SECTION 23 09 00
INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Section 23 00 00 and drawings are hereby made a part of this section as fully as if repeated herein.

B. The Mechanical Contractor shall coordinate with the work of Division 26 and the Fire Alarm System vendor for locations and mounting of all duct smoke detectors. These devices are shown on the Mechanical Drawings for reference only to show the intent of the work. All locations shall be determined based on approved shop drawings from the Fire Alarm System vendor and the Contractor for the work of Division 26, Electrical.

1.2 DESCRIPTION OF WORK

A. Provide labor, material and supervision necessary to install a complete direct digital control system of temperature controls with a host PC and full color graphics to control all HVAC Systems, associated components and accessories as described herein.

1.3 SUBMITTALS

A. Submit shop drawings and manufacturer's data sheets of all equipment.

B. Submit manufacturer's certificates of conformance with applicable codes.

C. Furnish point-to-point diagram of automatic temperature control system approval, including heating, ventilating and air conditioning equipment wiring diagrams where temperature control connections are required.

D. Provide ten (10) copies of submittal data within thirty (30) days of contract award.

E. Submittal shall consist of:

1. System Architecture showing all digital and pneumatically actuated devices.
2. Equipment lists of all proposed devices and equipment including data sheets of all products.
3. Valve, damper and well and tap schedules showing size, configuration, capacity and location of all equipment.
4. Data entry forms for initial parameters. Contractor shall provide English listing of all analog points with columnar blanks for high and low warning limits and high and low alarm limits, and a listing of all fan systems with columnar blanks for beginning and end of occupancy periods; and samples of proposed text for points and messages (for at least two systems of at least 15 points total) including sample 480-character alarm message. All text shall be approved prior to data entry.
5. Wiring and piping interconnection diagrams including panel and device power and sources.
6. Sketches of all graphics.

1.4 QUALITY ASSURANCE

A. Insure that all work and equipment is installed in accordance with manufacturer's warranty requirements.

B. Provide adequate supervision of labor force to assure that all aspects of specifications are being fulfilled.

C. The system shall be engineered, programmed and installed by personnel trained and regularly employed by the control’s manufacturer.

D. Supplier shall have technical support to promptly respond within 24 hours or less to service calls to the site with technical staff, spare parts inventory and test and diagnostic equipment.

E. Codes and Approvals:

1. The complete system installation shall be in strict accordance with national and local electrical codes. All devices designed for or used in line voltage applications shall be UL listed.

a. All microprocessor based devices shall be UL916 listed.

b. All electrical environmental control and monitoring devices shall be UL429 and/or UL873 listed.

2. All electronic equipment shall conform to the requirements of FCC regulation Class B, Part 15, Section 15 governing radio frequency electromagnetic interference and be so labeled.

3. The complete system shall conform to ANSI/ASHRAE Standard 135-2012, BACNET.

F. All system components shall be designed and built to be fault tolerant.

1. Provide satisfactory operation without damage at 100% above and 85% below rated voltage and at +3 Hertz variation in line frequency.

2. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients and induced magnetic interference. Bus connected devices shall be A.C. coupled or equivalent so that any single device failure will not disrupt or halt bus communication.

1.5 ELECTRICAL WIRING

A. All electrical wiring, components and accessories in connection with the Automatic Temperature Control System shall be furnished and installed by the control manufacturer.

1. Electrical Contractor shall provide all wiring to duct smoke detectors.

2. Unless stated otherwise in the design documents, the ATC Contractor is responsible for providing control power to all valves, actuators, devices and components within the DDC System regardless of the selected voltage of those devices. This also includes all 120 volt power circuits required for devices, panels and control equipment.

3. The ATC Contractor shall be responsible for providing the control interface between terminal unit condensate pumps and their respective units at the required voltage of these devices in order to shut down the terminal unit in the event of high water level in the condensate pump receiver.

1.6 AUTOMATIC TEMPERATURE CONTROL

A. Provide a DDC System of automatic temperature control which shall be by Tri-M Group, LLC. The system shall be complete in all respects including labor, materials, equipment and services necessary.

B. All electrical wiring in connection with the installation of the automatic temperature control system shall be furnished and installed under the direct supervision of the control manufacturer.

PART 2 – PRODUCTS

2.1 BMCS COMPUTER HARDWARE

A. Central Hardware: The central BMCS facility shall be located in the Building Engineer's Office as shown on the drawings and shall meet the following minimum criteria:

1. A Personal Computer (PC) based central, with minimum Intel Pentium Processor 2.8 GHz minimum clock speed, and Intel motherboard. PC shall be provided with a minimum of 2 GB of RAM, 1.44 MB diskette, 6 USB ports on the back and 2 on the front, 80 GB EIDE hard drive suitable for peripherals and applications herein specified and DVD ROM. Operator Work Station (OWS) shall include mouse, keyboard, ink-jet printer and 19-inch flat panel, monitor, an internal

56K modem connected to a PCI slot, and "NIC" card for network interface.

B. Portable Computer: Provide the following:

1. A laptop computer (PC) based central, with minimum Pentium processor, 1 GHZ minimum clock speed. PC shall be provided with a minimum of 256 MB of RAM, 1.44 MB diskett drive, 20 GB EIDE hard drive suitable for peripherals and applications herein specified, dual scan screen with 800 x 600 minimum resolution and 16,700 colors minimum, two-type 2 PC slots, 56.0 modem, CD-Rom and "NIC" card or PCMCI card.
2. Operator work storage cabinet shall be provided by the Owner.

C. Communications to other Facilities: Provide host software necessary for remote control of the BMCS. The BMCS manufacturer shall provide and install remote software in two existing DFM computers. A dial-up communications package shall allow a remote user to take control of the host PC via standard modems and phone connections. The phone lines shall be provided by the Owner.

2.2 TEMPERATURE SENSORS

A. Solid state room sensors shall be of the wire wound resistance type element. Sensors shall be equipped with visual readout and adjustment. Sensors shall be of the completely solid state type with no moving contacts. Printed circuit board under thermostat cover shall contain a low mass resistance type setpoint dial and amplifier. Provide test points for measuring output voltage. Sensors shall be direct or reverse acting as required for the sequence of operation.

B. Sensors shall provide the application for night setback override.

C. Sensors shall be mounted at ADA height (48" above floor).

2.3 SMOKE DETECTORS

A. Duct type ionization smoke detectors shall be furnished by the Electrical Contractor and installed by the Mechanical Contractor in the supply and return air stream. The Electrical Contractor shall provide wiring from each detector to the Fire Alarm System panel.

B. The Electrical Contractor shall provide an alarm output signal from the FAS panel to the BAS for unit shutdown.

2.4 ACTUATORS

A. Electronic actuators shall be sized to operate their appropriate dampers and valves with sufficient reserve power to provide smooth modulating action or two-position action as specified.

B. Provide integral, auxiliary switches for direct coupled actuators to indicate when a desired position is reached or to interface additional controls for a specific sequence.

C. Align actuator with drive shaft, provide permanent mark to identify closed position of end device.

2.5 SENSOR TRANSMITTERS

A. Duct and immersion sensors shall have minimum spans as required to meet the temperature requirements. Duct sensors shall have sensing elements of sufficient length and accuracy to measure average duct temperature in each location.

B. Sensors shall be of corrosion resistant construction, tamperproof, suitable for mounting on a vibrating surface. Exposed capillaries shall be temperature compensated, and armored or installed in protective tubing.

C. All sensing elements for water pipe mounting shall be of the rod and tube type with linear output and shall be furnished complete with separable protecting wells filled with heat conductive compound. Sensors shall be factory calibrated and tamperproof. If easily adjustable sensors are provided, they shall be located inside metal enclosures with cylinder lock and key to prevent unauthorized setting.

D. Safety Devices: Provide the following:

1. Low limit, electric type, with 20' long serpentine element, with manual reset, set for 37°F for "freeze" protection and 55°F for fan discharge application, unless otherwise noted.
2. Air and water duty flow switches: Differential pressure type for fan and pump status.
3. Carbon monoxide sensor/transducer/meter shall be analog type, requiring no field or periodic calibration, suitable for wall mounting.
   a. Microprocessor controlled digital display of 0 to 250 ppm CO.
   b. Analog output of 4 to 20 milliamps.
   c. UL listed housing, suitable for an operating environment of 0 to 125 F/ 10 to 90% RH.
   d. Repeatability of +/- 10% at 50 ppm; linearity of +/- 10%.
   e. Power input of 3.5 watts at 24 VAC.
   f. Make: Macurco inc. model CM-2B.
   g. Manufacturers: Air Test Technologies, Inc., Macurco, Rotronic Instrument Corp., Vaisala, Inc.
4. Carbon dioxide sensor/transducer suitable for wall or duct mounting.
   a. Analog output of 4 to 20 milliamps corresponding to 0 to 2000 ppm CO2.
   b. ABS plastic housing, suitable for an operating environment of 0 to 125 F/ 0 to 100% RH, non-condensing.
   c. Repeatability less than +/- 20 ppm.
   d. Response time less than 60 seconds.
   e. Power supply, 24 VAC.
   f. Make: Vaisala Inc. model GMD 20 (duct)
   g. Manufacturers: Air Test Technologies, Inc., Macurco, Rotronic Instrument Corp., Vaisala, Inc.
5. Make-up Water Monitoring System (Typical for chilled water & hot water heating system):
   (Manufacturer's Rep. 888-397-5353)
   a. Monitor data as received by flow meter on cold water make-up system. When flow exceeds 10 gal./1 min (adj.), ATC system to close normally open solenoid valve, alarm system (provide call out), shutdown boilers, pumps, chillers, etc., associated with respective system.
   b. Flow sensor, consisting of a removable flow sensor mounted in cast bronze housing, available in ½" to 1-1/2" pipe size. Sensor shall be rated for a flow range of 0.5 to 15 feet per second, 220°F max., 400 psig at 100°F max. pressure; Nylon impeller, Pennlon bearing, tungsten carbide shaft, PPS housing and EPDM seals. Manufacturer: Kele Model 250B, Data Industrial Series 250BR.
   c. Programmable analog flow transmitter shall be a loop-powered device that converts a flow sensor signal into a linear 4 – 20 mA signal. Electronic signal dampening, computer programmable, compact size in a metal enclosure. Power input, 9-35 VDC/0-1 kHz, 75 ohms at 24 VDC, accuracy of 0.1% of full scale. Manufacturer: Kele Model 310-02, Universal Flow Transmitter Model UFT-1.
6. Liquid Leak Detection System: Kele, Raychem, Trace Tek.
   a. Mechanical float devices attached to or inserted within the auxiliary pan are not acceptable.

b. Sensor shall be activated when there is at least ¼ inch of water, but no more than ½ inch of water in the auxiliary pan.

c. Equal to Kele Model WD-1B water detector.

(1) Weatherproof cast aluminum enclosure with adjustable mounting feet.

(2) 11-27VAC/VDC, 60 Hz, SPDT alarm contacts.

(3) LED indicators for power (green) and alarm (red).

(4) Fully adjustable detection level.

E. HUMIDITY TRANSMITTERS

1. Units shall be suitable for duct, wall (room) or outdoor mounting. Unit shall be two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor. Unit shall produce linear continuous output of 4-20 mA for percent relative humidity (%RH). A combination temperature and humidity sensor may be used for zone level monitoring. Sensors shall have the following minimum performance and application criteria:

a. Input Range: 0 – 100% RH

b. Accuracy (%RH): +/- 2% (when used for enthalpy calculation, dewpoint calculation or humidifier control) or +/- 3% (monitoring only) between 20-90%RH at 77°F, including hysteresis, linearity, and repeatability.

c. Sensor Operating Range: As required by application.

d. Long Term Stability: Less than 1% drift per year.

2. Acceptable Manufacturers: Units shall be Vaisala HM Series, General Eastern, Microline, or Hy Cal HT Series.

2.6 CONTROL DAMPERS

A. The ATC Sub-contractor shall furnish all the controlled dampers of the type and sizes indicated on the drawings for installation by the sheet metal Sub-contractor.

B. All 2-position control dampers shall be parallel blade and sized for minimum pressure drop, at the specified duct size.

C. All modulating dampers shall be opposed blade and sized for an effective linear air flow control characteristics within the angle of rotation and maximum pressure drops specified. Information shall be provided to the sheet metal Subcontractor for determining the proper duct reductions or baffles used.

D. Damper frames shall not be less than 16 gauge galvanized steel, formed with corner braces for extra strength, with mounting holes for enclosed duct mounting.

E. All damper blades shall be of not less than 16-gauge galvanized steel formed for strength and high velocity performance. Blades on all dampers must not be over 8" in width. Blades shall be secured to 1/2" diameter zinc plated axles by zinc plated bolts and nuts. All blade bearings shall be nylon or oilite. Blade side edges shall be sealed off against spring stainless steel seals. Teflon coated thrust bearings shall be provided at each end of every blade to minimize torque requirements and insure smooth operation. All blade leakage hardware shall be constructed of corrosion resistant, zinc plated steel and brass.

F. Dampers shall be suitable for operation between -40 and 200 degrees. The control manufacturer shall submit leakage and flow characteristics plus a size schedule for all controlled dampers.

G. All blade edges shall have inflatable seal edging that shall be rated for leakage less than 10 cubic feet

per minute per square foot of damper area at a differential pressure of 4" of water when the damper is being held by a torque not to exceed 50 inert lbs. Leakage shall not exceed 1/2 of 1% of total flow.

H. Provide permanent mark or scribe end of drive shaft to align damper with actuator in closed position.

2.7 CONTROL CABINETS

A. Control cabinets shall be constructed of 18-gauge steel with locking hinged door. Unless otherwise specified, all controllers, electric relays, switches and other equipment furnished as part of the control system which are not required to be mounted on mechanical equipment, shall be cabinet mounted. The temperature indicators and switches shall be flush mounted on the door tagged with plastic labels. All electrical devices shall be wired to a numbered terminal strip and all devices shall be completely adjusted and checked for proper operation prior to shipment to job site. All wiring shall be numbered according to the control diagram.

2.8 MOTORIZED, ROTARY ELECTRIC CONTROL VALVES

A. Capacitor type reversible electric motor, gear train, limit switches and terminal block in a die-cast aluminum enclosure, NEMA 4, for outdoor locations.

B. Output shaft shall e nickel plated to prevent corrosion. Actuator shall be suitable for any mounting position, in ambient range from -40 to +150°F.

C. Actuator shall be sized against the operating torque required by the butterfly valve manufacturer.

D. Motor shall be fractional horsepower, permanent split capacitor type designed for 120 VAC, 1 phase supply.

E. Reduction gearing shall be hardened alloy steel, permanently lubricated. Two (2) adjustable CAM actuated end travel limit switches shall be provided to control direction of travel.

F. Actuator shall be provided with handwheel for manual override operation of the valve in the event of malfunction or power failure. Handwheel shall be permanently attached to the actuator.

G. When in manual, the electric drive mechanism shall be locked out for safety.

H. Actuator shall have visual indication of valve position.

I. Valve actuator shall be Raymond Control Systems MAR-100 Series with Dezurik high performance butterfly valve.

2.9 SEQUENCE OF OPERATION

A. Host Computer and Operator’s Work Station (OWS)

1. The host computer and accessories shall be located in the Janitor’s Office on the second floor of Area ‘E’. Coordinate exact location with the owner.
2. All control programs and application features shall reside in the OWS.
3. Control manufacturer shall provide subsequent levels of control capability to whatever extent necessary to achieve performance required for individual units in their respective local control panels.
4. Work with the Owner to establish occupied/unoccupied schedules and setpoints. Enter the schedules and setpoints into the system. Provide the required number of input/output points to achieve the specified sequences of operation and monitoring points.
5. Work with the Owner to determine which points shall be trended and the sampling frequency. Set up the trend logs in the BAS.

B. Ductless Split System Unit Control (AC-1/ACC-1):

1. The unit shall be controlled by its factory controls. Mount and wire the thermostat, which is furnished by the equipment manufacturer, and interlock the controls from the indoor unit to the

outdoor unit. Set to maintain 75°F, adjustable.

2. Provide a space mounted temperature sensor for monitoring and alarm generation at the OWS. On a rise in space temperature above the programmed high limit setpoint of 80°F, adjustable, an alarm shall be activated. On a fall in space temperature below the programmed low limit setpoint of 50°F, adjustable, an alarm shall be activated.
3. The following items shall be displayed at the OWS:
   a. Space temperature.
   b. High and low limit alarms and setpoints.

C. Split System Heat Pump System Control (HP-1 &2/ACCHP-1)

1. The sequence that follows is for the multi-joint heat pump system shown on the drawings.
2. Mount and wire the System Controller furnished by the system manufacturer in a location as directed by the Owner. Extend control wiring from the Controller to all heat pump units within the system.
3. Interface each heat pump unit with its respective wall mounted temperature control furnished with each unit.
4. The System Controller shall activate the heat pump units according to its programmed occupied/unoccupied schedule. Set room temperature control for each heat pump unit to maintain occupied space temperature at 70°F, adjustable, in the heating mode, and 75°F, adjustable, in the cooling mode. Program unoccupied setpoints as directed by the Owner.
5. The System Controller shall provide full overview display, list all rooms connected to the system, monitor all room conditions, and monitor all heat pump unit configuration settings. Interface the system controller with the OWS for all monitoring and alarm capability. Coordinate with those points selected by the Owner.
6. For units mounted horizontally above finished ceilings, provide a water detector in the bottom of the auxiliary drain pan located under each unit. Upon sensing water in the pan, the unit shall stop and the controller shall initiate an alarm to the OWS.

D. Kitchen Hood Exhaust Fan & Make-Up Air Unit Control (EF-1 and MAU-1)

1. The hood exhaust fan and make-up air unit shall be energized automatically by temperature sensor(s) provided as part of the hood. Interface with these sensor(s) in accordance with hood manufacturer's written instructions.
2. The kitchen equipment manufacturer shall provide the BAS Contractor with wiring diagrams for the hood.
3. The following items shall be provided by the make-up air unit manufacturer:
   a. Motor starter and overload protection.
   b. Outside air damper and actuator.
   c. Terminal blocks for all wiring connections between equipment and control devices.
   d. Remote discharge air temperature setpoint controller.
4. Provide a current sensor on one phase of the power feeding the exhaust fan. When current is sensed, indicating that the exhaust fan has been energized, the make-up air unit outside air damper shall open 100% and the supply fan shall be energized. On a fall in discharge air temperature below setpoint of 65°F, adjustable, the gas heat shall stage and modulate through its unit-mounted controls to maintain setpoint.
5. Provide a current sensor on one phase of power feeding the supply fan for monitoring and alarm

generation at the OWS.

6. The system shall prevent the circulation of smoke. Upon activation of the duct smoke detector in the supply air duct at the discharge of MAU, the unit shall stop and all dampers shall close.
   a. The Mechanical Contractor shall install duct smoke detector furnished as part of the work of Division 26 – Electric.
7. Interface with a common fire alarm input to the BAS system from the fire alarm system (FAS). The fire alarm contact shall be provided by the fire alarm system vendor at the FAS panel. The status of the alarm contact shall be communicated throughout the BAS. When the fire alarm contact indicates an alarm condition, the BAS shall de-energize the supply fan, exhaust fan, gas heat and damper motors. When de-energized, the damper motor shall spring return the outside air damper closed.
   a. If the kitchen ventilator exhaust fan is running and the hood fire suppression system is activated manually, the exhaust fan shall continue to run until deactivated by the FAS or manually shut down at the hood.
   b. MAU shall shut down whenever the hood suppression system or fire alarm system is activated. Provide interface with each system.
8. The following items shall be displayed at the OWS:
   a. Discharge air temperature.
   b. Discharge air temperature setpoint.
   c. Discharge low limit alarm.
   d. Fire alarm system status alarm.
   e. Commanded status of fans.
   f. Supply fan operational status via current sensor.
   g. Exhaust fan operational status via current sensor.
   h. Smoke detector status/alarm.
   i. Diagram showing the layout of the equipment with major components and dynamic temperatures shown where temperature sensors exist in the system.

E. Rooftop Energy Recovery Unit Control (ERU-1):
1. The unit consists of a supply fan, exhaust fan, packaged DX cooling system with hot gas reheat, package indirect fired gas heating system, energy recovery wheel and drive, filters, air control dampers and actuators, VFD's for each fan, and unit controls.
2. The ERU shall be controlled by an individual DDC Controller.
3. The BAS Contractor shall furnish required sensing and control devices to the unit manufacturer for factory installation and wiring. The equipment manufacturer shall provide the BAS Contractor with wiring diagrams for the equipment. The BAS Contractor shall then provide wiring diagrams to the equipment manufacturer detailing installation and wiring requirements for the DDC Controls.
4. The occupied/unoccupied schedule shall correspond to the occupancy schedule as directed by Owner. Delay startup of the unit until the zone temperature has recovered from its previous setback or setup temperature during the unoccupied mode.
5. Once activated, supply fan, exhaust fan, and energy recovery wheel shall run continuously with the outside air and exhaust air dampers open. The gas fired heating section shall modulate to maintain the minimum discharge air temperature setpoint of 70 degrees F, adjustable. On a rise in

discharge air temperature, the DX cooling system shall be staged to maintain a cooling discharge air temperature setpoint of 55 degrees F, adjustable. On a fall in temperature the reverse shall occur.

a. Whenever the supply air duct humidity level exceeds 60%, adjustable, the unit control shall activate the modulating hot gas reheat section to reduce this condition to 50%, adjustable.

b. When the unit is deactivated, the fans, heating and cooling shall be off and all dampers shall be closed.

6. The DDC controller shall receive input from the unit's factory installed energy wheel rotation sensor for monitoring and alarm generation at the OWS.

a. Unit shall continue to run in manual mode until the unit is shut down manually or at the OWS whenever the energy wheel fails.

b. Whenever the outside air temperature is +/- 5°F, adjustable, of return air temperature in the unit, the energy recovery wheel shall stop.

7. Interface with a common fire alarm input from the fire alarm system. The fire alarm contact shall be provided at the fire alarm panel by the fire alarm contractor. The status of the alarm contact shall be communicated throughout the BAS. When the fire alarm contact indicates an alarm condition, the BAS shall de-energize the unit. When de-energized, the damper motors shall spring return the outside and exhaust air dampers closed. Provide an alarm at the OWS to indicate fire alarm status.

8. The following items shall be displayed at the OWS:

a. Discharge air temperature.

b. Discharge air temperature setpoint.

c. Return air temperature.

d. Exhaust air temperature.

e. Fire alarm system status alarm.

f. Commanded status of fans.

g. Supply fan operational status via a current sensor.

h. Exhaust fan operational status via a current sensor.

i. Energy recovery wheel commanded status and alarm.

j. Diagram showing the layout of the equipment with major components and dynamic temperatures shown where temperature sensors exist in the system.

F. Packaged Rooftop Unit Control: (RTU-1)

1. This unit consists of a supply fan, packaged air-cooled DX cooling system, gas fired heating section, air filters, air control dampers and actuators, and unit controls.

a. The unit is a constant volume system with minimum outside air and economizer mode of operation.

b. The unit shall be controlled by an individual DDC Controller. The DDC Controller shall be wired to sensors which shall include, but are not limited to, a discharge air temperature sensor, mixed air temperature sensor, return air temperature sensor, return air humidity sensor, global outside air temperature/humidity/enthalpy, CO2 sensors, and space temperature sensors. Provide additional temperature sensors for zone averaging control.

2. The following items shall be provided by the equipment manufacturer:

a. Motor starters and overload protection.

b. Control transformers.

c. Dampers and damper motors.

d. Terminal blocks for all wiring connections between equipment and control devices.

e. Standard factory control modules for all unit functions.

The following items shall be provided by ATC.

a. Discharge air temperature sensor.

b. Return air temperature and humidity sensors.

c. Global outside air temperature and humidity sensors.

d. Current sensor for one phase of the power feeding the fan.

e. Mixed air average temperature sensor.

f. CO2 sensors and space temperature sensors.

g. DDC Controller.

3. During the programmed occupied mode, the supply fan shall run continuously with the outside air damper closed. When fan fails to start once activated, initiate an alarm to the system after a twenty second delay. Monitor fan status with a current sensor on one leg of power feeding the fan motor. Delay opening the outside air damper to its minimum position until the zone space temperature has recovered from the setback or setup temperature setting.

   a. Outside air damper shall remain closed until return air CO2 level rises to 700 ppm. The outside air damper shall step open from the closed to full scheduled open position to maintain CO2 level at or below 700 ppm. The return air and relief air dampers in the system shall modulate in unison to maintain the balance of air in the system.

   b. On a continued rise in CO2 level above 900 ppm, activate an alarm at the OWS. On a decrease in CO2 level below 700 ppm, the outside air damper shall step closed.

4. On a drop in space air temperature below the programmed setpoint of 70°F, adjustable, the unit gas heating section shall be activated through its unit controls and modulate to maintain setpoint.

5. On a rise in space air temperature above setpoint, the mixing box economizer sequence shall be activated. On a further rise or if the economizer sequence is deactivated, the unit air-cooled DX system hall be activated through its unit controls to maintain setpoint. On a fall in temperature the reverse shall occur. Maintain 75°F, adjustable.

6. The mixing box economizer sequence shall be activated as the first stage of cooling. The DDC Controller shall receive input from the global outside air temperature and humidity sensors to calculate outside air enthalpy. If the outside air enthalpy is at 25 BTU/lb, adjustable, the mixing box dampers shall modulate to maintain the mixed air temperature setpoint of 55°F, adjustable. The outside air damper shall continue to open up to 100% outside air to satisfy cooling demand. The return/relief dampers in the unit shall move in unison to maintain the balance of air in the unit. The outside air damper shall not close below the minimum position during the occupied period.

7. During the programmed un-occupied mode, the fan, heating, cooling and mixing box dampers shall be cycled/modulated to maintain the un-occupied setpoints of 60°F (heating) and 85°F (cooling), all adjustable. Unless required for economizer cycle, the outside air and relief air dampers shall remain closed with the return air damper fully open.

8. Interface with a common fire alarm input from the fire alarm system. The fire alarm contact shall be provided at the fire alarm panel by the Fire Alarm Contractor. The status of the alarm contact shall be communicated throughout the BAS. When the fire alarm contact indicates an alarm

condition, the BAS shall de-energize the unit. When de-energized, the damper motors shall spring return all air dampers closed. Provide an alarm at the OWS to indicate fire alarm status.

9. The Mechanical Contractor shall install duct smoke detectors in the supply and return air ducts at the unit as furnished by the FAS vendor as part of the work of Division 26 – Electric. When wired to the fire alarm system as required by the Division 26 contractor, the duct smoke detectors shall alarm the FAS, which shall signal the BAS to de-energize the unit in a manner similar to item 8.
10. The following items shall be displayed at the OWS:
    a. Discharge air temperature and humidity.
    b. Discharge air temperature and humidity setpoint.
    c. Space air temperature.
    d. Space air temperature setpoint.
    c. Return air temperature and humidity.
    f. Return air temperature and humidity setpoint.
    g. Mixed air temperature.
    h. Mixed air temperature setpoint.
    i. Global outside air temperature, humidity and enthalpy.
    j. Fire alarm system status/alarm.
    k. Duct smoke detectors status: normal/alarm.
    l. Commanded status of fan.
    m. Supply fan operational status via current sensor.
    n. Diagram showing the layout of the equipment with major components and dynamic temperatures shown where temperature sensors exist in the system

G. Packaged Rooftop Unit Control: (RTU-2)

1. This unit consists of a supply fan, packaged air-cooled DX cooling system, gas fired heating section, air filters, air control dampers and actuators, supply fan VFD (for balancing) and unit controls.
    a. The unit is a constant volume system with minimum outside air and economizer mode of operation with powered relief air fan.
    b. The unit shall be controlled by an individual DDC Controller. The DDC Controller shall be wired to sensors which shall include, but are not limited to, a discharge air temperature sensor, mixed air temperature sensor, return air temperature sensor, return air humidity sensor, global outside air temperature/humidity/enthalpy, and space temperature sensor. Provide additional temperature sensors for zone averaging control.
2. The following items shall be provided by the equipment manufacturer:
    a. Motor starters and overload protection.
    b. Control transformers.
    c. Dampers and damper motors.
    d. Terminal blocks for all wiring connections between equipment and control devices.
    e. Standard factory control modules for all unit functions.

    The following items shall be provided by ATC.
    a. Discharge air temperature sensor.

b. Return air temperature and humidity sensors.

c. Global outside air temperature and humidity sensors.

d. Current sensor for one phase of the power feeding each fan.

e. Mixed air average temperature sensor.

f. Space temperature sensor.

g. DDC Controller.

3. During the programmed occupied mode, the supply fan shall run continuously with the outside air damper open to minimum position. When fan fails to start once activated, initiate an alarm to the system after a twenty second delay. Monitor fan status with a current sensor on one leg of power feeding the fan motor. Delay opening the outside air damper to its minimum position until the zone space temperature has recovered from the setback or setup temperature setting.

4. On a drop in space air temperature below the programmed setpoint of 70°F, adjustable, the unit gas heating section shall be activated through its unit controls and modulate to maintain setpoint.

5. On a rise in space air temperature above setpoint, the mixing box economizer sequence shall be activated. On a further rise or if the economizer sequence is deactivated, the unit air-cooled DX system hall be activated through its unit controls to maintain setpoint. On a fall in temperature the reverse shall occur. Maintain 75°F, adjustable.

   a. Whenever the supply air duct humidity level exceeds 60%, adjustable, the unit control shall activate the modulating hot gas reheat section to reduce this condition to 50%, adjustable.

6. The mixing box economizer sequence shall be activated as the first stage of cooling. The DDC Controller shall receive input from the global outside air temperature and humidity sensors to calculate outside air enthalpy. If the outside air enthalpy is at 25 BTU/lb, adjustable, the mixing box dampers shall modulate to maintain the mixed air temperature setpoint of 55°F, adjustable. The outside air damper shall continue to open up to 100% outside air to satisfy cooling demand. A limit switch on the outside air damper shall activate the unit powered relief air fan to maintain the balance of air in the unit during economizer operation. The return air damper in the unit shall move in unison with the outside air damper to maintain the balance of air in the unit. The outside air damper shall not close below the minimum position during the occupied period.

7. During the programmed un-occupied mode, the fan, heating, cooling and mixing box dampers shall be cycled/modulated to maintain the un-occupied setpoints of 60°F (heating) and 85°F (cooling), all adjustable. Unless required for economizer cycle, the powered relief air fan shall remain off, the outside air and relief air dampers shall remain closed with the return air damper fully open.

8. Interface with a common fire alarm input from the fire alarm system. The fire alarm contact shall be provided at the fire alarm panel by the Fire Alarm Contractor. The status of the alarm contact shall be communicated throughout the BAS. When the fire alarm contact indicates an alarm condition, the BAS shall de-energize the unit. When de-energized, the damper motors shall spring return all air dampers closed. Provide an alarm at the OWS to indicate fire alarm status.

9. The Mechanical Contractor shall install duct smoke detectors in the supply and return air ducts at the unit as furnished by the FAS vendor as part of the work of Division 26 – Electric. When wired to the fire alarm system as required by the Division 26 contractor, the duct smoke detectors shall alarm the FAS, which shall signal the BAS to de-energize the unit in a manner similar to item 8.

10. The following items shall be displayed at the OWS:

    a. Discharge air temperature and humidity.

    b. Discharge air temperature and humidity setpoint.

c. Space air temperature.
d. Space air temperature setpoint.
c. Return air temperature and humidity.
f. Return air temperature and humidity setpoint.
g. Mixed air temperature.
h. Mixed air temperature setpoint.
i. Global outside air temperature, humidity and enthalpy.
j. Fire alarm system status/alarm.
k. Duct smoke detectors status: normal/alarm.
l. Commanded status of each fan.
m. Supply fan operational status via current sensor.
n. Relief fan operational status via current sensor.
o. Diagram showing the layout of the equipment with major components and dynamic temperatures shown where temperature sensors exist in the system

H. Cabinet Unit Heater Control (ECH-1)
1. Cabinet unit heater shall be controlled by the BAS via a space temperature sensor.
a. Provide a separate DDC controller and flat plate space sensor; no override switch is required.
2. The unit fan shall cycle to maintain the programmed setpoint of 65°F, adjustable.
3. Provide a current switch on one phase of power feeding the unit fan for status indication at the OWS.
4. The following items shall be displayed at the OWS:
a. Space temperature
b. Space temperature setpoint
c. Commanded status of fan
d. Operational status of fan via current switch

I. Electric Panel Radiation Heater Control (EFR)
1. Provide control voltage relay for each unit for activation through the OWS based on the owner's occupancy schedule.
2. Provide a wall mounted temperature sensor with guard to control all heaters. Set to maintain 65°F during the occupied mode and 55°F during the unoccupied mode.
3. Provide space temperature and unit status as indications to the system.

J. Cold Storage Monitoring Control
1. Provide temperature sensor in each of the walk-in cold storage units in the culinary arts kitchens, as shown on the food service drawings.
2. Set high limit alarms for each cold storage unit as recommended by the unit manufacturer.
3. Provide high limit alarms to the OWS and any remote call-out as directed by the Owner.

K. Outdoor Lighting Control (LED):
1. DDC shall furnish and install four (4) control relays for site lighting control. Refer to Electrical Drawings for junction box tie-in locations. The lighting will be divided into four (4) zones.
2. Provide an outdoor, ambient light level sensor. During the programmed operation period, the

outdoor lighting shall be activated when the outdoor ambient light level falls below the programmed setpoint. Each zone shall have independent light level setpoints and time schedules. Set time schedules and light level setpoints as directed by the Owner. All time schedules and setpoints shall be adjustable at the OWS. If either the security system or fire alarm system is alarmed, all four (4) zones shall be activated as follows:

Zone #1 – On at dusk and off at 10:10 P.M. M-F, off Saturday & Sunday

Zone #2 – On at dusk and off at 10:10 P.M. M-F, off Saturday & Sunday

Zone #3 – On at dusk and off at 10:10 P.M. M-F, off Saturday & Sunday

Zone #4 – On at dusk and off at dawn – 365 days/yr

3. The following items shall be displayed at the OWS:
   a. Ambient light level.
   b. Time schedule per zone.
   c. Commanded status of each zone
4. When either the Fire Alarm or Security Systems goes into alarm, and Zones 1, 2, and 3 are scheduled off, they should be reenergized and left on until dawn and then deenergized even if the fire alarm or security system is deactivated. Zone 4 shall remain on per schedule in #2 above.

L. Off-Site Monitoring
1. DDC System shall provide dial-up monitoring conditions for the following alarms:
   a. Unit freezestat goes into alarm and make-up water system in alarm – initiate a call-in alarm.
   b. Low space temperature below 42˚F and outside below 42˚F, initiate a call-in alarm.
   c. Power off or rise in temperature in walk-in freezers/coolers – initiate a call-in alarm.
   d. If all of the above conditions are not met, the DDC system should go into local alarm only.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install system and materials in accordance with manufacturer's instructions and roughing-in drawings, and details and drawings. Install electrical work and use electrical products complying with requirements of these specifications. Mount controllers at convenient locations and heights.

B. All wiring shall be properly supported and run in a neat and workmanlike manner. All wiring exposed and in equipment rooms shall run parallel to or at right angles to the building structure. All wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals. All wiring shall be in accordance with all local and national codes. Low voltage wiring for space temperature sensors, communication bus between terminal units, etc., above accessible ceilings in finished spaces on the floors may be plenum rated cable. Wiring in all locations shall be installed in EMT conduit. All electronic wiring shall be #18 AWG minimum THHN and shielded if required, except standard network (Ethernet, LonWorks, etc.) cabling shall be as tested and recommended in lieu of #18 gauge twisted, #22 or #24 gauge is acceptable if used as a part of an engineered structured cabling system. The control manufacturer must submit technical and application documentation demonstrating that this cabling system has been tested and approved for use by the manufacturer of both the control system and the engineered structured cabling system.

C. Provide all sensing, control, and interlock wiring for the following:

System inputs and outputs

System communications

System power

System interlocks

Unit controls

D. The Control Manufacturer shall enter all computer data into the Host computer including all graphics, control programs, initial approved parameters and settings, and English descriptors. The Control Manufacturer shall maintain diskette copies of all data file and application software for reload use in the event of a system crash or memory failure. One copy shall be delivered to the owner during training sessions, and one copy shall be archived in the Control Manufacturer's local software vault.

3.2 DATA CONTROL (D/C) AND GRAPHICS SUMMARY

A. All hardware, custom software, application software, graphics, etc., necessary to accomplish the control sequences and display the graphics specified shall be provided as part of this contract. Provide all controllers, inputs, outputs, valves, dampers, actuators and flow meters required to provide the control and graphic data described. Provide software setpoints required for display in logical groups and graphics.

B. Each digital output shall have a software-associated monitored input. Any time the monitored input does not track its associated command output within a programmable time interval, a "command failed" alarm shall be reported.

C. Where calculated points (such as CFM) are shown, they shall appear in their respective logical groups.

D. Unless otherwise specified or approved prior to bidding, the primary analog input and the analog output of each DDC loop shall be resident in a single remote panel containing the DDC algorithm, and shall function independent of any primary or UC communication links. Secondary (reset type) analog inputs may be received from the primary network, but approved default values and/or procedures shall be substituted in the DDC algorithm for this secondary input if network communications fail or if the secondary input becomes erroneous or invalid.

3.3 ACCEPTANCE

A. The Control Manufacturer shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operations approved.

B. Witnessed acceptance demonstration shall display and demonstrate each type of data entry to show site specific customizing capability; demonstrate parameter changes; execute digital and analog commands; and demonstrate DDC loop stability via trend of inputs and outputs.

3.4 MANUALS

A. The following manuals will be provided:

1. An Operators Manual shall be provided with graphic explanations of keyboard use for all operator functions specified under Operator Training.

B. Computerized printouts of all GPC data file including all point processing assignments, physical terminal relationships, scales and offsets, command and alarm limits, etc.

C. A manual shall be provided including revised as-built documents of all materials required under the paragraph "SUBMITTALS" on this specification.

D. Two Operators Manuals, and two As-Built Manuals shall be provided to the owner.

3.5 TRAINING

A. All training shall be by the BMCS contractor and shall utilize operators manuals and as-built documentation.

B. Operator training shall include three (3) four-hour sessions encompassing modifying text and graphics, sequence of operation review, selection of all displays and reports, use of all specified OWS functions,

troubleshooting of sensors (determining bad sensors), and password assignment and modification. One training session shall be conducted at system completion, one shall be conducted forty-five days after system completion, and one at ninety (90) days, or as requested by the Owner.

3.6 SERVICE GUARANTEE

A. The control system herein specified shall be free from defects in workmanship and material under normal use and service. After completion of the installation, the control manufacturer shall regulate and adjust all thermostats, control valves, motors and other equipment provided under this contract. If within twelve (12) months from date of acceptance either for beneficial use of final acceptance, whichever is earlier, any of the equipment herein described is proven to be defective in workmanship or materials, it will be replaced or repaired free of charge. The control manufacturer shall, after acceptance, provide any service incidental to the proper performance of the control system under guarantee outlined above for the period of one year. Normal maintenance of the system or adjustments of components is not to be considered part of the guarantee. The control manufacturer will upon completion of the installation, during the warranty period, make available to the Owner, an annual service agreement covering all labor and material required to efficiently maintain the control system.

3.7 FINAL ADJUSTMENT

A. After completion of installation, adjust thermostats, control valves, motors and similar equipment provided as work of this section.

B. Final adjustment shall be performed by specially trained personnel in direct employ of installer of primary temperature control system.

END OF SECTION