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Note: All updates are in red text.

SECTION 230900

DDC CONTROLS (UMKC)

PART 1 GENERAL

1.1 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION EXCEPT FOR RETROFIT CONTROL PROJECTS.

- A. Hydronic Piping:
 - 1. Control valves
 - 2. Flow switches
 - 3. Pressure and temperature sensor wells and sockets
 - 4. Flow meters and switches
- B. Ductwork Accessories:
 - 1. Automatic dampers
 - 2. Airflow stations
 - 3. Terminal unit controls

1.2 DESCRIPTION

- A. Furnish all labor, materials, equipment, and service necessary for a complete and operating temperature control system, utilizing a high-speed, peer-to-peer network of Direct Digital Controls (DDC). The new controls shall tie into the existing Honeywell EBI Campus Building Automation system. Provide all control system hardware including, routers, repeaters, and electronic interfaces and actuation devices, as shown on the drawings and as described herein. Graphics for new work is to be added to the campus operator workstations. **All points will color change to red when put in Manual. NOTE: Unless otherwise directed, UMKC will contract separately with an electrical contractor for controls installation and wiring.**
- B. Provide monitoring and control of chillers, boilers, packaged mechanical equipment, variable frequency drives, fuel oil systems, low voltage lighting systems, electrical circuit breaker panels, utility metering, as shown on drawings, and described herein.
- C. The DDC Controls scope of work will be bid directly to the owner. Any conflict between the drawings and the controls specifications will be brought to UMKC for final approval. DDC Controls & Mechanical contractors shall coordinate their scopes of work prior to bid date to assure a functional system will be delivered per the plans and specifications.

1.3 APPROVED CONTROL SYSTEM MANUFACTURING CONTRACTORS

- A. Coordinate all controls. Electrical, HVAC & mechanical systems with the UMKC Project Manager.

1.4 CODES AND STANDARDS

- A. All work, materials, and equipment shall comply with the adopted codes of the University of Missouri listed on the drawings. Such codes, when more restrictive, shall take precedence over these drawings and specifications.

1.5 SUBMITTALS

- A. Product data and shop drawings: Contractor shall provide shop drawings or other submittals on all hardware, software, and installation to be provided. [6] copies are required. All drawings shall be prepared with AutoCAD and be provided via a digital means and/or a full-size 11" x 17" set of drawings. Each submitted piece of literature and drawings shall clearly reference the specification and drawing that the submittal is to cover.
 - 1. Project record documents: Upon completion of installation, submit [3] copies of record as-built documents. Documents shall be submitted for approval prior to final completion.
- B. Training manuals: If training is required, contractor shall provide a course outline and training manuals for all training classes at least six weeks prior to the first class.

1.6 WARRANTY

- A. Warrant all work as follows:
 - 1. Labor and materials for the control system specified shall be warranted free from defects for a period of 12 months after final completion and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. The contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours.
 - 2. All work shall have a single warranty date, even when the Owner has received beneficial use due to an early system start-up. At the end of the final start-up, testing, and commissioning phase, if equipment and systems are operating satisfactorily to the Engineer, the Engineer shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this Specification. The date of acceptance shall be the start of warranty.

PART 2 PRODUCTS

1.7 MATERIALS

- A. All products used in this project installation shall be new and currently under manufacture.

1.8 COMPUTER LAPTOP

- A. UMKC will furnish a laptop for each project. Honeywell to populate required software to assist with the installation, commissioning and testing of the controls system. Laptop and software will become property of UMKC Campus Facilities Management at the completion of the project.
- B. If a workstation/point server is required for the scope of the project, UMKC will furnish workstation/point server hardware for the project. Honeywell to populate required software to assist with the installation, commissioning and testing of the controls system. Workstation/point server and software will become property of UMKC Campus Facilities Management at the completion of the project.

1.9 NETWORK CONTROLLER (NC)

- A. The Network Controller (NC) shall be a Native BACnet® controller. NC shall be BTL (BACnet® Testing Lab) certified. It shall be capable of executing application control programs to provide:
 - 1. Calendar functions
 - 2. Scheduling
 - 3. Trending and Trending Backfill
 - 4. Alarm monitoring and routing
 - 5. Time synchronization
 - 6. Integration of BACnet® devices and BACnet® controller data
 - 7. Integration of MODBUS devices and serial MODBUS RTU controller data

B. The Network Controller must provide the following hardware features as a minimum:

1. One Ethernet Port -10 / 100 Mbps RJ45
2. Three independent BACnet® MS/TP Channels.
3. Battery Backup using Gold Capacitor to avoid low battery alarms and subsequent replacement during service life of the controller.
4. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
5. A Reset Button
6. The NC must be capable of operation over a temperature range of 0 to 50°C
7. The NC must be capable of withstanding storage temperatures of between 5 and 70°C
8. The NC must be capable of operation over a humidity range of 5 to 93% RH, non-condensing
9. Shall include expansion for Input/Output
10. Field Bus for remote I/O

C. Event Alarm Notification and actions

1. The NC shall provide alarm recognition, storage routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
2. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
 - a. To alarm
 - b. Return to normal
 - c. To fault
3. Provide for the creation of an unlimited number of alarm classes for the purpose of routing types and or classes of alarms based on priority.
4. Provide timed (schedule) routing of alarms by class, object, group, or priority.
5. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

D. Control equipment and network failures shall be treated as alarms and be annunciated.

- E. A log of alarms shall be maintained by the NC
- F. Provide a “query” feature to allow review of specific alarms by user defined parameters.
- G. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
- H. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

1.10 ADVANCED APPLICATION SPECIFIC CONTROLLERS (AASC)

1. All Advanced Application Controller shall be fully programmable and shall at all times maintain their BACnet® compliance. All control sequences within or programmed into the B-AAC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
2. Stand-alone, Native BACnet®, UL Listed Application Controllers shall be used to provide direct digital control of HVAC equipment. In addition to their standalone capabilities, they shall also provide the ability networked in a peer-to-peer, BACnet® MS/TP field network to other MS/TP controllers, and VAV/SPC zone controllers. These controllers may be used to optimize the energy consumption by implementing various control strategies such as temperature setup/setback etc.
3. Standard features for all Advanced Application Controllers shall include:
 - a. Should support BACnet® intrinsic alarm reporting
 - b. Should support calendar objects for scheduling
 - c. Flexibility to be used and connected to Network Controller to expand the I/O capacity of network controller
 - d. BACnet® MS/TP LAN with configurable baud rate from 9600 to 76.8k baud

1.11 AUXILIARY CONTROL DEVICES

- A. Motorized Control Dampers (Unless Specified Elsewhere):
 1. Control dampers shall be parallel or opposed airfoil type blade as below or as scheduled on drawings.

- a. Outdoor, return air mixing dampers and face and bypass (F&BP) dampers shall be parallel blade, arranged to direct air-streams toward each other.
 - b. Other modulating dampers shall be opposed blade type.
 - c. Two-position shutoff dampers may be parallel or opposed blade type with blade and side seals.
2. Damper frames shall be [16] gauge galvanized steel channel or 1/8" extruded aluminum with reinforced corner bracing.
 3. Damper blades shall not exceed 8" in width or 48" in length. Blades are to be suitable for medium-velocity performance (2,000 – 3,000 fpm). Blades shall be not less than 16 gauge.
 4. Damper shaft bearings shall be as recommended by manufacturer for application, synthetic, impregnated sintered bronze or stainless steel.
 5. All blade edges and top and bottom of the frame shall be provided with vinyl or neoprene seals. Side seals shall be spring-loaded aluminum. The blade seals shall provide for a maximum leakage rate of 8 cfm per sq. ft. at 4" w.c. differential pressure. Provide airfoil blades suitable for a wide-open face velocity of 1,500 fpm.
 6. Individual damper sections shall not be larger than 48" x 48". Provide a minimum of one damper actuator per section.
 7. Modulating dampers shall provide a linear flow characteristic where possible.
 8. Dampers shall have capability for internal and external linkages. Dampers over 48" in applications where sectioning is not applicable shall be supplied with a jackshaft to provide sufficient force throughout the intended operating range. **Otherwise, when a damper over 48" is sectioned, an actuator shall be provided for each damper.**
 9. Dampers shall be AMCA Certified Performance in accordance with AMCA Standard 511.
 10. Acceptable: Honeywell D1 Series or approved equal.
- B. Electric damper and valve actuators:
1. The actuator shall have mechanical or electronic stall protection to prevent damage to the actuator through the rotation of the actuator.
 2. Where shown, for power-failure and safety applications, an internal mechanical spring-return mechanism shall be built into the actuator housing.
 3. All rotary spring-return actuators shall be capable of clockwise or counter-clockwise spring-return operation. Linear actuators shall spring-return to the retracted position.
 4. Proportional actuators shall accept a 0 to 10 VDC control signal and provide a 2 to 10 VDC operating range.
 5. All 24 VAC/VDC actuators shall operate on Class 2 wiring.

6. All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 60 in-lb torque capacity shall have a manual crank for this purpose.
7. All modulating actuators shall have an external, built-in switch to allow the reversing of rotation direction.
8. Actuators shall be provided with a raceway fitting and a minimum 1 ft electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
9. Actuators shall be UL Standard 873 Listed as meeting correct safety requirements and recognized industry standards.
10. Actuator housings shall be NEMA 2 and plenum rated.
11. Actuators shall be designed for a minimum of 60,000 full-stroke cycles at the actuator's rated torque and 1.5 million repositions.
12. Acceptable manufacturer: Honeywell MS / MN series or approved equal.

C. Control Valves:

1. Control valves shall be two-way or three-way type for two-position or modulating service as shown.
2. Close-off (differential) pressure rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
 - a. Water valves:
 - 1) Two-way: 150 percent of total system (pump) head.
 - 2) Three-way: 300 percent of pressure differential between ports A and B at design flow or 100 percent of total system (pump) head.
 - b. Steam valves: 150 percent of operating (inlet) pressure.
3. Water Valves:
 - a. Standard design shall be **Ball valves for water application & Globe Valves for steam application.** Valves shall include body and trim style and materials per manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
 - b. Sizing criteria:

- 1) Two-position service: Line size, unless otherwise shown.
 - 2) Two-way modulating service: Pressure drop shall be a maximum of 5 psi.
 - 3) Three-way modulating service: Pressure drop shall be a maximum of 5 psi.
 - 4) Valves 1/2" through 2" shall be bronze body or cast brass ANSI Class 250, O-ring seal, EPDM packing, quick opening for two-position service. Two-way valves to have replaceable composition disc, or stainless steel ball. **Stainless steel ball is the preferred choice.**
 - 5) 2 1/2" valves and larger shall be cast iron ANSI Class 125 with guided plug and EDPM O-ring or Teflon packing, unless otherwise shown.
- c. Water valves shall fail normally open or closed as follows:
- 1) Hot water heating valves in air handlers—normally open.
 - 2) Chilled water control valves—normally closed (typical). Certain applications may require fail-in-place.
 - 3) Large butterfly valves fail-in-place, unless specified otherwise.
 - 4) Terminal unit valves fail-in-place unless specified otherwise.
 - 5) Other applications—as scheduled or as required by sequences of operation.
- d. Acceptable manufacturer:
- 1) Ball Valve: Honeywell VBN2 or VBN3 series or approved equal.
 - 2) Globe Valve: Honeywell V5011, V5013, VGF2 or VGF3 series or approved equal.
4. 2-Way AHU Chilled and Hot Water Valves:
- a. All valves shall be modulating pressure independent and be provided by the same manufacturer. The flow through the valve shall not vary more than +/- 5% due to system pressure fluctuations across the valve in the selected operating range. The control valve shall accurately control the flow from 1 to 100% full rated flow. The engineer may consider using high performance energy monitoring control valves as an

option, but only if the coil is designed for higher Delta T's.

- b. Balancing valves shall not be used where pressure independent valves are installed. The control valve must have the ability to limit flow to the maximum design flow specific for each coil at all valve differential pressure ranges from 5 to 70 PSID.
- c. Valve bodies 2" and smaller shall be brass. Valve bodies 8" and under shall be cast iron. All internal parts shall be brass, carbon steel, stainless steel, or Teflon. Internal plastic parts are not acceptable.
- d. Valves shall include a pressure ports on each side of the valve for testing purposes. The pressure taps shall have ½" extensions for accessibility.
- e. Valve flow characteristics may be modified without removing valve from the piping system.
- f. Valve actuators shall modulate via a 2-10Vdc control signal and be sized to provide proper torque to assure proper close off.
- g. Valve Tag shall include the model number, AHU being served, design flow and maximum flow for that valve.
- g. Acceptable manufacturer: Flow Control Industries or approved equal.

5. Steam Valves:

- a. Body and trim materials shall be per manufacturer's recommendations for design conditions and service. Linear ports for modulating service.
- b. Sizing criteria:
 - 1) Two-position service: pressure drop 10 percent to 20 percent of inlet psig.
 - 2) Modulating service: 15 psig or less; pressure drop 80 percent of inlet psig.
 - 3) Modulating service: 16 to 50 psig; pressure drop 50 percent of inlet psig.
 - 4) Modulating service: over 50 psig; pressure drop as scheduled on plans.
- c. Steam valves on air handlers shall fail normally open. Steam valves on heat exchangers shall fail normally closed.
- d. Acceptable manufacturer: Honeywell V5011N, V5011A/B, V5051A, VGF2 series or approved equal.

6. Central Plant Valves:
 - a. Ball valves shall be utilized for chiller & boiler isolation & control for valves under 6" and Butterfly valves shall be utilized for valves 6" and larger.
 - b. Bodies shall be 2-way or 3-way as required and shall be cast iron, equal percentage flow, with lugged connections.
 - c. Valves shall be rated for 50% glycol and 250psi max pressure.
 - d. 2"-4" Valves shall be spring return based on design requirements.
 - e. 5"-20" Valves shall fail in place unless critical design requirement or sequence states otherwise.
 - f. Valve operation shall be 2-position or modulating as required per sequence of operation. Actuator NEMA rating shall meet the requirements of intended use.
 - g. Acceptable manufacturer: Honeywell VFF1, VFF2, VFF3 series or approved equal.

- D. Digital temperature devices:
 1. Line-voltage space thermostat shall be bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, with heat anticipator, UL listed for electrical rating, concealed setpoint adjustment +35F to +95F setpoint range, 2F maximum differential, and vented ABS plastic cover. Acceptable manufacturer: Honeywell T451/651 series.

- E. Temperature sensors:
 1. Temperature sensors shall be resistance temperature detector (RTD) or thermistor, 20K ohm NTC type.
 2. Duct sensors for critical control locations (ie. Mixed air, discharge air, coil air) shall be averaging sensors. Duct sensors for non-critical locations (ie. Return air) shall be rigid single-point. Averaging sensors shall be a minimum of 5 ft in length per 10 ft² of duct cross section. Acceptable manufacturer:
 - a. Averaging Duct sensor: Honeywell C7041R
 - b. Single Point Duct sensor: Honeywell C7041C
 3. Immersion sensors shall be provided with a separable stainless steel or copper well. Pressure rating of well shall be consistent with the system pressure in which it is to be installed. The well shall withstand flow velocities in the pipe. Acceptable manufacturer: Honeywell C7041D
 4. Space sensors for unitary controllers shall be equipped with set point adjustment. Acceptable manufacturer: Honeywell TR20/TR40 series.

- F. Low limit temperature sensors:
1. The low limit sensor shall have an adjustable temperature range of 20-140F containing a window showing actual setpoint.
 2. A 20' capillary sensing element shall respond to the lowest temperature sensed in a given 1' section.
 3. Upon activation, the (2) auxiliary switches shall trip. The sensor will require a manual reset.
 4. Sensors shall be installed after the hot water coil, just before the chilled water coil. Sensor shall be installed away from each coil and in a way that provides the best sampling of mixed air and areas stratification. Recommended coverage is (1) 20' sensor per 20 ft² of chilled water coil.
 5. Acceptable manufacturer: Honeywell L482A or approved equal.
- G. Humidity sensors:
1. Duct and room sensors shall have a sensing range of 20 percent to 95 percent.
 2. Duct sensors shall be provided with a sampling chamber.
 3. Outdoor air humidity sensors shall have a sensing range of 20 percent to 95 percent RH. They shall be suitable for ambient conditions of -10F to +140F.
 4. Humidity sensor accuracy shall be +/- 3%.
 5. Humidity sensor's drift shall not exceed 1 percent of full scale per year.
 6. Humidity sensor shall have selectable 4-20ma, 0-10 Vdc or 0-5 Vdc output.
 7. Acceptable manufacturer:
 - a. Space Sensor: Honeywell H7625A series.
 - b. Duct Sensor: Honeywell H7625B series.
 - c. Outside Air Sensor: Honeywell H7635C series.
- H. Relays:
1. Control relays shall be UL Listed of the self-contained type. Contact rating, configuration, and coil voltage suitable for application.
 2. Time delay relays shall be UL Listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable 200% (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.
 3. Acceptable manufacturer: Veris V100 or approved equal.
- I. Current switches:
1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to

- match the current of the application and output requirements of the DDC system.
2. Current switch shall be split core & rated for usage with Variable Frequency Drives (VFD's).
 3. Acceptable manufacturer: Veris H900 series or approved equal.
- J. Pressure transducers:
1. Transducers shall have linear output signal. Zero and span shall be field-adjustable.
 2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50 percent greater than calibrated span without damage.
 3. Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducers shall be complete with 4 to 20 mA output, required mounting brackets. Acceptable manufacturer: Honeywell MLH series.
 4. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold. Acceptable manufacture: Honeywell PWT series or approved equal.
 5. Air differential pressure transducers shall be duct mounted for monitoring duct pressure, and panel mounted for all other applications. Transducers shall be complete with 0-10Vdc or 4 to 20 mA output and switch selectable pressure ranges. Accuracy shall be +/-1%. Acceptable manufacturer: Honeywell P7640 series or approved equal. **All air differential pressure transducers shall have their exact physical location noted on the drawings for final review by the owner. Should the location change in the field (with engineer approval), contractor red-lines shall be submitted. The location of the differential pressure transducer shall be indicated on the control's graphics.**
- K. Differential-pressure-type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application, or as shown. Acceptable manufacturer: Honeywell CLEPAS series.
- L. Liquid Flow Meters: (Chilled Water flow, Make-up Water)
1. Flow sensor shall be an ultrasonic type meter. Signal output shall be 0-10Vdc, 4-20mA or (preferred) Bacnet. Wetted parts shall be stainless steel. Acceptable manufacturers: GE AT600 or approved equal.
 2. Irrigation, cooling tower make-up and steam boiler make-up water supply shall have a Sewer Allowance Credit (SAC)

meter installed. SAC meter must be purchased, inspected and commissioned by KCMO Water Dept.

- M. Steam Flow Meters:
1. Flow sensor shall have a temperature range of 300F for steam applications. Signal output shall be 0-10Vdc, 4-20mA or (preferred) Bacnet. Steam meter must be capable of measuring flow in pounds per hour and pressure in PSI. Wetted parts shall be stainless steel. Acceptable manufacturers: Rosemount or approved equal.
- N. Natural Gas Flow Meters:
1. Gas flow sensor shall be an insertion type or inline meter with display, accuracy of +/- 0.5% of full scale. Repeatability of 0.2% and shall be calibrated for the specific pipe size. Signal output shall be 0-10Vdc, 4-20mA or Bacnet. Acceptable manufacturer: Sage SRA series or approved equal.
- O. Airflow measuring stations (electronic):
1. Airflow measuring devices of the vortex shedding type, capable of continuously monitoring the airflow volume of the duct served and electronically transmitting a signal linear to the airflow volume, shall be provided where indicated. Airflow measuring devices shall be of the insertion type, or built into airflow control valves, as required, with the capability of measuring velocity over the full range of 350 to 7000 FPM. Devices shall consist of multiple velocity sensors, supported on insertion probe bars. Tek-Air or approved equal
 2. Individual airflow sensors shall be of rugged construction, and shall not require special handling during installation. Sensors shall be mounted on support bars, as required to achieve an equal area traverse. Standard materials shall be aluminum bars with aluminum and ABS sensors. Support bars over one foot in length shall be supported on both ends. Where utilized in corrosive air streams, sensors and support bars shall be manufactured of corrosion resistant CPVC and ABS.
 3. Velocity-sensing methods, other than those specified, shall be acceptable provided the basic requirements for linear electronic output, turndown, accuracy, materials of construction, and output signal are met. If differential pressure devices are used, dual differential pressure transmitters, the span of the lower transmitter being 1/10 the span of the higher, with an accuracy not less than +/- 0.5 percent, shall be utilized to provide the required turndown.
 4. Thermal dispersion devices shall use two thermistors to determine the airflow rate and temperature at each sensing point location. Flow station shall output a 0-10Vdc or 4-20mA signal proportional to the flow rate. Acceptable: Honeywell AMD Series or Ebtron.

5. Airflow Measuring Stations (pneumatic): For general airflow sensing applications (5% accuracy), provide Honeywell AMS series airflow measuring stations.
- P. CO₂ Carbon dioxide sensors:
1. Sensing of carbon dioxide shall incorporate the NDIR—non-dispersive infrared—sensing method. The sensor shall incorporate sampling tubes for duct mounting and have optional LCD readout. Range of sensing shall be 0-2000 PPM, with an accuracy of ± 75 PPM from 0 to 2000 PPM and ± 5 percent above 1500 PPM. Annual drift shall be (20PPM nominal) and have a calibration interval of five years recommended. Output shall be 4-20 ma and have an operating temperature range of +32F to +122F and 0 to 95 percent RH, non-condensing. Acceptable manufacturer:
 - a. Wall mount - Honeywell C7232A series.
 - b. Duct mount - Honeywell C7232B series.
- Q. Electric Utility Meters: (Unless Provided Elsewhere):
1. Provide utility-grade (0.2% accuracy) 3-phase meter.
 - a. Voltage monitoring range up to 600Vac RMS
 - b. Current sensing range up to 3200 Amps RMS
 - c. Line frequency 50-60Hz
 - d. Temperature operation range -4F to 122F
 - e. Relative humidity range 0-95% non-condensing
 - f. Advanced 4-line display showing the following: kWh consumption, kW demand (with peak date & time), Power factor per phase
 - g. On-board setup options for IP address, date/time, Modbus/BacNet address
 - h. 0-2Vdc split-core current sensors for safety
 - i. Onboard installation diagnostics (proper current sensor and phase error diagnostics)
 - j. 2 auxiliary load inputs, readable via Modbus/BacNet register points
 - k. Built-in communications protocols BacNet
 1. Standard NEMA 1 enclosure, NEMA 4X available
 2. Acceptable manufacturer: Honeywell/Emon Advanced meter or approved other.
- R. Local control panels:
1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with [hinged door], key-lock latch, and removable sub-panels. A single key shall be common to all field panels and sub-panels.

2. Wires shall be color-coded solid conductors neatly installed in plastic troughs and/or tie-wrapped. All wires shall terminate to panel terminal blocks. Terminals for field connections shall be UL Listed for 600 volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
3. Provide on and off power switch with over-current protection for control power sources to each local panel.
4. All control panels shall be built in accordance with UL508A standards and be labeled with separate UL label numbers. Acceptable manufacturer: Honeywell 14506635-002.

S. Fan and Pump Motor Control:

1. Where applicable motors shall be controlled by a variable frequency drive (VFD). There shall not be more than 1 motor controlled by a single VFD.
2. VFD shall have a digital control panel and have an electronic by-pass. In applications where there is no back-up or redundant device the VFD shall be equipped with a Manual By-Pass.
3. Acceptable manufacturers: Preferred Eaton (Cutler Hammer), Toshiba or an approved equal.

1.12 WIRING AND RACEWAYS

- A. General: Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 26.
- B. All insulated wire to be copper conductors, UL labeled for 90C minimum service.

PART 3 EXECUTION

1.13 EXAMINATION

- A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the Owner for resolution before rough-in work is started.
- B. The Contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Owner for resolution before rough-in work is started.

- C. The Contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the Contractor’s work, and the plans and the work of others—the Contractor shall report these discrepancies to the Owner.

1.14 PROTECTION

- A. The Contractor shall protect all work and material from damage from its work or employees and shall be liable for all damages thus caused.
- B. The Contractor shall be responsible for its work and equipment until finally inspected, tested, and accepted. The Contractor shall protect any material that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

1.15 COORDINATION

- A. Site:
 1. Where the mechanical work will be installed in close proximity to, or will interfere with, the work of other trades, the Contractor shall assist in working out space conditions to make a satisfactory adjustment. If the Contractor installs its work before coordinating with other trades, so as to cause any interference with the work of other trades, the Contractor shall make the necessary changes in its work to correct the condition without extra charge.
 2. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.
- B. Submittals: Refer to “Submittals” Article in Part 1 of UMKC Specification for requirements.
- C. Test and balance:
 1. The Contractor shall furnish all tools necessary to interface to the control system for test and balance purposes.
 2. The Contractor shall provide training in the use of these tools. This training will be for a minimum of **(4) four** hours.
 3. In addition, the Contractor shall provide a qualified technician to assist in the test and balance process, until the first **(10)** terminal units are balanced.
 4. The tools used during the test and balance process are to be returned at the completion of the testing and balancing.

1.16 GENERAL WORKMANSHIP

- A. Install equipment, piping, and wiring raceway parallel to the building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part-A of the National Electric Code (NEC).
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility, and executed in strict adherence to local codes and standard practices.
- F. **All wiring cannot fill the conduit more than 80%.**

1.17 FIELD QUALITY CONTROL

- A. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this Specification.
- B. Contractor shall continually monitor the field installation for code compliance and quality workmanship.
- C. Contractor shall have work inspected by local or state authorities having jurisdiction over the work.
- D. After all testing is completed the critical data points (as defined by UMKC) shall be setup to trend for a minimum period of **3 months**.

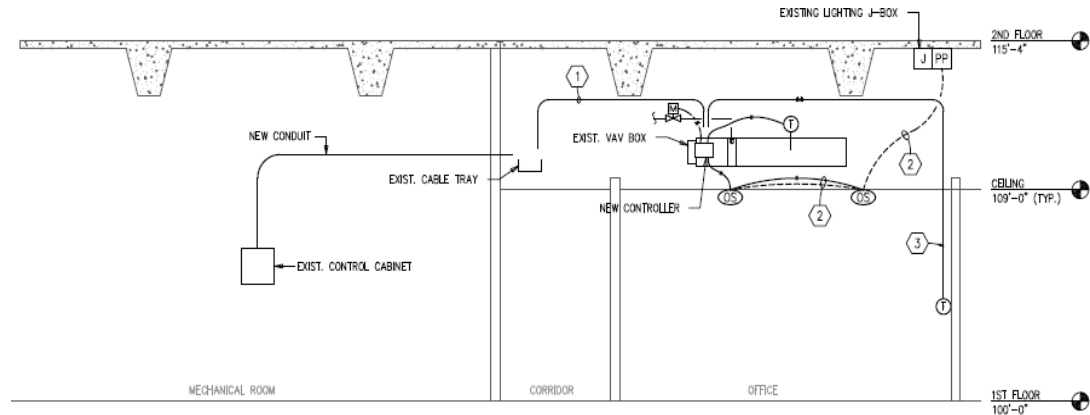
1.18 WIRING

- A. All control and interlock wiring shall comply with national electrical codes and Division 26 of this specification. Where the requirements of this section differ with those in Division 26, the requirements of this section shall take precedence.
- B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway per NEC and Division 26 requirements.
- C. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub-fused when required to meet the Class 2 current limit.)
- D. For new construction, all wiring, including mechanical rooms,

accessible, or concealed areas, shall be installed in raceway. Open plenum cable is not acceptable. Raceway shall consist of EMT for wiring runs. Flex conduit may be used for termination at field devices (maximum of 6’).

- E. All wiring cannot fill the conduit more than 80%.
- F. For retrofit construction, see RETROFIT DETAIL below for wiring methods. Flex conduit may be used for termination at field devices (maximum of 6’).
- G. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
- H. Do not install wiring in raceway containing tubing.
- I. All wire-to-device connections is to be at a terminal block or terminal strip. All wire-to-wire connections is to be at a terminal block or wire nut at junction box.
- J. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- K. All wiring is to be installed as continuous lengths, with no splices permitted between termination points.
- L. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.
- M. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures, unless they also contain Class 1 starters.
- N. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
- O. The contractor shall terminate all control and interlock wiring, and shall maintain updated wiring diagrams with terminations identified at the job site.

RETROFIT DETAIL:

**PLAN NOTES:**

- ① ROUTE 3/4" CONDUIT FROM CABLE TRAY TO VAV BOX CONTROLLER AS SHOWN. CONDUIT SHALL BE ROUTED AS HIGH AS POSSIBLE AND SUPPORTED FROM STRUCTURE ABOVE. CONDUIT SHALL CONTAIN 24V LOW VOLTAGE POWER WIRING AND MS/TP BUS FROM ADJACENT CONTROLLER. REFER TO HONEYWELL CONTROL DRAWINGS FOR ADDITIONAL INFORMATION.
- ② PROVIDE PLENUM RATED LOW VOLTAGE CONTROL WIRING AS SHOWN. WIRING SHALL BE ROUTED AS HIGH AS POSSIBLE AND ZIP-TIED TOGETHER NEATLY. WIRING SHALL NOT BE LAID ACROSS ACOUSTICAL CEILING.
- ③ ROUTE CONDUIT AND CONTROL WIRING FROM VAV BOX CONTROLLER TO NEW THERMOSTAT. WHERE NEW THERMOSTAT IS INSTALLED ON BLOCK WALL, PROVIDE WIREMOLD RACEWAY DOWN WALL TO THERMOSTAT. REFER TO HONEYWELL CONTROL DRAWINGS FOR ADDITIONAL INFORMATION.

WIRING LEGEND:	
---	LOW VOLTAGE (24V)
---	RS-485
---	CONTROL WIRING

1 TYP. VAV RETROFIT DETAIL
NOT TO SCALE

1.19 INSTALLATION OF SENSORS

- A. Install sensors in accordance with the manufacturer's recommendations.
1. Sensor locations are to be noted on graphics **with exact location** (ie. Duct pressure sensors, CO2 sensors, building pressure sensors, etc.).
 2. Mount sensors rigidly and adequately for the environment within which the sensor operates.

1.20 CONTROL SYSTEM CHECKOUT AND TESTING

- A. Startup testing: All testing listed in this Article shall be performed by the Contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owner's representative is notified of the system demonstration.
1. The Contractor shall furnish all labor and test apparatus required to calibrate and prepare for service all instruments, controls, and accessory equipment furnished under this Specification.
 2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

3. Enable the control systems and verify all input, output, safety, alarm, and interlock devices are working properly and according to the sequence of operations.
4. Demonstrate to Owner's representative that all systems work correctly.

1.21 TRAINING

- A. If so desired by the owner, provide a minimum of 12 hours of system training for maintenance staff. Training to be coordinated with owner.

1.22 SEQUENCES OF OPERATION

- A. Provide operation as shown on drawings.

END OF SECTION