coils shall be coated with a third-party non-metallic, non-bridging corrosion barrier material by a factory trained and authorized applicator. Coating shall meet ASTM B117 3000-hour accelerated salt spray test and shall have negligible (less than 1%) impact on equipment's capacity/performance.
8. Condensing fans shall be high-performance 1200 rpm with sound reduction type blades. Condensing fan motor shall be electrically-commutated (ECM) and capable of full modulation. All condensing fans shall modulate at the same speed to maintain the head pressure set point in the factory-provided microprocessor controller.

H. Gas heating section shall be AGA-certified, induced-draft, 10:1 turndown indirect gas furnace with electronic modulating gas valve, two-speed combustion fan, and 409 stainless steel heat exchanger.

I. Unit shall include a powered exhaust fan as indicated on the drawings. The fan shall be backward curved plenum type with gravity dampers.

J. Units shall be factory wired with a single point through base power connection according to NEC and listed per ETL. All major electrical components shall be UL listed. Unit's integral control center shall be isolated from supply airflow, exhaust airflow, compressors, and heating elements and shall include non-fused disconnect, sub-circuit fusing, low voltage transformers, control circuit fusing, terminal block, fan motor variable frequency drives, factory supplied, mounted, and wired phase and voltage monitor, and connection for controls.

K. Units shall include factory supplied, mounted, wired, and tested stand-alone microprocessor controls with space temperature and relative humidity sensor(s). Microprocessor controller shall be mounted in a weather-proof enclosure and accessible without exposing the operator to high voltage wiring or having to turn off or circumvent the main disconnect, and shall include local liquid crystal display (LCD) for user interface. The following sensors shall be factory supplied, mounted, and wired inside the unit:

1. Outdoor air humidity sensor.
2. Outdoor air temperature sensor.
3. Evaporator coil leaving air temperature sensor.
4. Supply air and return air filter pressure monitoring.

The following devices shall be factory supplied but ship loose and require field installation and wiring:

1. Wall-mounted room air temperature sensor with manual adjuster.
2. Wall-mounted room air humidity sensor.
3. Supply air temp temperature sensor.

L. Roof curbs shall be provided by the unit's supplier. Curbs shall be vibration isolation type custom made from 12 gauge or heavier as required galvanized steel with welded one-piece construction and insulated with 1-1/2" thick rigid insulation. Curb height shall be a minimum of 14" high above finished roof height. Secure curb to roof structure and unit to curb per manufacturer's recommendations for site's wind zone loading. Curbs shall have structural cross members.

M. Unit shall be run tested prior to shipment from the factory. Factory run test report shall be provided to the Engineer, Contractor, and Owner and also included with unit. Testing shall include passing a dielectric (hipot) test, all dampers, all fans, energy recovery wheel, and performance of refrigeration systems.

N. Startup and field testing shall be by factory authorized service representative.

O. Units shall be Trane, Valent, AAON, Munters, Semco, Venmar, or approved equal.

230507 POWER VENTILATORS AND LOUVERED PENTHOUSES

A. Power ventilators shall be tested and rated in accordance with the standards of AMCA 210, shall carry the AMCA seal, and shall be UL labeled. Fans shall be Greenheck, Cook, Carnes, Twin City, American Coolair, or approved equal.

B. Power roof ventilators shall be centrifugal, direct or belt driven and upblast or downblast as indicated on the drawings. All units shall be provided with bird screen, back draft dampers, and insulated roof curbs. Disconnect switches for three phase fans will be by the Electrical Contractor. Disconnect switches for single phase fans shall be by the Heating and Air Conditioning Contractor. Power roof ventilators shall have spun aluminum hood. Motors shall be EISA 2007 NEMA premium efficiency with efficiency rating stamped on motor nameplate. Belt drive units shall have adjustable V-drive. Direct drive units shall have solid state motor speed controllers with an "OFF" position.

C. In-line fans shall be centrifugal in-line ventilator with variable speed belt drive or direct drive as indicated on the drawings. Housing shall be constructed of steel with removable drive door and access panel. Wheel shall be dynamically and statically balanced. Motor base shall be adjustable and have locking screws and guides to provide positive belt tension and correct alignment. Ball bearings shall be heavy-duty self-aligning, relubricable flange type with locking collars. Bearings must be selected for 125,000 hours average service life at maximum cataloged operating speed. Drives shall be cast iron and have a minimum of 1.25 service factor. Drives shall be isolated from the airstream. Motors shall be EISA 2007 NEMA premium efficiency with efficiency rating stamped on motor nameplate. All units shall be provided with backdraft dampers, hanging vibration isolators, motor/drive guards, and disconnect switches. Direct drive units shall have solid-state motor speed controllers with an "OFF" position.

D. Ceiling exhaust fans shall have plug disconnect switch, interior fiberglass insulation, forward curved centrifugal blower wheel, back draft dampers, permanently lubricated motor, and white steel grille. Units shall have solid-state motor speed controller with an "OFF" position. Where indicated on the drawings, provide ceiling exhaust fans with factory integral UL labeled radiation damper. Where indicated on the drawings, provide fans with factory 277 volt to 115 volt transformers. Furnish wall cap with birdscreen where shown on drawings. Caps shall have baked enamel finish of color selected by the Architect.

E. High Volume Low Speed (HVLS) Air Movement Fans shall be four blade minimum of diameter indicated on the drawings. Formed aluminum blades and hub shall have polished finish with powder coated finish of color selected by Architect on motor frame and gear reducer cover. Each fan shall have three-way motor-to-hub safety connection. Entire assembly shall be rotationally balanced. Fan's sound shall be less than 60 dBA measured 20 feet below and 20 feet from fan's center. Full CFM performance shall be tested to ANSI/AMCA 230. Fan shall include factory structure mounting kit and fan variable speed, on/off, forward/reverse controller. Fan's factory warranty shall be 50,000 hours minimum on entire unit. Fans shall be installed by manufacturer trained technician. Fans shall be MacroAir Airvolution – D or approved equal.

F. Louvered penthouses shall have the top panel insulated with 1-1/2" fiberglass rigid insulation and shall be hinged. Bird screen shall be 1/2" x 1/2" PVC coated wire. Louvered penthouses shall be aluminum with mitered corner waterproof louvers and factory aluminum finish. Provide vertical snow and storm baffle at base to protect against storm driven rain and snow.

G. Roof curbs for roof-mounted equipment shall be provided by the Heating and Air Conditioning Contractor. It shall be the responsibility of the Heating and Air Conditioning Contractor to give the General Contractor the proper locations and sizes required for all roof openings. Opening will be framed and cut by the General

Contractor. Roof curbs shall be insulated. Equipment shall be attached to roof curbs with a minimum of two stainless steel fasteners and EPDM washers on each side of roof curb.

230508 DIFFUSERS, GRILLES AND REGISTERS

A. Diffusers, Grilles, and Registers shall be as manufactured by Carnes, Metal Aire, Titus, Krueger, Price, Duct Sox, or approved equal unless otherwise noted.

B. Lay-In Supply Air Diffusers: Shall be steel construction, fixed square louvered face, 4-way blow, panel type to drop in 24" x 24" "T" bar ceiling grid, with adjustable vertical pattern. Vertical air adjustment shall be made by adjusting four perimeter blades to force air down in the vertical position.

C. Sidewall Supply Air Registers: Shall be steel with adjustable front vertical and back horizontal airfoil vanes on 2/3" centers. Registers shall have opposed blade dampers.

D. Slot Diffuser: Shall be complete with factory installed fully adjustable dual air pattern vanes and factory-insulated plenum. The diffuser shall be constructed of 24-gauge galvanized steel and internally insulated with 1/2" thick, 4-lb/ft^3 density fiberglass insulation. The plenum shall be constructed of 24-gauge galvanized steel. All exposed surfaces shall have factory applied baked enamel finish of color selected by Architect. The diffuser when shown to be mounted in a lay-in ceiling shall be designed to straddle ceiling tee and have appropriate factory made notches to accommodate crossing of ceiling grid tees. The air slots shall be designed for horizontal coanda flow. See Schedule on drawings for size, quantity, and blow direction of slots. Continuous slot diffuser shall be the same except with blank off strips as necessary where plenum boxes are not installed. Blank off strips shall be factory painted with black enamel. Return air slot grille shall be the same as diffuser. Continuous slot diffuser where indicated on drawings shall have cable operated inlet dampers.

E. Lay-in Ceiling Return Air Registers: Shall be aluminum 1/2" x 1/2" x 1" egg crate with steel frame, opposed blade damper and designed to lay in an inverted "T" bar ceiling grid. Registers shall be full flow across the entire face of register and tapered up to neck size.

F. Sidewall Return Air Registers and Grilles: Shall be heavy duty steel with fixed 40º horizontal all welded face bars. Face bars shall be 1/8" thick with rounded edges. Registers shall have opposed blade dampers.

G. Exhaust Registers and Grilles: Shall be aluminum construction with fixed blades on 1/2" centers set at 35º angles. Registers shall have opposed blade dampers.

230509 HEATERS

A. Electric unit heaters shall be listed by Underwriters Laboratories, Inc., and shall bear the appropriate UL label. Heaters shall be furnished and installed in accordance with the manufacturers' published recommendations. The elements shall be metal sheath fintube type. Heaters shall be complete with adjustable discharge louvers, ceiling or wall mounts, built-in contactors with 24 volt control circuit, built-in fuses, 18 gauge steel cabinet, built-in thermal overload protection, combination fan guard and motor mount, continuous duty motor, unit mounted thermostat, and separate field installed-unit mounted power disconnect switch. Unit heaters shall be Markel Series 5100, Raywall, Indeeco, or approved equal.

230510 CONTROLS

A. See Section 230900.

230511 FIRE, MANUAL, AND MOTORIZED DAMPERS

A. Fire dampers shall be provided in the duct systems at wall, floor, or ceiling penetrations in accordance with NFPA Standard No. 90A and shall conform to NFPA Standard No. 90A for materials and workmanship. The dampers shall be spring loaded dynamic rated multi-leaf type UL approved and labeled for installation into the rated assembly (a 1-1/2 hour damper for a 2 hour rated assembly and two 3 hour dampers for a 4 hour rated assembly) and shall be installed according to the manufacturer's recommendations. Dampers shall be Ruskin, Pottorff, Prefco, Air Balance, United Enertech, or approved equal.

B. Manual and Motorized dampers shall be low leakage type provided in the duct systems as indicated on the drawings in accordance with NFPA Standard No. 90A and shall conform to NFPA Standard No. 90A for materials and workmanship. Blades shall have extruded vinyl double edge seals. Jambs shall have flexible metal compression type seals. Maximum damper leakage at 1.0 in w.g. shall be 40 cfm/sf of damper area for dampers smaller than 24 inches in either dimension and shall be 20 cfm/sf for larger manual dampers. Leakage ratings shall be when tested in accordance with AMCA Standard 500. Motorized dampers shall have electric operators and shall be normally closed, unless indicated otherwise in the control diagrams on the drawings. Wiring to operators shall be by the Heating and Air Conditioning Contractor. To facilitate service access and insulation installation, manual damper handles shall be on 2" stand-off brackets. Handles shall be spray painted red. Dampers shall be installed according to the manufacturer's recommendations. Dampers shall be Ruskin, Pottorff, Prefco, Air Balance, United Enertech, or approved equal.

C. Manufacturer's installation instructions for all dampers shall be furnished at time of final inspection. Installation instructions shall be affixed to damper access doors.

230512 ACCESS DOORS

A. Access doors shall be provided for access to all fire and motorized dampers and duct mounted smoke detectors.

B. Duct mounted access doors shall be constructed of No. 22 US gauge zinc-coated sheet steel and shall be gasketed, air tight and provided with not less than two (2) cam-type latches. Doors shall be square and shall be 12" x 12" or two inches less than the height of the duct. Doors shall be two-piece with 1" rigid insulation between the metal sides. Doors shall have engraved plastic laminated labels with 1/2" tall letters indicating item accessed through door.

C. Provide 3/4" diameter red dot on ceiling grid below all duct access doors.

D. Wall and ceiling access doors shall be provided as specified in Section 083113.

230513 ELECTRICAL

A. Electrical circuit sizes are based on capacities of the drawings and it shall be the responsibility of Heating and Air Conditioning Contractor to change any and all electrical work in order to fit mechanical equipment. Heating and Air Conditioning Contractor shall coordinate with Electrical Contractor to assure that all units are properly connected and shall check wiring prior to starting units. Any damage to units resulting from improper wiring or connections shall be the responsibility of Heating and Air Conditioning Contractor. Flexible electrical conduits shall be 18 inches in length maximum. All electrical work shall be installed in accordance with codes having jurisdiction and the Electrical Division, Division 26, of these specifications.

B. Starters shall have integral 120V Control power transformer. Starters shall have holding coil for 120V control with hand-off-auto switch. The starters shall be inoperative if the thermal unit is removed. All magnetic starters shall be NEMA sized with applicable melting alloy overload relays and applicable

enclosure. Starters shall be G.E. or approved equals by Allen-Bradley, Square D, Siemens or Cutler-Hammer.

C. All three phase motors shall be provided with phase loss protection.

D. Fused disconnect switches shall be heavy duty industrial type in accordance with the Electrical Division, Division 26, of these specifications.

E. Motor Starters and Fused Disconnect Switches shall be neatly arranged, and securely fastened to walls with expansion bolts, lead shields, etc. Each starter or switch shall have its usage or letter designation indicated on its cover with engraved plastic laminated labels with 1/2" high contrasting letters. Where connections are made to motors not near walls or columns, a vertical conduit attached to floor and ceiling shall be installed and the wiring carried in and out of this conduit by means of condulets. An 36-inch length of flexible metallic conduit shall be installed in the circuit to each connection to a motor. Liquid tight shall be used in all wet locations. Grounding wire shall run inside of flexible conduit.

230514 DUCTWORK

A. Mechanical drawings are schematic only and do not show all offsets etc. required. Heating and Air Conditioning Contractor shall familiarize himself with the complete contract documents and site conditions before fabricating ductwork. Any changes to ductwork found necessary to accommodate the conditions at the building shall be made without additional cost to the Owner, and as directed by the Engineer.

B. During construction, interior of ductwork shall be protected. All open ends of ductwork shall be covered with self-adhesive 3 mil polyethylene film.

C. Ductwork shall be of galvanized steel with standard gauges and construction in accordance with the recommendations of SMACNA HVAC Duct Construction Standards, Metal and Flexible, Third Addition, 2005 for appropriate pressure class. Airfoil turning vanes with 1-1/8" spacing and rail support system shall be installed in all 90º elbows. Ductwork shall be cross broken on all sides and shall be supported at both ends of each joint and at 10'-0" intervals maximum with galvanized angles supported by galvanized threaded rods of sizes and spacing in accordance with SMACNA. Ductwork to be exposed shall be constructed in a first class, neat, professional manner and exposed ductwork with excessive hammer marks shall be replaced. Round supply takeoffs from trunk ducts shall be made with factory 45º entry branch rectangular to round type fittings with dampers. Damper handles shall be on 2" stand-off brackets. Handles shall be spray painted red. Splitter dampers shall be provided where indicated with adjustment quadrant locking device and shall be constructed of two thicknesses of 24-gauge-galvanized steel. All dimensions on the drawings are free inside dimensions. All components of the air distribution system shall be mechanically fastened with at least three equally spaced sheet metal screws with screws not more than on 12" centers. All duct joints shall be sealed in accordance with SMACNA Seal Class A before insulation is applied. All sealants shall meet the provisions of UL181.

D. Ductwork on exterior shall have support system of 1-5/8” galvanized steel strut stand mounted on hot dipped galvanized base plates. Stainless steel bolts, nuts and washers shall be used to attach the components together.

E. Final 8'–0" of the runout to the air outlet may be factory fabricated flexible ducts complying with NFPA Standard No. 90A, UL 181, and shall be UL Class 1 R-6 insulated type with foil vapor barrier. The flexible duct shall be air tight for factory test when bent to full recommended radius and under not less than 10" water gauge internal pressure and shall be limited to 8'-0" maximum length. Flexible ducts shall be supported by galvanized steel straps in accordance with SMACNA at intervals not exceeding 4'-0" and at each change of direction. Flexible ducts shall have a minimum of one support.

F. Spiral ductwork shall be round, 18-gauge spiral lockseam with flanged joints, paint-grip finish to receive painting by the General Contractor, double wall, and internally insulated at the factory. Inner wall shall be perforated. Provide factory angle trim ring at wall penetrations. Duct shall be fastened using sheetmetal screws only and no duct tape. Dents in ductwork will not be acceptable and ductwork shall be replaced by the Heating and Air Conditioning Contractor. Diffuser, register, and grille openings shall be double wall internally insulated and made at the factory ready for the air distribution device.

230515 PIPING

A. Drain pan condensate piping shall be Type L copper with all joints soldered with 95-5 solder. Piping shall have dielectric connection to ferrous pipe. Drain pan condensate piping shall have a minimum slope of 1/4" per linear foot, and shall be at least as large as unit condensate connection.

230516 PIPE HANGERS

A. Condensate piping on roof shall be supported by adjustable height pipe supports with integral pipe securement. Support base shall be UV resistant and be made of HDPE, fiberglass reinforced nylon or stainless steel. Support shall be Portable Pipe Hangers, MAPA Products or approved equal. Walk pads under each support shall be appropriate for roof per roof's warranty requirements.

230517 INSULATION

A. All piping and ductwork shall be inspected and tested before insulation is applied. All insulation shall meet UL 723 and ASTM-E84 flame spread and smoke developed requirements of 25/50 and shall comply with NFPA 90A and the latest edition of the NC Building Code. Insulation shall be Certainteed, Owen Corning, Knauf, or Johns-Manville.

B. Interior air conditioning supply, return and outside air ducts and back of diffusers and grilles shall be externally insulated with 2" thick 1 lb. density foil scrim kraft jacketed insulation. Adhere insulation to duct with fire retardant adhesive in sufficient quantities to prevent sagging. Ducts with a width over 30" shall be further secured on the underside with mechanical fasteners on 18" maximum centers. Insulation shall be butted with facing overlapping all joints at least 2" and sealed with fire retardant vapor barrier adhesive. Tape all joints, breaks, punctures, and any penetrations with SMACNA foil faced kraft duct tape.

C. Ductwork exposed on exterior shall be externally insulated with 2" thick R-8.0 minimum duct board with FSK facing. All joints shall be taped per manufacturer's recommendations. Insulation shall be completely secured to ductwork with pins and washers on all surfaces and sides. Exterior of duct board shall be completely encapsulated with Flex Clad or approved equal duct sealing system. Sealing system shall be waterproof, weather resistant, UV-stable, multi-layered, flexible jacketing system that fully adheres to the duct board. System shall be factory finished in standard color selected be Architect.

230518 VIBRATION ISOLATION

A. Pad type isolators shall be as indicated on the drawings.

B. Flexible duct connections, both at inlet and discharge of air handling units, shall be made of 30 oz. workinglass fiber coated with neoprene, sewn together at edges and joints. These flexible connections shall withstand the operating air-pressure, shall not permit air leakage, and shall not transmit vibration.

230519 OPENINGS

A. The Heating and Air Conditioning Contractor shall furnish all blockouts, sleeves, and openings required for his work. Pipe sleeves, where firestop penetration system allows, shall be standard weight black steel pipe and shall be provided where pipes pass through walls and floor. Sleeves through walls shall butt flush with the wall finish and shall be of sufficient size to permit passage of pipe covering through the area where pipe is installed. Sleeves through floors shall extend 3/4" above the finished floor and sealed watertight. Any penetrations of ducts through floor shall be curbed 3" high x 6" wide with concrete. Specifically inform the General Contractor as to the correct size and location of openings and sleeves to insure that they shall be cast in their proper location. Sleeves and duct opening frames shall be furnished and installed by the Heating and Air Conditioning Contractor. Failure to indicate such openings in time to avoid delaying the General Contractor shall result in the Heating and Air Conditioning Contractor providing all cutting and repairing at his own expense. Repairing shall include sealing tight around pipe sleeves and duct frames in a neat and professional manner and in accordance with the "Cutting and Patching" section of this specification.

B. All openings in rated floors, firewalls and any other fire separations shall be sealed using on approved UL listed method with an "F" rating equivalent to the rating of the membrane being penetrated for particular piping materials used and membrane construction type:

1 hour floor or wall	F = 1
2 hour floor or wall	F = 2
4 hour wall	F = 4

230520 COLOR CODING/PAINTING

A. All insulated and uninsulated piping in finished areas or in mechanical equipment rooms shall be painted with two coats of gloss enamel. Painting shall be primed accordingly. Color coding shall be as follows:

1. All Ferrous Valves, Hangers, and Supports - Black.
2. All exposed mechanical equipment in finished areas including ductwork, piping hangers, etc., shall be painted the same color as the adjacent ceiling and walls. Heating and Air Conditioning Contractor shall treat all items as necessary to receive paint.

230521 NAMEPLATES

A. All heat pumps, split systems, packaged gas/electric A/C units, dedicated outside air units, power ventilators, and heaters shall be furnished with engraved plastic laminated labels permanently attached to the equipment. Lettering shall be ½" tall. Label shall include equipment number, area served, final acceptance date, number and size of filters, and capacities. Final acceptance date shall be on a separate label so as to allow equipment nameplates to be installed prior to final acceptance.

230522 CUTTING AND PATCHING

A. The Heating and Air Conditioning Contractor shall do all cutting and patching necessary to install all equipment as required under his contract in accordance with the General Conditions of these specifications and shall re-establish all finishes where cutting and patching occur to their original condition. All cutting of the structure, where unavoidable, must be approved by the Engineer and be done by the General Contractor, but shall be paid for by the Heating and Air Conditioning Contractor.

230523 SEISMIC RESTRAINTS

A. The Heating and Air Conditioning Contractor shall be responsible for providing restraints to resist the earthquake effects on mechanical system components per the requirements found in Section 1613 of the

North Carolina Building Code. All tables and references shall conform to building's location. Restraints shall be per Seismic Design Category C. Coordinate all requirements with the Structural documents for this project.

B. The Heating and Air Conditioning Contractor shall refer to the latest edition of the "Seismic Restraints Manual Guidelines for Mechanical Systems" published by SMACNA for guidelines to determine the correct restraints for sheet metal ducts, piping and conduit, etc. This manual refers to Seismic Hazard Level (SHL).

C. The anchorage of the equipment and machinery for this project shall be an integral part of the design and specification of such equipment and machinery. Manufacturers of all equipment including unit ventilators, chiller, air handling units, pumps, boilers, tanks, compressors, etc. shall provide anchorage details, isolators, seismic mounts and restraints, etc. necessary to comply with Section 1613 to the Heating and Air Conditioning Contractor for installation. It shall be the Heating and Air Conditioning Contractor's responsibility to provide and install the equipment, machinery, systems, and assemblies, etc. for this project that satisfy these requirements. Where seismic restraints are required, the Heating and Air Conditioning Contractor shall provide restraints per details and instructions included in SMACNA's Seismic Restraints Manual. The Heating and Air Conditioning Contractor shall include shop drawings of the specific methods of seismic restraint to be used for this project before installation of piping, ductwork, and equipment.

D. The Heating and Air Conditioning Contractor shall retain the services of a Professional Engineer registered in the State of North Carolina to design seismic restraint elements required for this project. The Engineer's computations, bearing his professional seal, shall accompany shop drawings that show Code compliance including certification that the seismic system components comply with the testing requirements of North Carolina Building Code Chapter 17. Computations and shop drawings shall be submitted for review prior to the purchasing of materials, equipment, systems, and assemblies.

E. Internal seismic restraint elements of manufactured equipment shall be certified by a professional engineer retained by the manufacturer. Such certificate applies only to internal elements of the equipment. All equipment anchorage requirements shall be coordinated with the building structure and shall be compatible thereto. All such anchorage shall be reviewed by the project's structural engineer.

F. The Professional Engineer retained by the Heating and Air Conditioning Contractor for seismic restraint calculations shall visit the job site as necessary to comply with the Special Inspections requirement of the Code. This engineer shall provide in writing verification of compliance of the installation with the approved seismic submittal. This verification shall be submitted as a Special Inspections Report and shall bear the Engineer's professional seal. Job site inspections by other than this engineer are not acceptable.

G. Review of the seismic design and shop drawings by the Engineer/Architect or his agent shall not relieve the Heating and Air Conditioning Contractor of his responsibility to comply with the seismic or any other requirements of the North Carolina Building Code

230524 PIPING PRESSURE TESTING

A. The Heating and Air Conditioning Contractor shall make the following tests before the systems are insulated or covered by construction. The systems shall have no decrease in pressure during the test periods. All system components shall be protected from test pressures that exceed manufacturer's design limits.

B. Notify Engineer and Architect 48 hours in advance of all tests.

C. Condensate piping shall be tested by applying a hydrostatic pressure of 50-psig for a period of two hours.

D. No caulking of joints shall be permitted. Any joint found to leak under this test shall be broken, remade, and a new test applied. Welded joint pinhole leaks shall be repaired by welding; however, welds that show numerous pinholes shall be replaced.

230525 TESTING AND BALANCING

The Heating and Air Conditioning Contractor shall hire an independent AABC or NEBB certified Test and Balance Company employing a certified Test and Balance Engineer to provide all testing and balancing of heating, ventilating, and air conditioning systems. All instruments used shall be accurately calibrated and in good working order. The tests shall be in strict accordance to the Standards of AABC, NEBB, or procedures outlined in the Testing, Balancing, and Adjusting of Environmental Systems manual published by Sheet Metal and Air Conditioning Contractors National Association, Inc.

Air balance and testing shall not begin until the systems have been installed in full working order and shown to be operating satisfactory on both heating and cooling. The Contractor shall place all heating, ventilating, and air conditioning systems into full operation and shall continue operation of the system until balancing is completed. All operational cost shall be borne by the Heating and Air Conditioning Contractor. The Engineer and Architect shall be given advance notice of time when tests are to be made.

Upon completion of the heating, ventilating, and air conditioning systems, the Heating and Air Conditioning Contractor shall compile the test data and submit three copies of the completed test data separate for each building to the Engineer for evaluation and approval. At final inspection and prior to final commissioning verification, Heating and Air Conditioning Contractor shall have a copy of test and balance report and all necessary personnel and equipment to facilitate spot-checking of test and balance data by the Engineer or his representative. Final payment to the Contractor shall be withheld until the complete test and balance data has been approved.

A. Testing Procedure (Air):

1. Test and adjust unit fan's RPM and CFM to design requirements. Record all data.
2. Test and record motor full load amperes on all motors.
3. Adjust all main supply, exhaust, return, relief and outside air ducts to proper design CFM when air handling systems are in normal operating mode. Record exhaust and outside air data.
4. Test and adjust each diffuser, grille, and register for supply, exhaust, or return systems to within 10% of design requirements. Record all data.
5. All adjustments to air diffusing devices where possible shall be made in trunk or run out dampers, not at diffuser volume control.
6. Power ventilator fans shall be tested and balanced for the requirement as shown on the plans. Record all data.
7. The Heating and Air Conditioning Contractor shall make any changes in the pulleys, belts, filters, dampers, or valves necessary or as recommended by the Engineer for correct balance at no additional cost to the Owner.

230526 INSTRUCTIONS/TRAINING

A. The Heating and Air Conditioning Contractor shall provide a minimum of two 8-hour days' instruction and training period in the operation of the apparatus to the persons who will be in charge of the system.

230527 MAINTENANCE DATA

A. For all items requiring maintenance, the Heating and Air Conditioning Contractor shall furnish two weeks prior to Final Acceptance and deliver to the Owner's representative on the job multiple copies of complete data as prepared by the manufacturer covering the details of operation and maintenance and complete parts list for all equipment specified. Each copy of the maintenance data shall be assembled into a 3-ring hardback binder with indexing and label on cover and spine. Data shall have equipment model numbers,

etc. indicated and referenced with the same mark as shown on equipment on the drawings. Provide filter schedules for all equipment requiring filters. Manuals shall have index with page numbers, Contractor's certificate of Final Acceptance, copy of all warranties, list of all subcontractors and suppliers with names, addresses, and phone numbers, certified test and balance report, complete start-up, operation, and shut-down procedures for each system, lubrication schedules and types of lubricates, equipment summary showing all capacities and ratings, and all submittal data and shop drawings.

230528 RECORD DRAWINGS

A. Heating and Air Conditioning Contractor shall maintain "during the course of the work" a set of specifications and drawings marked up to show the work as installed, **including dimensions to indicate locations and elevations of buried work**. Upon completion of the work, return this set of drawings to the Engineer.

230529 GUARANTEE

A. The Heating and Air Conditioning Contractor shall guarantee the heating and air conditioning systems subject to the General Conditions of these specifications, except:

1. Refrigeration compressors for heat pumps, split systems, packaged gas/electric A/C systems, and dedicated outside air units shall have a four-year extended warranty for the compressors only. Labor, freight, refrigerant, and other required parts shall be provided or paid for by the Owner.
2. Heat exchangers for packaged gas/electric A/C systems and dedicated outside air units shall carry a ten-year warranty.

END OF SECTION 230500

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 DESCRIPTION OF WORK

A. Furnish and install an electric control system to fulfill the intent of the drawings and specifications. The systems shall include all necessary labor, electrical wiring, controllers, programmable thermostats, devices, and materials for a complete installed control system. The control system shall be erected, assembled, and installed by factory-trained mechanics regularly employed by the control manufacturer or manufacturer's authorized distributor as a subcontractor to the Heating and Air Conditioning Contractor. All equipment, unless specified to the contrary, shall be fully proportional and shall be the product of the control manufacturer.

B. The control diagrams indicated on the drawings or specified herein show the intended sequences of operation of the various control systems and shall be followed as closely as practicable. All required devices and control schemes may not be shown on the drawings. It is the Contractor's responsibility to provide all devices and control schemes whether shown or not.

C. Additional General Requirements for Controls:

1. All wiring, conduit, and panels for all temperature controls.
2. Power required for controls shall be provided by the Controls Contractor from points coordinated with the Electrical Contractor.
3. Perform all wiring in accordance with all local and national codes and Division 26 of these specifications.
4. Surge transient protection shall be incorporated in the design of the system to protect electrical components in all system components as described below under "General Product Description."
5. System modifications necessary to fine-tune sequences during commissioning of systems at no additional cost to the Owner.
6. Mount control devices inside of a UL-listed steel enclosure panel, with hinged locking cover and key locking latch.

D. Wiring and Controls:

1. Control Contractor shall be responsible for the installation and wiring of temperature controls, control interlock wiring, electrical controls and devices in the temperature control system.

1.3 QUALITY ASSURANCE AND STANDARDS

A. Materials and equipment shall be the cataloged products of manufacturers regularly engaged in production and installation of integrated control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

B. All products used in this project installation shall be new and currently being manufactured. This installation shall not be used as a test site for any new products. Spare parts shall be available for at least five years after completion of this contract.

C. Install system using competent workmen who are fully trained in the installation of integrated control systems.

D. Single source responsibility of Contractor shall be the complete installation and proper operation of the control system and shall include debugging and proper calibration of each component in the entire system.

E. Contractor shall have an in-place support facility within 100 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

F. The Contractor and manufacturer representative shall support the installed system for a minimum of 1 year. The support shall provide full material warranty of controllers and 8 hours of on-site training.

G. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, governing Radio Frequency Electromagnetic Interference and be so labeled.

H. Design and build all system components to be fault-tolerant.

1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3-Hertz variation in line frequency.
2. Static, transient and short-circuit protection on all inputs and outputs.
3. Protect communication lines against incorrect wiring, static transients and induced magnetic interference.
4. Network-connected devices to be A.C. coupled or equivalent or that any single device failure will not disrupt or halt network communication.
5. All real time clocks and data file RAM to be battery-backed for a minimum 72 hours and include local and system low battery indication.
6. All programs shall retain their memory for a minimum of 7 days upon loss of power.

I. Comply with NFPA 90A, Standard for Installation of Air Conditioning and Ventilating Systems.

J. Provide wiring in accordance with NEC requirements and Division 26 of these Specifications.

1.4 SUBMITTALS

A. Product Data: Submit copies of manufacturer's technical product data for each control device furnished. Indicate dimensions, capacities, performance, electrical characteristics, material finishes; also include installation and start-up instructions.

B. Shop Drawings: Submit copies of shop drawings for each control system, containing at least the following information:

1. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, control devices and all interconnections between devices.
2. Indicate all required electrical wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
3. Written description of sequence of operation.

C. Number of copies of Product Data and Shop Drawings shall be per Division 1 of these Specifications.

1.5 DELIVERY, STORAGE AND HANDLING

A. Provide equipment and control devices in factory shipping carton. Maintain in cartons while shipping, storing and handling as required to prevent equipment damage and to keep dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Building controls, controllers, and communications between devices shall be provided as necessary to achieve specified sequences of operation.

B. Room heating and cooling thermostats shall be programmable, low voltage, automatic changeover, dual setpoint type with battery backup, key pad lockout, temporary program override, temperature warmer/cooler adjustment, night temperature setback control, and relative humidity sensing/control. Thermostat shall have heat anticipation, fan on-off switch, multi-stage cooling control and multi-stage heating control to match units controlled, and all capabilities to satisfy the sequences of operation as specified.

C. Motorized control dampers that will not be integral to the equipment shall be furnished by the Control System Contractor. See Section 230500 for specification of motorized control dampers.

D. Control damper actuators shall be furnished by the Control System Contractor. Two-position or proportional electric actuators shall be direct-mount type sized to provide a minimum of 5 in-lb torque per square foot of damper area. Damper actuators shall be spring return type. Operators shall be heavy-duty electronic type for positioning automatic dampers in response to a control signal. Motor shall be of sufficient size to operate damper positively and smoothly to obtain correct sequence as indicated. All applications requiring proportional operation shall utilize truly proportional electric actuators.

E. Duct-Mounted Temperature Sensors: 20,000-ohm thermistor temperature sensors with an accuracy of ± 0.2ºC. Outside air sensors shall include an integral sun shield. Duct-mounted sensors shall have an insertion measuring probe of a length appropriate for the duct size, with a temperature range of -40 to 160 degrees F. The sensor shall include a utility box and a gasket to prevent air leakage and vibration noise. For all mixed air and preheat air applications, install bendable averaging duct sensors with a minimum 8 - foot long sensor element. These devices shall have accuracy of 0.5 degrees, F., over the entire range.

F. Humidity sensors shall be thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH and 32 to 140 degree F. Sensors shall be selected for wall, duct or outdoor type installation as appropriate. Duct mounted sensors shall have LCD display.

G. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point. Current switch to include an integral LED for indication of trip condition and a current level below trip set point. Manufacturer: Veris, or approved equivalent.

H. Relays: Start/stop relay model shall provide either momentary or maintained switching action as appropriate for the motor being started. All relays shall be plugged in, interchangeable, mounted on a subbase and wired to numbered terminals strips. Relays installed in panels shall all be DPDT with indicating lamp. Relays installed outside of controlled devices shall be enclosed in a NEMA enclosure suitable for the location. Relays shall be labeled with UR symbol. RIB-style relays are acceptable for remote enable/disable.

I. Control Power Transformers: Provide step-down transformers for all DDC controllers and devices as required. Transformers shall be sized for the load, but shall be sized for 50 watts, minimum. Transformers shall be UL listed Class 2 type, for 120VAC/24VAC operation.

J. Line voltage protection: All control system panels that are powered by 120 VAC circuits shall be provided with surge protection. This protection is in addition to any internal protection provided by the manufacturer. The protection shall meet UL, ULC 1449, IEEE C62.41B. A grounding conductor, (minimum 12 AWG), shall be brought to each control panel.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Install systems and materials in accordance with manufacturer's instructions in a neat workmanlike manner.

B. Coordinate with other trades on the project as the work progresses so that each will be aware of the extent of all work. Carefully plan all work and check for interferences before installation. No extras will be allowed for changes caused by failure to check for interferences.

C. Provide structural supports as required for panels and control devices.

D. Supervise installation of all control dampers.

E. Install metering devices away from bends and elbows with minimum upstream and downstream straight distances per manufacturer's recommendations and as shown on Drawings.

3.2 CONTROL WIRING

A. Install color-coded control wiring without splices between terminal points in accordance with National Electrical Code.

B. Install circuits over 25 volts with color-coded No. 12 or 14.

C. Install circuits under 25 volts with color-coded cable as recommended and approved by the manufacturer.

D. All wiring and cable used shall be plenum rated.

E. Wiring above hard ceilings, in walls, or where exposed including in mechanical rooms shall be in 3/4” minimum EMT conduit with steel-plated hexagonal compression connectors. Wiring above lay-in ceilings may be installed as properly supported cable. Flexible metallic conduit shall be 1/2” minimum in size and not exceed 3’-0” in length.

F. All wiring in floor slabs or on exterior shall run in rigid conduit.

3.3 TESTING

A. When installation of the control system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line.

B. Provide a cross check of each control point within the control system by making a comparison between the control command and the field-controlled device.

C. Replace any work found defective. After replacement, repeat test.

3.4 START-UP AND DEMONSTRATION

A. After completion and testing of the installation, regulate, adjust and service as necessary all control devices in the systems, placing each item in complete and proper operation.

B. Demonstrate all systems to Owner, Architect and Engineer, and that all are operable from local controls in the specified failure mode upon electronic control system failure or loss of power.

C. Complete all commissioning requirements as necessary to this scope of work.

3.5 INSTRUCTION

A. Provide the services of manufacturer's technical personnel for 8 hours of instruction to Owner's personnel in the operation, maintenance and programming of the control system. Orient the training specifically to the system installed rather than a general training course.

B. Provide training manuals, equipment and material required for classroom training.

C. Training to include the following items:

1. Operation of equipment
2. Programming
3. Diagnostics
4. Failure recovery procedures
5. Alarm formats (where applicable)
6. Maintenance and calibration
7. Trouble shooting, diagnostics, and repair instructions

PART 4 - POINTS LISTS AND SEQUENCES OF OPERATION

4.1 SUMMARY

A. The drawings indicate the individual types of systems and the points required in each system.

B. System sequences of operation shall be as indicated on the drawings and as specified herein.

END OF SECTION 230900