



## DIVISION 25 INTEGRATED AUTOMATION

The Facility Management Energy and Engineering (E&E) unit has developed a Building Automation System (BAS) guideline standard that is comprised of the technical information and control strategies utilized at the University. All projects with a BAS component are expected to seamlessly connect with the campus wide BAS as defined in the guideline. No BAS should be designed as a stand-alone or local control system.

Consultants and designers are expected to apply the BAS guideline standards to include coordination of Division 22, 23, 25, and 26 equipment/systems included in the project.

The Building Automation unit of Energy and Engineering has also prepared template equipment control drawings and sequences that follow the BAS guideline. Example guideline documents are available upon request to E&E from Planning and Project Management or the assigned Project Manager in either pdf or dwg format.

Guideline sections included in the combined document are:

- 25 08 00 Integrated Automation Commissioning
- 25 11 13 Integrated Automation
- 25 11 16 Network Routers Bridges Switches Hubs and Modems
- 25 14 13 Remote Control Panels
- 25 15 16 Software for Control and Monitoring of Networks
- 25 35 00 Instrumentation and Terminal Devices for HVAC
- 25 35 11 Actuators and Operators
- 25 35 16 Sensors and Transmitters
- 25 35 19 Control Valves
- 25 55 00 Control of HVAC
- 25 55 00.19 Control of HVAC Object Naming Convention
- 25 95 00 Control Sequences for HVAC



## SECTION 25 08 00 INTEGRATED AUTOMATION COMMISSIONING

### GENERAL

#### 1.01 SECTION INCLUDES:

- A. BAS and equipment testing and start-up
- B. Validation of proper and thorough installation of BAS and equipment
- C. Functional testing of control systems
- D. Documentation of tests, procedures, and installations
- E. Coordination of BAS training
- F. Documentation of BAS Operation and Maintenance materials

#### 1.02 GENERAL DESCRIPTION

- A. This section defines responsibilities of the BAS Contractor to commission the BAS.

### PRODUCTS

#### 1.03 INSTRUMENTATION

- A. Instrumentation required to verify readings and test the system and equipment performance shall be provided by the Contractor and made available to the Commissioning Authority. Generally, no testing equipment will be required beyond that required to perform Contractor's work under these Contract Documents. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 12-month period. Certificates of calibration shall be made available when requested.

### EXECUTION

#### 1.04 STARTUP TESTING, ADJUSTING, CALIBRATION

- A. Work and/or systems installed under this Division shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems as described below:
  - 1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
  - 2. Verify proper electrical voltages, amperages and verify that all circuits are free from faults.
  - 3. Verify integrity/safety of all electrical connections.
  - 4. Coordinate with TAB subcontractor to obtain the following control settings once TAB work is complete:
    - a) Optimum duct static pressure setpoints for VAV air handling units.
    - b) Minimum outside air damper settings for air handling units.
    - c) Optimum differential pressure setpoints for variable speed pumping systems.
    - d) Calibration parameters for flow control devices such as VAV boxes and flow measuring stations.
  - 5. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the



6. BAS/Local Control Display and the reading at the device. Record the measured value and displayed value for each device in the Start-Up Report.
7. Check and set zero and span adjustments for all transducers and transmitters. Excessive signal buffering is not acceptable, span adjustments must be within 2% of their respective end points. (i.e. Do not control a 2-10vdc actuator with a 0-10vdc signal; worst case signal should be 1.8-10.2vdc.)
8. For dampers and valves:
  - a) Check for adequate installation including free travel throughout range and adequate seal.
  - b) Where loops are sequenced, check for proper control without overlap.
9. For actuators:
  - a) Check to ensure that device seals tightly when the appropriate signal is applied to the operator.
  - b) Check for appropriate fail position, and that the stroke and range is as required.
  - c) For sequenced electronic actuators, calibrate per manufacturer's instructions to required ranges.
10. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the Operator Interface display. Record the results for each device in the Start-Up Report.
11. For outputs to reset other manufacturer's devices (for example, VSDs) and for feedback from them, calibrate ranges to establish proper parameters.
12. Verify proper sequences by using the approved checklists to record results and submit with Start-Up Report. Verify proper sequence and operation of all specified functions.
13. Verify that all safety devices trip at appropriate conditions. Adjust setpoints accordingly.
14. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the Start-Up Report.
15. For interface and DDC control panels:
  - a) Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the record drawings.
  - b) Ensure that terminations are safe, secure and labeled in accordance with the record drawings.
  - c) Check power supplies for proper voltage ranges and loading.
  - d) Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
  - e) Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
  - f) Ensure that all outputs and devices fail to their proper positions/states.
  - g) Check for adequate grounding of all BAS panels and devices.
  - h) Thoroughly clean interior and exterior of control panel per manufacturer



16. For Operator Interfaces:

- a) Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
- b) Output all specified reports for review and approval.
- c) Verify that the alarm logging is functional and per requirements.
- d) Verify that trends are archiving to the CSS and provide a sample to the Commissioning Authority and Owner for review.

17. Verify proper interface with fire alarm system.

- B. Submit Start-Up Test Report: Report shall be completed, submitted, and approved prior to Substantial Completion.

1.05 SENSOR CHECKOUT AND CALIBRATION

- A. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation.
- B. Calibration: Calibrate all sensors using one of the following procedures:
1. Temperature, Humidity, CO<sub>2</sub>, and CO Sensors: Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat or gage) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Offset shall not exceed more than 5% of the sensor span. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20% of the expected range.
  2. Pressure Sensors: Disconnect sensor. With the equipment in normal steady state operation, override the control point to match the current control value (i.e. Lock the supply fan speed output to the current steady state value). Connect calibrated device in parallel with the pressure sensor(s). Make a reading with a calibrated test instrument. Verify that the sensor reading (via the permanent thermostat or gage) is within the tolerances specified. If not, replace the sensor and repeat. For pressure sensors, where steady state operation of the equipment cannot be maintained for calibration purposes, perform a similar process with a suitable signal generator.
- C. Sensor Tolerance: Sensors shall be within the tolerances specified for the device. Refer to Section 25 55 00.

1.06 COIL VALVE LEAK CHECK

- A. Verify proper close-off of the valves. Ensure the valve seats properly by simulating the maximum anticipated pressure difference across the circuit. Calibrate air temperature sensors on each side of coil to be within 0.5°F of each other. Via the Operator Interface, command the valve to close. Energize fans. After 5 minutes, observe air temperature difference across coil. If a temperature difference is indicated, and the piping surface temperature entering the coil is within 3°F of the water supply temp, leakage is probably occurring. If it appears that it is occurring, close the isolation valves to the coil to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing



the seat or replacing the valve as applicable.

#### 1.07 VALVE STROKE SETUP AND CHECK

- A. For all valve and actuator positions checked, verify the actual position against the Operator Interface readout.
- B. Set pumps to normal operating mode. Command valve closed, verify that valve is closed, and adjust output zero signal as required. Command valve open, verify position is full open and adjust output signal as required. Command the valve to various few intermediate positions. If actual valve position doesn't reasonably correspond, replace actuator.

#### 1.08 VERIFICATION TESTING

- A. Perform the following verification tests for each control system to ensure that the described control system components are installed and functioning per this specification.
- B. Verification test procedures, testing and activities shall be developed and conducted so as not to cause personal injury, damage to components, damage to systems, or damage the building or other property.
- C. General Requirements:
  - 1. Intent of the procedure is to demonstrate that the exact functions of control systems meet requirements outlined by approved shop drawings and written Sequence of Operation.
  - 2. Verify each air handling unit, equipment system, steam and hydronic system in automatic mode of operation, utilizing actual field devices and final control elements. Tune each control loop.
  - 3. Indicate type and cause of failures, as well as required remedial actions, on test report. Requested tests, not outlined herein, will be evaluated for feasibility and impact on schedule and cost prior to implementation.
  - 4. Systems will not be accepted by the Owner, CA or A/E without approval of tests and required remedial action.
  - 5. Provide a schedule to the Owner for execution of these tests. The Owner shall participate in any or all of the contractor's testing at the Owner's discretion.
  - 6. Provide all necessary BAS equipment and field adjustments to ensure that the HVAC equipment in the expansion and the base building operates to meet or exceed the acceptance criteria specified herein during all operating modes and HVAC related failure modes of the facility.
- D. Control System Static Check
  - 1. Prior to static check of system, identify each CU by description, tag number, and address. Verify proper system communication with these devices, as well as values indicated.
  - 2. Operational static check shall include verification of all field wiring associated with CUs. Include continuity testing between wiring from field device (sensor, actuator, or other components) to appropriate block on terminal strip in appropriate enclosure. Verify control loop wiring diagrams and panel wiring diagrams for the following:
    - a) Digital Inputs: Energize each digital input (smoke detector, end switch, control relay, flow switch, differential pressure switch, or other components)



- in the field. Verify at panel.
- b) Digital Outputs: Force on each digital output (solenoid valve, motor starter, control relay, or other components) at control panel. Field verify corresponding final element for proper stroke/status.
  - c) Analog Inputs: Compare field reading of each analog input (transmitters, thermistor, or other components) with that displayed on graphic screens, and auxiliary panels.
  - d) Analog Outputs: Force each analog output (I/P) to values of 0 percent, 25 percent, 50 percent, 75 percent and 100 percent. Field verify corresponding final element (valve or damper) positions from fully closed to open, based upon stated range.
3. Calibration of Test Instruments: Use calibrated test instruments for all point checks as specified herein. The calibration of the test instruments shall be traceable to the National Institute of Standards And Technology (NIST) standards. A static system checkout shall be performed on a BAS instrument if the date of the test instrument calibration is within one year of the date of the check. Recalibrate test instruments annually and submit the NIST traceable instrument reports along with the static system checkout sheets.
- E. Control System Dynamic Check
1. Operational dynamic check shall include verification that control system, including sensors and actuators, performed as specified while interconnected to the process.
  2. Verify proper system communication with controllers and the ability to reset setpoints remotely from operator workstations.
  3. Verify the operation of each air handling unit, equipment system, steam system and hydronic systems in automatic.
  4. Verify and demonstrate that operator workstation interface graphic screens are displayed consistent with the drawings. Verify the status of each digital and analog value on every graphic screen is consistent with actual field device reading. Use only graphic screens accepted by the A/E and owner.
  5. Test each control loop to verify that it indicates proper percent of scale and correct scaling of engineering units.
  6. Verify stability of all control loops. Record and provide graphical trends for each control loop to verify loop stability is within specified limits.
  7. Test system failures, start-up sequences for air handling units, exhaust fans, heat recovery units, and hydronic systems. Verify warnings and fail to start logic.
  8. Submit Dynamic Performance Test Sheets indicating operating conditions after detailed dynamic checkout of the systems. The dynamic performance test sheets shall be in a tabular format and represent the contractor's sequence of operations and the tests described above. The person performing verification shall initial and date each verification test form adjacent to the test. Once the sequences and tests listed above are passed successfully, the test sheets shall be submitted for record.
- F. Alarms
1. The BAS Contractor will coordinate all alarming parameters with the Owner, or Owner's representative, prior to implementation of the database on the Central System Server (CSS).



2. For each project, each alarm and events shall be classified per the Owner's instruction for the proper category: Emergency, Life Safety, Security, Supervisory, Trouble, High, Medium, and Low.
3. Test each alarm identified in the contract documents. Verify that the control system displays proper indication. Test and verify proper acknowledgement of alarms from operator workstation.

#### 1.09 DEMONSTRATION

- A. Demonstration of a completely commissioned system shall be a requirement for final completion.
- B. Demonstrate the operation of the hardware, software, and all related components and systems to the satisfaction of the Commissioning Authority and Owner. Schedule the demonstration with the Owner's representative 1 week in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved. If the Work fails to be demonstrated to conform to Contract specifications, so as to require scheduling of additional site visits by the Commissioning Authority and Owner for re-demonstration, Contractor shall reimburse Owner for costs of subsequent Commissioning Authority site visits.
- C. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the job site.
- D. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner and CA.
- E. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:
  1. Demonstrate that required software is installed on each workstation. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
  2. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
  3. Demonstrate that remote communication abilities are in accordance with these Specifications.
  4. Demonstrate correct calibration of input/output devices using the same methods specified for the Start-Up Tests. A maximum of 10 percent of I/O points shall be selected at random by the Commissioning Authority and/or Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by Commissioning Authority for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
  5. Demonstrate that all DDC and other software programs exist at respective field panels. The Direct Digital Control (DDC) programming and point database shall be as submitted and approved.
  6. Demonstrate that all DDC programs accomplish the specified sequences of



operation.

7. Demonstrate that the panels automatically recover from power failures, as specified.
  8. Demonstrate that the stand-alone operation of panels meets the requirements of these guidelines. Demonstrate that the panels' response to LAN communication failures meets the requirements of these guidelines.
  9. Identify access to equipment selected by the Commissioning Authority and by the Owner. Demonstrate that access is sufficient to perform required maintenance.
  10. Demonstrate that required trend graphs and trend logs are set up per the requirements.
  11. Test each control loop display to verify that it indicates proper percent of scale and correct scaling of engineering units.
  12. Alarms: Test each alarm identified in Contract Documents. Verify that control system displays proper indication. Test and verify proper acknowledgement of alarms from supervisory station.
  13. For each system, demonstrate:
    - a) Cold start.
    - b) Sequence of operation.
    - c) Seasonal control as applicable.
- F. The demonstration shall be completed and approved prior to Substantial Completion.
- G. Any tests successfully completed during the demonstration will be recorded as passed for the functional performance testing and will not have to be retested.
- H. After completed system balancing, verify all space control operation including temperature, humidity and flow/static pressure recovery operation.
- I. Provide complete demonstration of equipment or systems requiring seasonal operation, during operating season. Perform multiple demonstrations as required within six months.
- J. Indicate type and cause of failures, as well as required remedial actions, on test report. Start-up and testing will be witnessed and verified by A/E, Owner, and/or commissioning agent. Requested tests, not outlined herein, will be evaluated for feasibility and impact on schedule and cost.
- K. Systems will not be accepted by Owner and A/E without approval of tests and required remedial action.
- L. Provide signed verification reports to the Owner for each system tested.
- M. Provide system demonstration and instructions.

#### 1.10 TREND LOGS

- A. The Contractor shall configure and analyze all trends required under all specification sections. The BAS Contractor shall demonstrate functional trends two weeks prior to Functional Performance Testing.
- B. Record and print graphical trends for each control loop to verify loop stability is within specified performance limits. Each trend shall be for a duration of no less than 12 hours.



1. PARAMETER MAXIMUM ACCEPTABLE DEVIATION FROM SETPOINT

- |                            |                             |
|----------------------------|-----------------------------|
| a) Duct Static Pressure    | Plus or minus 0.05 In. W.C. |
| b) Space Temperature       | Plus or minus 2 degrees F   |
| c) Air Flow                | Plus or minus 5%            |
| d) Duct Relative Humidity  | Plus or minus 5%            |
| e) Space Relative Humidity | Plus or minus 5%            |

1.11 WARRANTY PERIOD:

- A. Warranty Period shall not commence until successful completion of the Demonstration.
- B. Trending: Throughout the Warranty Period, trend logs shall be maintained. Contractor shall forward archive trend logs to the Commissioning Authority/Owner for review upon Commissioning Authority/ Owner request. Commissioning Authority/ Owner will review these and notify contractor of any warranty work required.
- C. Opposite Season Testing: Within 6 months of completion of the Acceptance Phase, Commissioning Authority/ Owner shall schedule and conduct Opposite Season functional performance testing. Contractor shall participate in this testing and remedy any deficiencies identified
- D. End of Warranty Visit: Commissioning Authority/ Owner will conduct an End of Warranty walkthrough prior to the end of the Warranty Period. Contractor shall participate in this walkthrough and remedy any deficiencies identified.

1.12 SOFTWARE OPTIMIZATION ASSISTANCE

- A. The Contractor shall provide the services of a Technician as specified above at the project site to be at the disposal of the Commissioning Authority/Owner. The purpose of this requirement is to make changes, enhancements and additions to control unit and/or workstation software that have been identified by the Commissioning Authority/Owner during the construction and commissioning of the project and that are beyond the specified Contract requirements. The cost for this service shall be included with the bid. Requests for assistance shall be for contiguous or non-contiguous 4-hour sessions, unless otherwise mutually agreed upon by Contractor, Commissioning Authority, and Owner. The Owner's representative shall notify contractor 2 days in advance of each day of requested assistance.
- B. The Technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the Technician provided cannot perform every software task requested by the Commissioning Authority/Owner in a timely fashion, contractor shall provide additional qualified personnel at the project site as requested by the Commissioning Authority/Owner, to meet the total specified requirement [per building] on-site.

1.13 OPERATOR TRAINING

- A. Documented Owner's training shall be a requirement for final completion.
- B. On-Site Training: Provide services of BAS Contractor's qualified technical personnel for two 4-hour days to instruct Owner's personnel in operation and maintenance of



BAS. Provide services of Contractor's qualified technical

personnel for one 8-hour day to instruct the Owner's personnel in the operation and maintenance of Integrated Installer Control Sub-Systems, i.e. Chiller, Boiler, etc. Instruction shall be in a classroom setting at the project site for appropriate portions of the training. Training may be in non-contiguous days at the request of the Owner. The Owner's representative shall notify the contractor 1 week in advance of each day of requested training. The Contractor's designated training personnel shall meet with the Owner's representative for the purpose of discussing and fine-tuning the training agenda prior to the first training session. Training agenda shall generally be as follows:

1. Basic Operator Workstation (OWS) or Control Panel Interface Training – For all potential users of the OWS or Display:
  - a) Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of portable controller and built-in operator interface device display capabilities
  - b) Brief overview of the various parts of the O&M Manuals, including hardware and software programming and operating publications, catalog data, controls installation drawings, and DDC programming documentation
  - c) Demonstration of login/logout procedures, password setup, and exception reporting
  - d) Demonstration of menu penetration and broad overview of the various features
  - e) Overview of systems installed.
  - f) Present all site-specific point naming conventions and points lists, open protocol information, configuration databases, back-up sequences, upload/download procedures, and other information as necessary to maintain the integrity of the system.
  - g) Overview of alarm features.
  - h) Overview of trend features.
  - i) Overview of reports and reporting
2. Hardware Training – For Maintenance and Control Technicians
  - a) Review of installed components and how to install/replace, maintain, commission, and diagnose them
3. Technician Training
  - a) Introduction to controller programming and overview of the programming application interface
  - b) General review of sequence of operation and control logic for the project site, including standalone and fail-safe modes of operation
  - c) Uploading/Downloading and backing up programs.
  - d) Network administration
  - e) Review of setpoint optimization and fine-tuning concepts

End of Section



## SECTION 25 11 13 INTEGRATED AUTOMATION NETWORK SERVERS

### GENERAL

#### 1.02 SECTION INCLUDES:

- Operator Workstations (OWS)
- Control System Servers (CSS)
- Portable Operator Terminal (POT)

#### 1.03 DESCRIPTION OF WORK:

Furnish and install software for Operator Interfaces and Control System Servers as required for the BAS functions specified. The manufacturer shall support all installed software for a period of two years after Substantial Completion at no additional cost to the Owner.

### PRODUCTS

#### 2.01 CONTROL SYSTEM SERVER (CSS)

The CSS is a virtual machine provided by American University. Coordinate all software requirements with the AU BAS/OIT Department to ensure compatibility with the virtual machine operating system and resources.

### PART 3 EXECUTION

#### 3.01 INSTALLATION

Install all software on the provided computers and verify that the systems are fully operational. Ensure licensing is provided for all software.

No components required for the legal use of the computer shall be withheld from the Owner.

All information required to install, configure, operate, diagnose, and maintain the system shall not be withheld from the Owner.

Install systems and materials in accordance with manufacturer's instructions.

END OF SECTION



## SECTION 25 11 16 NETWORK ROUTERS, BRIDGES, SWITCHES AND HUBS

### GENERAL

#### 1.01 SECTION INCLUDES:

- A. Network Connections
- B. Local Supervisory LAN Gateways/Routers
- C. Communication Wiring, Raceways, Cabling
- D. Integrated Installer Provided Control Sub-Systems

#### 1.02 DESCRIPTION OF WORK:

- A. BAS Contractor shall provide all interface devices and software to provide an integrated system connecting BCs, AACs, ASCs and Gateways to the Owner's LAN.

### PRODUCTS

#### 2.01 NETWORK CONNECTIONS

- A. Owner's WAN: American University will provide an internetwork connecting the BAS across multiple structures with a CSS. The BAS Contractor is not required to configure any components of this WAN. The final BAS internetwork shall use this WAN as the Primary LAN.
- B. All new sub networks must be BACnet/IP or BACnet/MSTP. No new work may implement an FLN network.
- C. All projects that require BBMD management must use a dedicated hardware BBMD management device. No software BBMD management within a controller will be allowed.
- D. BAS connections to third-party BACnet objects must implement a virtual point bound to the object and not hard coded in the BAS software. Third-party BACnet object connections must be configured to allow for the fastest refresh rate available from the third-party vendor not to exceed 3 seconds at the BAS interface. Third-party BACnet object connections must maintain a continuous reliable connection to the BAS. The BAS contractor is responsible for adding hardware/software as necessary to accomplish this connectivity requirement.

If the BAS contractor determines they are not able to communicate with the vendors BACnet object to meet performance requirements defined in Division 25 an alternative communications method may be requested. The BAS contractor must request an alternative communication method via RFI to the Design Team and AU BAS Department.

#### 2.02 LOCAL SUPERVISORY LAN GATEWAYS/ROUTERS

- A. The Supervisory Gateway shall be a BC that acts as a gateway/router



- between the Supervisory LAN CSSs and the Primary LAN.
- B. The gateway shall perform information translation between the Primary LAN and the Local Supervisory LAN, which is Ethernet TCP/IP and shall preferably use BACnet over IP.
  - C. The gateway shall contain its own microprocessor, RAM, battery, real-time clock, communication ports, and power supply as specified for a BC in Section 25 55 00. Each gateway/router shall be mounted in a lockable enclosure.
  - D. The gateway/router shall allow centralized overall system supervision, operator interface, management report generation, alarm annunciation, acquisition of trend data, and communication with control units. It shall allow system operators to perform the following functions from the CSS, OWSs, and POTs:
    - 1. Configure systems.
    - 2. Monitor and supervise control of all points.
    - 3. Change control setpoints.
    - 4. Override input values.
    - 5. Override output values
    - 6. Enter programmed start/stop time schedules.
    - 7. View and acknowledge alarms and messages.
    - 8. Receive, store and display trend logs and management reports.
    - 9. Upload/Download programs, databases, etc. as specified.
  - E. Upon loss of power to the Gateway, the battery shall provide for minimum 100-hour backup of all programs and data in RAM. The battery shall be sealed and self-charging.
  - F. The Gateway shall be transparent to control functions and shall not be required to control information routing on the Primary LAN.

## 2.03 COMMUNICATION WIRING, CABLING AND RACEWAYS

- A. Wiring and Raceways
  - 1. General: Provide copper conductors, plenum cable, and raceways as specified in the applicable sections of Division 26, and 25 5500. Where the documents conflict request clarification from the Owner.
  - 2. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.
- B. Fiber Optic Cable
  - 1. Optical cable: Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.
  - 2. Connectors: Terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.



## 2.04 INTEGRATED INSTALLER PROVIDED CONTROL SUB-SYSTEMS

- A. The Gateway defined in Article 2.03 shall perform information translation between the Primary LAN or the Local Supervisory LAN, which is 100 Mbps Ethernet TCP/IP, and the Installer Provided Control Sub-System.
- B. The Gateway and the Installer Provided Control Sub-System shall use the agreed upon communication protocol required to connect the control sub-system to the BAS. This protocol shall be agreed upon and as defined in Section 25 5500.
- C. The Gateway and the Installer Provided Control Sub-System shall support full bi-directional communication translation as defined by the applicable protocol implementation specification as defined in Section 25 5500.
- D. The Installer Provided Control Sub-System shall provide all objects, points, variables and any other configuration parameters defined by its protocol implementation conformance specification without any added network protocol translation devices other than the BAS BC and its own control sub-system components. The following points shall be provided at a minimum:  
Edit the following list(s) as necessary to meet the project needs of the University based on equipment size and application.
  1. The following Chilled Water System points shall be mapped as a minimum:
    - a) CHW Supply and Return Temperatures
    - b) CW Supply and Return Temperatures
    - c) Power Consumption (kW)
    - d) Percent of Power Consumption (compared to maximum)
    - e) Bearing Temperature
    - f) Suction and Head Pressures
    - g) Suction and Head Temperatures
    - h) All available alarms; common alarm as minimum
    - i) Chiller Status
    - j) Enable/Disable
    - k) Current Limit Percent
    - l) CHW Setpoint and Setpoint Reset
  2. The following Hot Water System points shall be mapped as a minimum:
    - a) Boiler Supply Temperatures
    - b) Boiler Pressure
    - c) Call for Heat
    - d) Boiler Ignition On
    - e) All available alarms; common alarm as minimum
    - f) Boiler Status
    - g) Firing Rate
    - h) Enable/Disable



- i) HW Setpoint and Setpoint Reset
3. The following Variable Frequency Drive points shall be mapped at a minimum:
  - a) Output Frequency
  - b) Motor Speed (RPM, %, or Engineering units)
  - c) Motor Current
  - d) Calculated Motor Torque
  - e) Calculated Motor Power (kW)
  - f) DC Bus Voltage
  - g) Output Voltage
  - h) kWh meter (resettable)
  - i) mWh meter
4. The following Computer Room Air Conditioner points shall be mapped as a minimum:
  - a) Space Temperature and Humidity
  - b) Change Filter
  - c) Humidifier Status
  - d) Unit Off Local / Off Remote
  - e) All available alarms; common alarm as minimum
  - f) Unit Status
  - g) Enable/Disable
  - h) Space Temperature and Humidity Setpoints.
5. All Lucid Meter Management points shall be mapped:
  - a) This requirement applies to projects with Nexus, Flexim, or Shark utilities meters monitored by Lucid Meter Management software.
  - b) Provide an interface to the management software and/or meter to collect utility for use by the BAS.
  - c) BAS connection to the utility meter must not interfere with the meter's operation or calibration.
  - d) BAS connection to the management software must not interfere with the software meter connection or data collection process.
  - e) Coordinate utility meter data management with AU before implementation.

## EXECUTION

### 3.01 INSTALLATION OF CONTROL SYSTEMS:

- A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.
- B. BAS Contractor shall provide leadership as the Integration Coordinator for all Installer Provided Control Sub-Systems. Contractor to coordinate work



progress, see Section 25 55 00 for details.

- C. BAS Contractor shall coordinate and supervise all interface devices and software to provide an integrated system.
- D. BAS Contractor shall confirm all third party vendor connections meet Division 25 performance requirements. Provide a report to the Design Team and AU BAS Department for any connections that fail to pass performance requirements. This includes all BACnet/IP, BACnet/Ethernet, BACnet/MSTP, MODBUS and similar approved connections.
- E. BAS Contractor shall closely coordinate with the A/E to locate all required Ethernet ports and request IP address assignments from the Owner's IT department. The BAS Project Manager shall provide the required activation date for Ethernet ports and addresses at least 30 days in advance.
- F. The BAS network shall be connected to the permanent BAS Server prior to the start of TAB to ensure all TAB data is retained on the permanent server and available for review by the CxA and A/E prior to final completion and turnover.
- G. Temporary BAS Internetwork: Should the final network connection not be available during the commissioning phase of the project; the BAS Contractor shall install a temporary internetwork for the BAS until such time that the WAN is available. This network can be of any type and configuration as it is temporary in nature. The only restriction is to provide some level of access control to the network.

END OF SECTION



## SECTION 25 14 13 REMOTE CONTROL PANELS

### GENERAL

#### 1.01 SECTION INCLUDES:

- A. Building Controller (BC)
- B. Advance Application Specific Controller (AAC)
- C. Application Specific Controller (ASC)

#### 1.02 DESCRIPTION OF WORK:

- A. Furnish and Install DDC Control units and/or Smart Devices required supporting specified building automation system functions.

### PRODUCTS

#### 2.01 GENERAL REQUIREMENTS

- A. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified in Sections 25 55 00. Every device that integrates with the BAS must conform to a standard BACnet Device profile as specified in ASHRAE 135. BACnet Secure Connect (BACnet/SC) must be applied for all BACnet/SC capable controllers.
- B. All controller hardware shall be suitable for anticipated ambient conditions. Controllers used outdoors or in wet ambient conditions shall be mounted in NEMA rated waterproof enclosures and shall be rated for operation at -20°F to 140°F. Controllers used in conditioned spaces shall be mounted in dust-protective enclosures and shall be rated for operation at 32°F to 120°F.
- C. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

#### 2.02 STAND-ALONE FUNCTIONALITY

- A. General: These requirements clarify the requirement for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone functionality is specified with the controller and for each Application Category specified in Part 3. The BAS Contractor shall comply with Section 25 55 00 to select the appropriate controllers.
- B. Functional Boundary: Provide controllers so that all points associated with and common to one unit or complete system/equipment shall reside within a single control unit. The boundaries of a standalone system shall be as dictated in the contract documents. Generally, systems specified for the Application Category will dictate the boundary of the standalone control functionality.
- C. The following configurations are considered unacceptable with reference to a controller's standalone functionality:



1. Multiple controllers enclosed in the same control panel to accomplish the point requirement.
- D. In normal operation, components comprising the BAS system shall communicate over its own independent Ethernet LAN. However, control panels and controllers shall function independently in stand-alone mode, in the event of any network or server failure.
- E. BAS Local Area Network Level (LAN): The communication extension shall support a series of controllers and shall communicate bi-directionally with the peer-to-peer network for transmission of global data.

## 2.03 BUILDING CONTROLLER (BC)

- A. General Requirements:
  1. The BC(s) shall provide fully distributed control independent of the operational status of the CSS. All necessary calculations required to achieve control shall be executed within the BC independent of any other device. All control strategies performed by the BC(s) shall be both operator definable and modifiable through the Operator Interfaces.
  2. BCs shall perform overall system coordination, accept control programs, perform automated system functions, control peripheral devices and perform all necessary mathematical and logical functions. BCs shall share information with the entire network of BCs and AACs/ASCs for full global control. BC shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.
  3. BCs shall be connected to a network that qualifies as a Primary Controller LAN.
  4. A communication port for operator interface through a terminal shall be provided in each BC. It shall be possible to perform all program and database back up, system monitoring, control functions, and BC diagnostics through this port.
  5. BC Power Loss:
    - a) Upon a loss of power to any BC, the other units on the primary controlling network shall not in any way be affected.
  6. BCs may include LAN communications interface functions for controlling secondary controlling LANs.
  7. BCs shall be mounted in packaged equipment enclosures or in locking wall-mounted enclosures.
  8. BC must be capable of performing primary integration to third party BACnet devices and in this case comply as a BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE Standard 135. Where possible, BACnet Secure Connect (BACnet/SC) should be applied for secure BAS communications.



9. Trend data shall be stored at the BC and uploaded to the supervisory station when retrieval is desired and scheduled. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in 3rd party personal computer software.

## 2.04 ADVANCED APPLICATION SPECIFIC CONTROLLER (AAC) AND APPLICATION SPECIFIC CONTROLLER (ASC)

### A. General Requirements:

1. AACs and ASCs shall provide intelligent, standalone control of systems and equipment. It shall be able to share information with every other BC and AAC /ASC on the entire network.
2. All point data, algorithms and application software within an AAC /ASC shall be modifiable from the Operator Workstation. Non-customizable algorithms are not acceptable.

### B. Air Terminal Unit Controllers:

1. Terminal box controllers used in HVAC applications controlling damper positions to maintain a quantity of supply or exhaust air serving a space shall have an automatically initiated function that resets the volume regulator damper to the fully closed position on a scheduled basis. The controllers shall initially be set up to perform this function once every 24 hours. The purpose of this required function is to reset and synchronize the actual damper position with the calculated damper position and to assure the damper will completely close when commanded. The software shall select scheduled boxes randomly and shall not allow more than 5% of the total quantity of controllers in a building to perform this function at the same time. When possible, the controllers shall perform this function when the supply or exhaust air system is not operating or is unoccupied.

## EXECUTION

### 3.01 INSPECTION:

- A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to the BAS Contractor.

### 3.02 INSTALLATION OF CONTROL SYSTEMS:

- A. General: Install systems and materials in accordance with manufacturer's instructions, specifications roughing-in drawings and details shown on drawings. BAS Contractor shall install all controllers in accordance with the manufacturer's installation procedures and practices.
- B. Mount BC and CUs adjacent to associated equipment on vibration free walls or freestanding angle iron supports. Do not mount on AHU housing. Provide nameplates for instruments and controls inside and identify associated system on face of cabinet. Provide mechanically fastened cabinet



nameplates, using nomenclature matching that used for devices in the approved Div. 25 submittal.

### 3.03 HARDWARE APPLICATION REQUIREMENTS

- A. General: The functional intent of this specification is to allow cost effective application of the control system while maintaining the integrity and reliability of the control functions. The specific requirements indicated below are required for the respective application.
- B. Standalone Capability: Each Control Unit (CU) shall be capable of performing the required sequence of operation for the associated equipment. All physical point data and calculated values required to accomplish the sequence of operation shall originate within the associated CU.
- C. Mounting:
  - a) Refer to Section 25 55 00 for details of mounting enclosures.
  - b) CUs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure (36" clearance required) and shall be rated for plenum use.
  - c) CUs that control equipment mounted in a mechanical room may either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
  - d) CUs that control equipment mounted outside the building envelope or in occupied spaces shall either be located inside the unit or in a proximate mechanical space.
- D. Programmability: Operator shall be able to modify all setpoints (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, inter-stage timing parameters, and mode settings. Application-specific block control algorithms may be used application specific controllers (ASC) to meet the sequence of operations. The control algorithm must be customizable for advanced application controllers (AAC) and building controllers (BC).
- E. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.
  - 1. Application Category 0 (Distributed monitoring):
    - a) Applications in this category include the following:
    - b) Monitoring of variables that are not used in a control loop, sequence logic, or safety
      - i. Points on BCs, AACs, and ASCs may be used in these applications as well as SDs and/or general-purpose I/O modules.
      - ii. Where these points are trended, BAS Contractor shall verify and document that the network bandwidth is acceptable for such trends and is still capable of acceptable and timely control function.
  - 2. Application Category 1 (Application Specific Controller):



- a) Applications in this category typically include the following terminal equipment controllers:
    - i. Fan Coil Units
    - ii. Airflow Control Boxes (VAV and Constant Volume Terminal Units)
    - iii. Misc. Heating Units
    - iv. Single Zone; Unitary equipment less than 15- ton Package Terminal AC Units, Package Terminal Heat Pumps, Split-System AC Units, Split-System Heat Pumps, Water-Source Heat Pumps
    - v. Variable Speed Drive (VSD) controllers not requiring safety shutdowns of the controlled device.
  - b) Network Restrictions: Limit the number of nodes on the network to 80% of the maximum recommended by the manufacturer.
3. Application Category 2 (General Purpose Terminal Controller)
- a) Applications in this category include the following:
    - i. Unitary Equipment greater than or equal to 15- ton Air Conditioners, Heat Pumps, Packaged Heating/Cooling Units etc.
    - ii. Small, Constant Volume Single Zone Air Handling Units
    - iii. Constant Volume Pump Start/Stop
    - iv. Misc. Equipment Start/Stop
    - v. Misc. Monitoring not directly associated with a control sequence and where trending is not critical
  - b) All outputs must have manual override capability.
  - c) BCs may be used in these applications.
  - d) ASC's may be used in these applications provided the ASC meets all requirements specified below. This category requires a general-purpose ASC to which application-specific control algorithms can be attached.
  - e) Standalone Capability: Only the following data (as applicable) may be acquired from other CUs via LANs. In the event of a loss of communications with any other CUs, or any fault in any system hardware that interrupts the acquisition of any of these values, the CU shall use the last value obtained before the fault occurred. All points configured for trending shall continue to store data at the local module.
  - f) Network Restrictions: Limit the number of nodes servicing any one of these applications on the AAC/ASC LAN to 80% of the manufacturer's recommended maximum.
4. Application Category 3 (Advanced Application Controller)
- a) Applications in this category include the following:
    - i. Unitary Equipment greater than or equal to 15- ton Air Conditioners, Heat Pumps, Packaged Heating/Cooling Units etc.
    - ii. Large Constant Volume Air Handlers
    - iii. VAV Air Handlers {generally >5,000 and <10,000cfm}



- iv. Dual Duct Air Handlers {generally >5000 and <10,000 cfm}
  - v. Multi-Zone Air Handlers
  - vi. Self-Contained VAV Units
  - b) All outputs must have manual override capability.
  - c) BCs may be used in these applications.
  - d) AAC's may be used in these applications provided the AAC's meets all requirements specified below:
    - i. All control functions and physical I/O associated with a given unit reside in one AAC.
  - e) Standalone Capability: Only the following data (as applicable) may be acquired from other CUs via LANs. In the event of a loss of communications with any other CUs, or any fault in any system hardware that interrupts the acquisition of any of these values, the CU shall use the last value obtained before the fault occurred. All points configured for trending shall continue to store data at the local module.
  - f) Network Restrictions: Each LAN which participates in the transfer of data between the CU and the local operator workstation shall be subject to the following criteria:
    - i. The building controller LAN shall be subject only to the manufacturer's published LAN limitations.
5. Application Category 4
- a) Applications in this category include the following:
    - i. Central Cooling Plant
    - ii. Central Heating Plant
    - iii. Cooling Towers
    - iv. Sequenced or Variable Speed Pump Control
    - v. Local Chiller Control (unit specific)
    - vi. Local Free Cooling Heat Exchanger Control
    - vii. Air Handlers over 10,000 cfm or serving critical areas
    - viii. Variable Speed Drive (VSD) controllers for air handlers, exhaust systems and variable volume pumping
  - b) All outputs must have manual override capability.
  - c) BCs shall be used in these applications.

### 3.04 CONTROL UNIT REQUIREMENTS

- A. Refer to Section 25 55 00 for requirements pertaining to control unit quantity and location.

### 3.05 CONTROL MODULE INSTALLATION

- A. Building Controller (BC):
  - 1. The BAS Contractor shall follow the specifications shown in the manufacturer's hardware installation guide unless stated otherwise.



2. Refer to Section 25 5500 for power supply requirements. Power shall enter the control panel at an internal junction box that includes a standard receptacle and switch for panel power.
- B. Field Bus Controllers (AAC/ASC):
1. The BAS Contractor shall follow the specifications shown in the manufacturer's hardware installation guide unless stated otherwise herein.
  2. Controller Power shall have a separate disconnect (or fuse) for each controller.
- C. Expansion Modules:
1. The BAS Contractor shall follow the specifications shown in the manufacturer's hardware installation guide unless stated otherwise herein.

END OF SECTION



## SECTION 25 15 16 SOFTWARE FOR CONTROL AND MONITORING NETWORKS

### GENERAL

#### 1.01 SECTION INCLUDES:

- A. System Software
- B. Programming Description
- C. Control Algorithms
- D. Energy Management Applications
- E. Password Protection
- F. Alarm Reporting
- G. Trending
- H. Data Acquisition and Storage
- I. Dynamic Color Graphics

#### 1.02 LICENSING

- A. All software used for the operator interface, programming environment, networking, database management and any other software used by the BAS Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided.
- B. Include all required third-party software licenses.
- C. Provide copies/backup of licensing and original software.

### PRODUCTS

#### 2.01 GENERAL SOFTWARE REQUIREMENTS

- A. **Functionality and Completeness:** The BAS Contractor shall furnish and install all software and programming necessary to provide a complete and functioning system as specified. The BAS Contractor shall include all software and programming not specifically itemized in these Specifications, which is necessary to implement, maintain, operate, and diagnose the system in compliance with these Specifications.
- B. **Software Rights:** No aspect of the control programming that executes the sequence of operations shall be considered proprietary. The University and its representatives shall have full and unlimited access to all programming manuals, site specific programming at all levels, updates to all manuals, etc. Advanced programming training is specified. Properly trained individuals will be given applicable password access to view and modify control programming without consent or notification of the contractor. Any system in which control sequence programming is considered proprietary in any way will not be considered.
- C. All application software shall be user programmable based upon user access control privileges.



- D. Custom Software: Contractor shall be required to retain backup copies of custom software drivers and documentation of same for no less than ten years with free access to AU for the same period. If the backup is not available within the specified time frame, Contractor shall recreate the custom software at no charge to AU.

## 2.02 ALARM AND EVENT MANAGEMENT REPORTING

- A. The BAS Contractor will implement Alarming for all alarm configurable points.
- B. Alarm management shall be provided to monitor and direct alarms to operator devices. All alarms and events shall be routable to all Operator Workstations.
  - 1. Alarm Descriptor: Each alarm or point change shall include that point's English language description, the time and date of occurrence. The user shall be able to display and archive all alarm information for future reference.
  - 2. Alarm Prioritization: The software shall allow users to define the handling and routing of each alarm by their assignment to discrete priority levels. Users shall have the ability to manually inhibit alarm reporting for each individual alarm and for each priority level. Contractor shall coordinate with the Owner to establish alarm priority definitions.
    - a) Life Safety – any life safety event (i.e. smoke detector)
    - b) Emergency – major system failure or damage possible (i.e. controller failure)
    - c) High – environmental sensors (i.e. out-of-range temperature)
    - d) Medium - energy waste (i.e. fighting valves)
    - e) Low- maintenance message (i.e. runtime monitor, filter status)
    - f) Supervisory - control events (i.e. Totalization Resets, Scheduled Events Occurrence, etc.)
  - 3. Alarm Report Routing: All alarms associated with a given priority level shall be routed to all operator devices associated with that priority level. A default operator device shall be configured to receive all alarms regardless of priority level.
  - 4. Alarm Acknowledgment: For alarm priority levels that are directed to a workstation screen, an indication of alarm receipt shall be displayed immediately, and shall remain on the screen until acknowledged by a user having a password that allows alarm acknowledgment. Upon acknowledgment, the complete alarm message string (including date, time, and username of acknowledging operator) shall be archived.
- C. It shall be possible for any operator to receive a summary of all alarms, regardless of acknowledgement status.



## 2.03 TRENDING

- A. The software shall be able to display historical data in both a tabular and graphical format. The requirements of this trending shall include the following:
  - 1. Install historical trends for all physical (AI, AO) analog points, all physical digital points (DI, DO) and all virtual points used in any loop control algorithm. Unless directed otherwise from the Owner use a ten-minute interval for analog values and change of value for digital values.
  - 2. The trended value range shall be selectable by the operator.
  - 3. The data points must be exportable from any operator interface in comma-separated values (CSV) or MS Excel format.

## 2.04 TOTALIZATION

- A. The software shall support totalizing analog, digital, and pulsed inputs and be capable of accumulating, storing, and converting these totals to engineering units used in the documents. These values shall generally be accessible to the Operator to support management-reporting functions.
- B. Totalization of electricity use/demand (hourly, daily & monthly) shall allow application of totals to different utility tariff rate periods, which shall be user definable.
- C. When specified to provide electrical or utility Use/Demand, the BAS Contractor shall obtain from the local utility all information required to obtain meter data, including k factors, conversion constants, and the like.
- D. Provide detailed energy consumption reports for all facility utilities stored as their final calculated value on a daily, monthly, and yearly basis. The archive of this data shall be for no less than one year.

## 2.05 SCHEDULING

- A. All schedules must use BACnet objects with read/write capability enabled. The schedule must allow monitoring and manipulation of the schedule through external BACnet software. No hard coded or proprietary schedule routines are allowed.
- B. Provide a graphic utility for user-friendly operator interface to adjust equipment-operating schedules.
- C. Scheduling feature shall include multiple day occupancy schedules, holiday schedules and override schedules, each with start time and stop time. Schedules shall be individually editable for each day and holiday.
- D. Scheduling feature shall allow for schedules to be applied to individual equipment units, floorplans, buildings and/or the campus.
- E. Schedules shall be hierarchical allowing all devices/systems below a given device/system to follow the same schedule.
- F. Timed override feature shall allow an operator to temporarily change the state of scheduled equipment. An override command shall be selectable to apply to an individual unit, all units assigned to a given master schedule, or



to all units in a building. Timed override shall terminate at the end of an operator selectable time, or at the end of the scheduled occupied/unoccupied period, whichever comes first.

- G. A yearly calendar feature shall allow assignment of holidays, and automatic reset of system real time clocks for transitions between daylight savings time and standard time.

## 2.06 OVERRIDES

- A. BAS shall provide an audit log report of all overrides currently active and historical overrides along with the user who initiated the override.
- B. Timed override feature shall allow an operator to temporarily change the state of scheduled equipment. An override command shall be selectable to apply to an individual unit, all units assigned to a given schedule, or to all units in a building. Timed override shall terminate at the end of an operator selectable time, or at the end of the scheduled occupied/unoccupied period, whichever comes first.

## 2.10 OBJECT STRUCTURING AND NAMING

- A. Object Definition: An object is any component in the BAS that requires naming using printable Standard English language characters in a format easily understood by the end user of the software. Examples of objects are:
  - 1. BAS Architecture Devices
  - 2. Zone and Event Definitions
  - 3. Schedule Definitions
  - 4. Report Definitions
  - 5. Dynamic Graphics and Graphic Background Drawings
  - 6. Programs
  - 7. Points
- B. Refer to the Object Naming Guide in Section 25 55 00.13.
- C. All object names shall adhere to the format as established in the Object Naming Guide. Objects shall include all physical I/O points, calculated points used for standard reports, and all application program parameters. For each BAS object, a specific and unique object name shall be required.
- D. General: Name objects consistently across all facilities. The BAS Contractor shall configure the systems from the perspective of the entire WAN and attached BAS networks, not solely the local project. The Object Naming Guide shall be implemented as much as practical, and any deviations from the guide shall be pre-approved by the Owner or Owner's representative. The BAS Contractor must obtain the latest Object Naming Guide documents prior to developing their object database.
  - 1. All tables defined below shall be provided in both hard copy and in electronic format (MS Excel and PDF).
  - 2. The BAS Contractor shall coordinate with Owner and compile and submit all proposed tables for review prior to any object programming



- or project startup.
  - 3. Project closeout documents shall include up-to-date and accurate completed versions of all tables. The BAS Contractor shall deliver to the Owner the final table versions prior to Substantial Completion of the system.
  - 4. See Section 25 55 00 for the general requirements for point control performance parameters.
- E. Point Name Summary Table
- 1. The term 'Point' is a generic description for the class of object represented by analog and binary inputs, outputs, and values.
  - 2. With each schematic, the BAS Contractor shall provide a Point Name Summary Table listing:
    - a) Building number and/or abbreviation
    - b) System Name
    - c) Device Name
    - d) Full point name (see Object Naming Guide)
    - e) Point description
    - f) Ethernet backbone network number,
    - g) Integration Network number
    - h) Integration Device ID
    - i) Integration Device MAC address
    - j) Integration Object ID (object type, instance number)
    - k) State Text
    - l) Change of Value Assigned
    - m) Engineering Units
  - 3. The Point Name Summary Table shall illustrate Network Variables and Data Link Bindings when necessary.
- F. BAS Architecture Device Name Summary Table
- 1. The term "Device" refers to an individual programmatic representation of a BAS controller in the facility.
  - 2. With each schematic the BAS Contractor shall provide a BAS Architecture Device Name Summary Table listing the names of all controllers that will be incorporated into the project.
  - 3. The table shall include the proposed location in the facility of the device.
  - 4. The table shall contain empty columns labeled as the following:
    - a) Host Name
    - b) DHCP Server Address
    - c) Default Gateway
    - d) Subnet Mask
    - e) IP Address



- G. Device Addressing Convention:
  - 1. All assignments of network numbers, TCP/IP addresses and Device Object IDs shall be coordinated with the Owner's network manager.
  - 2. The BAS Contractor shall coordinate with the Owner to ensure that no duplicate Device Object IDs or names occur.
  - 3. Alternative Device ID schemes shall be approved before project commencement by the Owner.
  - 4. Device object ID must be unique per the naming convention requirements within the BACnet internetwork.

## 2.11 OPERATOR INTERFACE GRAPHIC SOFTWARE

- A. Graphic software shall facilitate user-friendly interface to all aspects of the System Software specified above. Provide a graphic package that provides for intuitive operation of the systems without extensive training and experience. It shall facilitate logical and simple system interrogation, modification, configuration, and diagnosis. Context sensitive help shall be provided within the user interface via a 'help' function.
- B. The software shall allow for the user's creation of user-defined, color graphic displays of geographic maps, building plans, floor plans, and mechanical and electrical system schematics. These graphics shall be capable of displaying all point information from the database including any attributes associated with each point (i.e., engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic.
- C. Dynamic Data Displays: Dynamic physical point values shall automatically update without operator intervention. Point value fields shall be displayed with a color code depicting normal, abnormal, override and alarm conditions.
- D. Point Override Feature: Each displayed point shall be capable of individual enable/disable to allow override of digital points or changing of analog point values. The graphic point override feature shall be subject to password level protection. Points that are overridden shall be reported as an alarm, and shall be displayed in a coded color. The alarm message shall include the operator's username. A list of points that are currently in an override state shall be available through menu selection.
- E. Zone/Equipment Color: Floor plan graphics shall be color coded by the equipment served as follows; green = zone temperature within setpoint, blue/dark blue = zone temperature below setpoint, yellow/orange = zone temperature above setpoint, red = zone temperature/equipment in alarm range, white = equipment on normal, grey = equipment off normal.
- F. Graphics Development Package: Graphic development and generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
  - 1. The BAS Contractor shall use the BAS vendor's Standard Graphical packages when creating graphic backgrounds.
  - 2. All Graphics created shall use a common background template with



which to base all custom graphical representations. The template shall contain the following attributes;

- a) Status Bar: A single bar across the bottom of every graphic containing hierarchical graphic links to other system graphics, general OA conditions and the current BAS system time.
  - b) Title Bar: A single bar across the top of every graphic containing the System Name the graphic represents. Additionally, where required the title bar shall contain the areas served by the System represented.
  - c) Mode Bar: A single bar just below the Title bar of equal dimensions to the Title bar. This bar is optional but must be included on all system graphics where the system contains programmatic modes of operation or distress modes. The Mode bar shall display the current operating mode and any other relevant information to mode operation.
3. The BAS Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), mechanical system components (e.g., pumps, chillers, cooling towers, boilers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
  4. The Graphic Development Package shall use touchscreen input, mouse, or similar pointing device to allow the user to perform the following:
    - a) Define symbols
    - b) Position items on graphic screens
    - c) Attach physical or virtual points to a graphic
    - d) Define background screens
    - e) Define connecting lines and curves
    - f) Locate, orient and size descriptive text
    - g) Define and display colors for all elements
    - h) Establish correlation between symbols or text and associated system points or other displays.
    - i) Create hot spots or link triggers to other graphic displays or other functions in the software.

## EXECUTION

### 3.01 SYSTEM CONFIGURATION

- A. BAS Contractor shall thoroughly and completely configure BAS system software, supplemental software, network communications, CSS, OWS, portable operator's terminal, and remote communications.



### 3.02 SITE-SPECIFIC APPLICATION PROGRAMMING

- A. Provide all database creation and site-specific application control programming as required by the Specifications, national and local standards and for a fully functioning system. The BAS Contractor shall provide all initial site-specific application programming and thoroughly document programming. It is the BAS Contractor's responsibility to request clarification on sequence issues that are unclear or subject to interpretation.
- B. All site-specific programming shall be fully documented and submitted for review and approval, prior to downloading into the panel, at the completion of functional performance testing, and at the end of the warranty period.
- C. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the project will be the property of AU and shall remain on the workstation(s)/server(s) at the completion of the project.

### 3.03 PASSWORD SETUP

- A. The BAS Contractor shall assist operators with assigning usernames, passwords, and password levels.

### 3.04 POINT PARAMETERS

- A. Provide the following minimum programming for each I/O point as applicable:
  - 1. Name
  - 2. Address
  - 3. Engineering units
  - 4. State Text, custom State Text where required.
  - 5. Offset calibration and scaling factor for engineering units
  - 6. Output Range
  - 7. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary and/or secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides, or failure of any network over which the point value is transferred.

### 3.05 TREND DATA MANAGEMENT

- A. The BAS Contractor shall create, establish, and store trend logs for all trend capable hardware points, virtual points and calculated setpoints.
- B. The Owner or his representative will analyze trend logs of the system operating parameters to evaluate normal system functionality. The BAS Contractor shall establish these trends and ensure they are being stored properly on the CSS.
  - 1. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field or



single date stamp. Recorded parameters for a given piece of equipment or component shall be trended at the same intervals and be presented in a maximum of two separate 2-dimensional formats with time being the row heading and field name being the column heading.

- C. The BAS Contractor shall create standard graphical trends representing the setpoint and measured value for each system.
- D. The CSS shall be configured and/or upgraded as necessary to provide historical trend archiving for up to one year for all trend capable points on this project. Historical trend data older than one year shall be automatically purged to maintain database integrity and size.

### 3.06 ALARMS

- A. General: The BAS Contractor will be responsible for setting initial enhanced alarm parameters. No reporting actions will be initiated during construction unless directed by the Owner. See Section 25 5500 for the general requirements.
- B. Override Alarms: Any point that is overridden through the override feature of the graphic workstation software shall be reported as an alarm.
- C. Analog Input Alarms: For each analog input, program an alarm message for reporting whenever the analog value is outside of the programmed alarm limits. Report a 'Return-to-Normal' message after the analog value returns to the normal range, using a programmed alarm differential. Contractor shall coordinate with the Owner for final values based on the following parameters:
  - 1. Space temperature, except as otherwise stated in sequence of operation (all values adjustable):
    - a) Low alarm: 64°F
    - b) Low return-to-normal: 68°F
    - c) High alarm: 85°F
    - d) High return-to-normal: 80°F
  - 2. Controlled media temperature other than space temperature (e.g. AHU discharge air temperature, condenser water supply, chilled water supply, etc.). If controlled media temperature setpoint is reset, alarm setpoints shall be programmed to follow setpoint (all values adjustable):
    - a) Low alarm: 3°F below setpoint
    - b) Low return-to-normal: 2°F below setpoint
    - c) High alarm: 3°F above setpoint
    - d) High return-to-normal: 2°F above setpoint.
  - 3. AHU mixed air temperature (all values adjustable):
    - a) Low alarm: 45°F
    - b) Low return-to-normal: 46°F
    - c) High alarm: 90°F



- d) High return-to-normal: 89°F
4. Duct Pressure:
  - a) Low alarm: 0.5" w.g. below setpoint
  - b) Low return-to-normal: 0.25" w.g. below setpoint
  - c) High alarm: 0.5" w.g. above setpoint
  - d) High return-to-normal: 0.25" w.g. above setpoint
5. Space humidity:
  - a) Low alarm: 35%
  - b) Low return-to-normal: 40%
  - c) High alarm: 75%
  - d) High return-to-normal: 70%
6. Air Quality CO<sub>2</sub>:
  - a) High alarm: 1,300 ppm
  - b) High return-to-normal: 1,000 ppm
- D. BAS System Failure Alarm: Generate alarm that reads "BAS System Failure". Alarm shall be generated when communication is lost to any controller or when any controller is determined to be in an abnormal state.

### 3.07 GRAPHIC SCREENS

- A. General:
  1. All Graphics shall be visible on all OWS displays in full screen mode without the use of scroll bars.
  2. All Graphics shall be printable with a blank/white background.
  3. All Graphics must have a unique background graphic, except Terminal Equipment Controllers. The color behind background graphic shall be the same for all graphics.
  4. All Graphics must contain all setpoints for the system represented. All displayed setpoints must be adjustable from the graphic and may not be hard coded in software.
  5. All Graphics must contain all physical points comprising the system.
  6. All Graphics shall include outside air sensor data.
  7. All relevant systems Graphics must contain a unique Graphical Link to the As-Built Sequence of Operations.
  8. All Graphics shall contain a Dynamic Graphical Links to the contract document As-Built mechanical, electrical and complete BAS drawing(s) for the represented system.
  9. All Graphics shall display any points that are currently in alarm with a graphical alarm representation that is consistent across all BAS projects to indicate the point is in alarm. All alarm points must be on a graphic.
  10. All animated Graphics shall accurately reflect the state of the equipment/device represented.



11. Provide zone level environmental index and building performance dashboard.
  12. The main building/site graphic must include a software emergency shutdown button. The software emergency shutdown button will shut down all HVAC systems within the building/site as described in the Sequences of Operation. Activation of the software shutdown button will be user level restricted.
- B. Floor Plan Screens: The contract document drawings will be used as the template for all floor plan graphic backgrounds.
1. Clearly display the building name and floorplan name at the top of each individual building floorplan graphic.
  2. Provide a campus map graphic (or edit existing graphic) to identify location of building(s) for this project with clickable links.
  3. Provide a per building floor plan graphic showing all thermographic color floorplans scaled to fit on one screen and designed to quickly evaluate building status. Include status off all major building systems and access to 'global' building setpoints.
  4. Provide two-dimensional thermographic color floor plan screens for each floor, wing, or tower of the building. Indicate the location of all equipment that is not located on the equipment room screens. Indicate all equipment zones with corresponding ON/OFF status. Indicate the location of temperature sensors associated with each temperature-controlled zone (i.e., VAV terminals, fan-coils, single-zone AHUs, etc.) on the floor plan screens. Display the space temperature point adjacent to each temperature sensor symbol. Use a distinct line or symbol to demarcate each terminal unit zone boundary. Use distinct colors to demarcate each air handling unit zone. Mechanical floor plan drawings will be made available to the user via a dynamic graphic link to the actual document. Indicate room numbers as provided by the Owner. Provide a drawing link from each space temperature sensor symbol and equipment symbol shown on the graphic floor plan screens to each corresponding equipment schematic graphic screen.
  5. Provide two-dimensional graphic floor plan screens for each mechanical equipment room and a plan screen of the roof. Indicate the location of each item of mechanical equipment. Provide a drawing link from each equipment symbol shown on the graphic plan view screen to each corresponding mechanical system schematic graphic screen.
  6. If multiple floor plans are necessary to show all areas, provide a graphic building key plan. Use elevation views and/or plan views as necessary to graphically indicate the location of all the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens. The key here is to assure all graphics can be linked to another and found dynamically by viewing a hierarchical tree like structure that contains all graphics in the system.



- C. System Schematic Screens:
1. Provide graphic system schematic screen for each controlled and monitored System and Sub-System.
  2. System graphics shall include flow diagrams with status, setpoints, current analog input and output values, operator commands, etc. as applicable.
  3. Operator adjustable points shall be adjustable through the graphic interface.
  4. General layout of the system shall be schematically correct and in the point of view as if an Operator were standing beside the most important access point for the system as physically installed.
  5. Input/output devices shall be shown in their schematically correct locations. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics.
  6. Indicate all adjustable setpoints on the applicable system schematic graphic screen or, if space does not allow, on a supplemental linked-setpoint screen.
  7. For each sub-system (i.e. VAV box) provide a link to all other systems serving that system (i.e. HW System, VAV AHU). Include pertinent data from the serving system on the sub-system graphic (i.e. VAV AHU supply temperature at VAV box primary air intake).
  8. All valve and damper position indicators should read “100% open” when the valve or damper is actually fully open and “0% open” when the valve or damper is fully closed. Normally open (N/O) or normally closed (N/C) action of valve or damper actuator shall be indicated on the graphic.
  9. Indicate occupancy status and temperature (via color bar graphic) on each zone level equipment graphic.

END OF SECTION



## SECTION 25 35 00 INSTRUMENTATION AND TERMINAL DEVICES FOR HVAC

### GENERAL

#### 1.01 SECTION INCLUDES:

- A. Description of Work
- B. Products Furnished but Not Installed Under this Section

#### 1.02 DESCRIPTION OF WORK:

- A. Furnish and Install DDC instrumentation and control devices required supporting specified building automation system functions as detailed herein and Section 25 55 00.

### PRODUCTS

#### 2.01 NAMEPLATE SUBMITTAL

- A. A complete nameplate and labeling schedule shall be provided to the Owner for approval prior to creating any label or nameplate. – Naming convention to be followed, consult with Owner on questions.

#### 2.02 MATERIALS AND EQUIPMENT

- A. General: Provide Direct Digital Control products in sizes and capacities indicated, consisting of valves, dampers, thermostats, clocks, controllers, sensors, and other components as required for complete installation, reviewed, and approved by the Owner or the Owner's representative. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.
- B. Instrument Pipe and Tube
  - 1. Hydronic and Instruments
    - a) Connection to Main Piping: Provide ½ inch minimum size thread-o-let, ½" x 2 inch brass nipple, and ½" ball valve for connection to welded steel piping. Provide tee fitting for other types of piping.
    - b) Remote Instruments: Adapt from ball valve to specified tubing and extend to remote instruments. Provide a union or otherwise removable fitting at ball valve so that connection to main can be cleaned with straight rod. Where manifolds with test ports are not provided for instrument, provide tees with ¼" FPT branch with plug for use as test port. Adapt from tubing size to instrument connection.
    - c) Line Mounted Instruments: Extend rigid piping from ball valve to instrument. Do not use close or running thread nipples. Adapt from ball valve outlet to instrument connection size. Provide a plugged



- tee if pipe makes 90 degree bend at outlet of valve to allow cleaning of connection to main with straight rod without removing instrument.
- d) Instrument Tubing: Seamless copper tubing, Type K or L, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder-joint fittings, ANSI B16.22; or brass compression-type fittings. The solder shall be 95/5 tin antimony, or other suitable lead free composition solder. Tubing OD size shall be not less than the larger of ¼" or the instrument connection size.
  - e) Rigid Piping for Line Mounted Instruments: Schedule 40 threaded brass, with threaded brass fittings.
2. Low Pressure Air Instrument Sensing Lines
- a) Connections: Use suitable bulkhead type fitting and static sensing tip for static pressure connections. Adapt tubing to instrument connection.
  - b) Tubing: Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, and with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.
- C. Communication Wiring: All wiring shall be in accordance with the manufacturer's requirements, Division 26 and Section 25 5500.
- 1. The Contractor shall supply all communication wiring as detailed in Section 25 55 00.
  - 2. Local Supervisory LAN: For any portions of this network required under this section of the specification, contractor shall use Fiber or Category 5e of standard TIA/EIA (100/1000BaseT). Network shall be run with no splices and in separate conduit from any other wiring.
  - 3. Primary and Secondary Controller LANs: Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any other wiring. Shield shall be terminated and wiring shall be grounded as recommended by BC manufacturer.
- D. Signal Wiring: Contractor shall run all signals wiring in accordance with National Electric Codes, Division 26 and Section 25 5500.
- 1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be per manufacturer's requirements. Signal wiring shall be run with no splices and separate from all other wiring above thirty (30) volts.
  - 2. Signal wiring shield shall be grounded at the controller end only unless otherwise recommended by the controller manufacturer.
- E. Low Voltage Analog Output Wiring: Contractor shall run all low voltage control wiring in accordance with National Electric Codes, Division 26 and Section 25 55 00. All wire insulation shall be color-coded and labeled for ease of identification.
- 1. Low voltage control wiring shall be per manufacturer's requirements. Low voltage control wiring shall be run with no splices separate from



- any wiring above thirty (30) volts.
- F. Control Panels: Provide control panels with suitable brackets for wall mounting for each control system. Locate panel adjacent to systems served.
1. Fabricate panels of 16-gage furniture-grade steel, or 6063-T5 extruded aluminum alloy, totally enclosed on four sides, with hinged door and keyed lock, with manufacturer's standard shop-painted finish and color.
  2. Provide UL-listed cabinets for use with line voltage devices.
  3. Control panel shall be completely wired prior to delivery and all electrical connections made to a labeled terminal strip. Control panel shall have standard manufacturer's color.
  4. All gauges and control components shall be identified by means of nameplates.
  5. All control wiring shall be run neatly and orderly in open slot wiring duct with cover.
  6. Complete wiring termination drawings shall be mounted in or adjacent to the panel.
  7. Unitized cabinet type for each system under automatic control. Provide quantity of enclosures required to house all relays, transducers, solenoid valves, pneumatic devices, and other interface controls. Mount temperature, humidity, airflow and pressure indicators, (or operator interface display with keypad), pressure gauges, pilot lights, pushbuttons and switches flush on cabinet panel face. All transformers and power supplies shall be mounted outside of the central panel. Provide laminated nameplates for all devices utilizing tag name as submitted on shop drawings. Mechanically fasten nameplates to panel. Self-adhesive type nameplates are not acceptable.
  8. Provide NEMA-1 general-purpose enclosure for all applications where panel will be installed in relatively dust free and dry spaces. All control panels for use in mechanical rooms, wash-down locations or installed outdoors shall be rated NEMA-4. All cabinets shall use a common key. Provide means of storing control system instructions and drawings inside cabinet.
  9. Finish: Factory applied enamel, except that panels in finished spaces shall be primed for field painting.
  10. Provide surface mounted or freestanding, steel supported types for mechanical equipment rooms. Provide fully recessed wall-mounted types elsewhere.
  11. All panels shall be fully recessed in walls in public spaces, where possible.
  12. Interior arrangement of control panel components shall be such that tubing and wire raceways shall be separated and aligned horizontally and vertically, in a fashion that allows for an organized appearance and a practical means for the tubing/wire to be exit the raceway to its intended component.



13. All tubing shall enter the panel through standard bulkhead compression fittings. Poly tubing may be run in conduit and enter panels via conduit fittings. All tubing lines shall be labeled at both ends of the tubing.
  14. All wire shall enter panels via conduit fittings. All wires shall terminate on terminal blocks and then continue from the terminal block to the device. Direct connection to the device is not permitted. Use of wire nuts is not permitted, except in applications in which a control device is provided from the factory with "pigtails". All wires shall be labeled at both ends of the terminal blocks. All penetrations of the BAS or outboard gear panels in mechanical rooms shall be from the bottom of the enclosure with wire-way and conduit stubs from the wire-way up to the panel.
  15. Power Supplies:
    - a) Provide a regulated, protected power supply as required with the ability to produce at least 33 percent more current than required by the transmitters and controls being installed. Output regulation shall be less than 0.5 mV. There shall be no overshoot on turn ON or OFF. The operating temperature shall be minus 20 to plus 70 degrees C.
    - b) The BAS Contractor shall certify in writing at the time of shop drawing submittal that the DDC equipment provided will not cause, as a result of its operation, either directly or indirectly, electrical interference to be induced into the building's electrical power systems.
  16. Class II transformers shall be used.
- G. Refer to Sections 25 5500 and Division 26 for means, methods and materials. Provide 120-volt power wiring from dedicated circuit breakers in electrical panels to BAS control panels. Provide necessary transformers. Coordinate with Division 26. See Section 25 55 00 for power quality requirements of each Control Panel circuit.
  - H. Control and Signal Circuits: Per NEC Article 725 (excluding thermocouple wiring). Control or signal circuits not run entirely in conduit, in areas classified as plenum space and vertical shafts shall be energized from listed Class 2 power supplies and shall be installed in Type "CL2P" listed plenum cable exclusively. Plenum rated cable shall be permitted in applications above an accessible ceiling or in between drywall where there is no insulation.
  - I. Provide all power and control wiring exposed outdoors, within rigid conduit properly labeled as BAS wiring. All power and control wiring above inaccessible ceilings within finished spaces, in drywall partitions with insulation or in block walls, in mechanical spaces and in vertical shafts shall be installed in electric metallic tubing (EMT).
  - J. Classify line (120 volt) and low (below 120 volt) voltage wiring from BAS and other control panels to control devices as control wiring.
  - K. Low Voltage Control Wiring: Wire shall be compatible with specific



application and in accordance with Division 26.

- L. For Hazardous location circuits as delineated in the design documents, refer to NFPA Article 500 for installation requirements.
- M. All cables shall be run parallel with structure, properly bundled, mounted (J Hooks) and secured every five feet. Provide labels every 20 feet (minimum) to identify associated system (i.e., BAS).

### PART 3. EXECUTION

#### 3.01 INSTALLATION OF CONTROL SYSTEMS:

- A. Plenum Wiring: All low voltage wiring external to control panels shall be in conduit, unless pre-approved. Conduit type, sizing, and installation requirements shall conform to NEC, Division 26 and Section 25 5500.
  - 1. Installation of wiring shall generally follow building lines. Run in a neat and orderly fashion, bundled where applicable, and completely suspended (strapped to rigid elements or routed through wiring J rings) away from areas of normal access. Tie and support conductors neatly with suitable nylon ties. Conductors shall not be supported by the ceiling system or ceiling support system. Conductors shall be pulled tight and be installed as high as practically possible in ceiling cavities. Wiring shall not be laid on any adjacent component or structure. Conductors shall not be installed between the top cord of a joist or beam and the bottom of roof decking. Contractor shall be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance. Under no circumstances will exposed splices be permitted.

#### 3.02 NAMEPLATES

- A. Provide engraved phenolic or micarta nameplates for all equipment, components, and field devices furnished. Nameplates shall be 1/8 thick, black, with white center core, and shall be minimum 1" x 3", with minimum 1/4" high block lettering. Nameplates for devices smaller than 1" x 3" shall be attached to adjacent surface.
- B. Each nameplate shall at a minimum include the object name of the device or sensor.
- C. For all Variable Speed Drives (VSDs/VFDs), provide an additional engraved nameplate at the drive indicating the location of the controlled variable when the controlled variable is not adjacent to the drive.

#### 3.03 TESTING EQUIPMENT

- A. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete testing successfully. The contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices



shall be at least twice as accurate as respective field device (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range).

END OF SECTION



## 25 35 13 ACTUATORS AND OPERATORS

### GENERAL

#### 1.01 SECTION INCLUDES:

- A. Description of Work
- B. Valve Actuators and Operators
- C. Damper Actuators and Operators

#### 1.02 DESCRIPTION OF WORK:

- A. Furnish and Install DDC instrumentation and control devices required supporting specified building automation system functions as detailed herein and Section 25 55 00.

### PRODUCTS

#### 2.01 ACTUATORS

##### A. General:

1. Actuators shall be either modulating, 2-position or spring return as indicated in the applicable control sequence.
2. As indicated in the applicable specification, all fail-safe operations shall require mechanical spring return or capacitive power generation or UPS power delivery for operation during the fail-safe condition.
3. Size actuators and linkages to operate their appropriate dampers or valves with a single actuator with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified.
4. The Owner must preapprove multiple actuators for any single application.
5. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied.
6. Actuators relying on batteries for any operation are not acceptable.
7. All electronic actuators shall be UL listed.

##### B. Damper and Valve Actuators:

1. Ambient Operating Temperature Limits: -10 to 150°F (-12.2 to 66 °C)
2. Two Position Electric Actuators: Low voltage or line voltage with spring return.
3. Electronic Actuators: Provide actuators with spring return for two-position (24v), 0-5 VDC, 0-10 VDC, 2-10VDC, 4-20 mA, or PWM input (subject to restrictions) as required. Actuators shall travel full stroke in less than 90 seconds for non-critical applications and travel less than 3 seconds for fast acting critical applications. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed.



Provide stroke indicator. Actuators shall have a positive positioning circuit. When two actuators are required in parallel or in sequence, provide an auxiliary actuator driver. Actuators shall have current limiting motor protection. Actuators shall have manual override where indicated.

4. Close-Off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off pressure for two-way water valve applications shall be 150% of the shutoff head of associated pump. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent.
5. Acceptable Manufacturers: Subject to compliance with requirements, approved manufacturers are as follows:
  - 1) Bray
  - 2) Siemens
  - 3) Substitutions: As allowed per Division 01.

C. Quarter-Turn Actuators for Ball and Butterfly Valves and Air Valves:

1. Electric Actuation:
  - a) Motor: Suitable for 120 or 240 VAC single-phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 100 percent duty cycle. Motors shall have inherent overload protection.
  - b) Gear-Train. Motor output shall be directed to a self-locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque.
  - c) Wiring: Power and control wiring shall be wired to a terminal strip in the actuator enclosure
  - d) Failsafe Positioning: Actuators shall be spring return type for failsafe positioning.
  - e) Enclosure: Actuator enclosure shall be NEMA-4 rated and shall have a minimum of two threaded conduit entries. Provide an enclosure heater for actuators located outside of buildings.
  - f) Limit Switches: Travel limit switches shall be UL and CSA approved. Switches shall limit actuator in both open and closed positions.
  - g) Mechanical Travel Stops: The actuator shall include mechanical travel stops of stainless steel construction to limit actuator to specific degrees of rotation.
  - h) Manual Override: Actuators shall have manual actuator override to allow operation of the valve when power is off. For valves 4 inches and smaller the override may be a removable wrench or lever or geared hand-wheel type. For larger valves, the override shall be a fixed geared hand-wheel type. An automatic power cut-off switch shall be provided to disconnect power from the motor when the



- hand-wheel is engaged for manual operation.
- i) Valve Position Indicator: A valve position indicator with arrow and open and closed position marks shall be provided to indicate valve position.
  - j) Torque Limit Switches: Provide torque limit switches to interrupt motor power when torque limit is exceeded in either direction of rotation.
  - k) Position Controller: For valves used for modulating control, provide an electronic position driver capable of accepting 4-20 mA, 0-10 VDC, 2-10 VDC, and 135-Ohm potentiometer.
  - l) Ambient Conditions: Actuator shall be designed for operation from -22 to 122 °F ambient temperatures with 0 to 100 percent relative humidity.
  - m) Timing: Actuators shall travel full stroke in less than 90 seconds for non-critical applications and travel less than 3 seconds for fast acting critical applications.
  - n) Acceptable Manufacturers:
    - 1) Bray
    - 2) Siemens
    - 3) Substitutions: As allowed per Division 01

## EXECUTION

### 3.01 GENERAL

- A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the BAS Contractor or Installer.
- B. Refer to Section 25 35 00 for general requirements.

### 3.02 INSTALLATION OF CONTROL SYSTEMS:

- A. Plenum Wiring: All low voltage wiring external to control panels shall conform to NEC, Division 26 and Section 25 55 00.
  - 1. Installation of wiring shall generally follow building lines. Run in a neat and orderly fashion, bundled where applicable, and completely suspended (strapped to rigid elements or routed through wiring J rings) away from areas of normal access. Tie and support conductors neatly with suitable nylon ties. Conductors shall not be supported by the ceiling system or ceiling support system. Conductors shall be pulled tight and be installed as high as practically possible in ceiling cavities. Wiring shall not be laid on any adjacent component or structure. Conductors shall not be installed between the top cord of a joist or beam and the bottom of roof decking. Contractor shall be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance. Under no circumstances will exposed splices be permitted.



- B. Electric and Electronic Damper Actuators:
  - 1. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.
  - 2. To compress seals when spring-return actuators are used on normally closed dampers, power actuators to approximately 5° open position, manually close the damper, and then tighten linkage.
  - 3. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
- C. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down. Always refer to manufacturer's recommended installation best practices prior to installation.

END OF SECTION



## 25 35 16 SENSORS AND TRANSMITTERS

### GENERAL

#### 1.01 SECTION INCLUDES:

- A. Description of Work
- B. General Field Device Requirements
- C. Sensors
- D. Meters
- E. Electric Control Components; Switches, EP Valves, Thermostats, Relays, Smoke Detectors, etc.
- F. Transducers
- G. Transmitters
- H. Voltage and Phase Monitors
- I. Air Flow Measuring Stations (AFMS)
- J. Current Switches

#### 1.02 GENERAL FIELD DEVICE REQUIREMENTS

- A. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.
- B. It shall be the BAS Contractor's responsibility to ensure that all field devices are compatible with controller hardware and software.
- C. Field devices specified herein are generally 'two-wire' type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power or is not designed to work with 'two-wire' type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide 'four-wire' type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required. All such examples shall be coordinated and agreed upon with the BAS Contractor.
- D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices. All such examples shall be coordinated and agreed upon with the BAS Contractor.
- E. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability, and hysteresis. Refer to Section 25 55 00 for reporting performance requirements.



## PRODUCTS

### 2.01 TEMPERATURE SENSORS (TS)

- A. Sensor Range: When matched with A/D converter of BC, AAC/ASC, or SD. Where thermistors are used, the stability shall be better than 0.25°F over 5 years.
- B. Room Temperature Sensor: Shall be an element contained within a ventilated cover, suitable for wall mounting. Provide insulated base. Following sensing elements are acceptable:
  - 1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point. Provide setpoint adjustment where indicated. The setpoint adjustment shall be a warmer/cooler indication that shall be scalable via the BAS (initial range of +/- 2°F).
  - 2. Provide an occupancy override button on the room sensor enclosure where indicated. This shall be a momentary contact closure
  - 3. Provide temperature indication via an LCD readout where indicated.
- C. Single-Point Duct Temperature Sensor: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph A.
  - 1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.2°F accuracy at calibration point
  - 2. For duct mounted installations, flange mount sensor to side of duct using manufacturer's standard recommendations and select probe lengths suitable for sensor location at center of duct.
- D. Averaging Duct Temperature Sensor: Shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each three square feet of cooling coil/duct face area. Temperature range as required for resolution indicated in paragraph A.
  - 1. Sensing element shall be platinum RTD, or thermistor, +/- 0.2°F accuracy.
  - 2. For duct mounted installations, flange mount sensor to side of duct using manufacturer's standard recommendations and select minimum probe length of one linear foot per three square feet of cross sectional area. Install sensor in serpentine fashion across duct area with no contact with other devices or coil surfaces.
- E. Liquid Immersion Temperature Sensor: Shall include brass thermowell, sensor and connection head for wiring connections.
  - 1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.



- F. Surface Mount Temperature Sensor: Shall include electrical utility box, sensor and connection head for wiring connections, and suitable for installation under insulation. Provide thermally conductive paste (compatible with pipe material) at pipe contact point. These may only be used where specifically indicated, typically on a temporary basis.
  - 1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.
- G. Outside Air Sensors: Shall consist of a sensor, sun shield, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as require for resolution indicated in Paragraph A
  - 1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

## 2.02 HUMIDITY TRANSMITTERS

- A. Units shall be suitable for duct, wall (room) or outdoor mounting. The unit shall be a 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:
  - 1. Input Range: 0 to 100% RH.
  - 2. Accuracy (% RH): +/- 2% (when used for enthalpy calculation, dew-point calculation or humidifier control) or +/- 3% (monitoring only) between 20-90% RH at 77°F, including hysteresis, linearity, and repeatability.
  - 3. Sensor Operating Range: As required by application
  - 4. Long Term Stability: Less than 1% drift per year.
- B. For duct mounted installations, flange mount sensor to side of duct using manufacturer's standard recommendations and select probe lengths suitable for sensor location at center of duct.
- C. Accessories: Duct-mounting plate, quick mount duct flange adapter, sensor dust filter, and single point calibrator for on-line/on-site calibration.
- D. Provide other accessories as required to protect sensors for up to 2500 fpm velocities.

## 2.03 PRESSURE TRANSMITTERS

- A. General Purpose - Liquid:
  - 1. General: Loop powered two-wire transmitter.
  - 2. Output: two-wire 4-20 mA output with zero and span adjustments.
  - 3. Overall Accuracy: less than 0.1% of span.
  - 4. Housing: Polymer housing suitable for surface mounting.
  - 5. Valve Bypass (where required by AU): Provide a five-valve bypass kit for calibration. Kit shall include high- and low-pressure isolation valves,



high- and low-pressure vent valves, and a bypass valve contained in a NEMA-1 enclosure. Enclosure shall be mounted no higher than 6 feet above floor level.

6. Range: Select for specified setpoint to be between 25% and 75% full-scale.
- B. General-Purpose Low-Pressure Air: Generally, for use in static measurement of duct pressure or constant volume air velocity pressure measurement where the range is applicable.
1. General: Loop powered two-wire differential capacitance cell-type transmitter.
  2. Output: two-wire 4-20 mA output with zero adjustment.
  3. Overall Accuracy: Plus or minus 1%.
  4. Minimum Range: 0.1 in. w.c.
  5. Maximum Range: 10 inches w.c.
  6. Housing: Polymer housing suitable for surface mounting.
  7. Acceptable Manufacturers: Johnson Controls, Schneider Electric, Siemens, Setra, and Veris Industries. Substitutions shall be allowed per Division 01.
  8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
  9. Range: Select for specified setpoint to be between 25% and 75% full-scale.
- C. General Purpose Low Pressure/Low Differential Air: Generally, for use in static measurement of space pressure or constant volume air velocity pressure measurement where the range is applicable.
1. General: Loop powered, two-wire differential capacitance cell type transmitter.
  2. Output: Two-wire 4-20 mA output with zero adjustment.
  3. Overall Accuracy: Plus or minus 1%.
  4. Minimum Range: 0 in. w.c.
  5. Maximum Range: 0.1, 0.25, or 0.5 inches w.c.
  6. Housing: Polymer housing suitable for surface mounting.
  7. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
  8. Range: Select for specified setpoint to be between 25% and 75% full-scale.
- D. VAV/CAV Velocity Pressure: Generally, for use to measure volume of air velocity pressure measurement where the range is applicable.
1. General: Loop powered two-wire differential capacitance cell type transmitter.
  2. Output: Two-wire, 4-20 mA output with zero adjustment.
  3. Overall Accuracy: Plus or minus 0.25%



4. Minimum Range: 0 in. w.c.
5. Maximum Range: 1-inch w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Range: Select for minimum range that will accept the maximum velocity pressure expected.

#### 2.04 DIFFERENTIAL PRESSURE SWITCHES (DPS)

- A. General Service - Air: Diaphragm with adjustable setpoint and differential and snap acting Form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing
- B. General Service - Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential and snap-acting Form C contacts rated for the application. 0°F to 160°F operating temperature.

#### 2.05 PRESSURE SWITCHES (PS)

- A. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150% of rated pressure.

#### 2.06 PHASE-VOLTAGE-FREQUENCY MONITOR

- A. Monitoring of equipment operating at 480V or below shall be accomplished using a device capable of directly monitoring voltage (line to line, line to neutral, phase to phase), current (each phase), and instantaneous kW demand or a direct connection to the facility distributed electrical SCADA system via MODBUS TCP.

#### 2.07 CURRENT SWITCHES (CS)

- A. Clamp-On Design Current Operated Switch (for Constant Speed Motor Status Indication)
  1. Range: 1.5 to 150 Amps.
  2. Trip Point: Adjustable.
  3. Switch: Solid state, normally open, 1 to 135 VAC or Vdc, 0.3 Amps. Zero off state leakage.
  4. Lower Frequency Limit: 6 Hz.
  5. Trip Indication: LED
  6. Approvals: UL, CSA
  7. Max. Cable Size: 350 MCM
  8. Acceptable Manufacturers: Veris Industries, Senva. Substitutions shall be allowed per Division 01.
- B. Clamp-on Wire Through Current Switch (CS/CR) (for Constant Speed Motors): Same as CS with 24V command relay rated at 5A @ 240 VAC resistive, 3A @ 240 VAC inductive, load control contact power shall be



induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable Manufacturers shall be Veris Industries Model # H938/735; or Senva C-2330. Substitutions shall be allowed per Division 01.

1. When used for single-phase devices, provide the CS/CR in a self-contained unit in housing similar with override switch to Kele RIBX. Substitutions shall be allowed per Division 1.
- C. Clamp-On Design Current Operated Switch for Variable Speed Motor Status Indication
1. Range: 1.5 to 135 Amps.
  2. Trip Point: Self-calibrating based on VA memory associated with frequency to detect loss of belt with subsequent increase of control output to 60 Hz.
  3. Switch: Solid state, normally open, 1 to 135 VAC or VDC, 0.3 Amps. Zero off state leakage.
  4. Frequency Range: 5-75 Hz
  5. Trip Indication: LED
  6. Approvals: UL, CSA
  7. Max. Cable Size: 350 MCM
  8. Acceptable Manufacturers: Senva or Veris Industries. Substitutions shall be allowed per Division 01.
- D. Clamp-On Wire Through Current Switch (CS/CR) (for Variable Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 VAC resistive, 3A @ 240 VAC inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). An acceptable manufacturer shall be Senva or Veris Industries. Substitutions shall be allowed per Division 01.
- E. Variable Speed Status: Where current switches are used to sense the status for variable speed devices, the CT shall include on-board VA/Hz memory to allow distinction between a belt break and subsequent ramp up to 60 Hz, versus operation at low speed. The belt break scenario shall be indicated as a loss of status and the operation at low speed shall indicate normal status.

## 2.08 CURRENT TRANSDUCER (CT)

- A. Clamp-On Design Current Transducer (for Motor Current Sensing)
1. Range : 1-10 Amps minimum, 20-200 Amps maximum ; Range shall match application
  2. Trip Point: Adjustable
  3. Output: 4-20 mA.
  4. Accuracy:  $\pm 0.2\%$  from 20 to 100 Hz.
  5. Acceptable Manufacturers: Senva or Veris. Substitutions shall be allowed per Division 01.



## 2.09 OUTDOOR AIR STATIC PRESSURE SENSING TIP

- A. Pressure sensor: Pressure sensing tip shall be designed to minimize the effects of wind and resulting velocity pressure up to 80 mph.
- B. Low Air Pressure Surge Dampener: 30-second time constant. Acceptable manufacturer shall be Amphenol Advanced Sensors. Substitutions shall be allowed per Division 01.

## 2.10 LIGHT SENSOR

- A. Units shall be suitable for wall (room) or outdoor mounting. Unit shall be three-wire transmitter. Unit shall produce linear continuous output of 4-20 mA for foot-candle (fc) reading. Sensors shall have the following minimum performance and application criteria:
  - 1. Input Range: 50 – 750 fc.
  - 2. Accuracy: +/- 1%.
  - 3. Operating Voltage: 12 – 24 VDC.
  - 4. Sensor Operating Range: As required by application

## 2.11 CONTINUOUS LEVEL TRANSMITTERS

- A. Capacitance Type
  - 1. Provide a loop powered, continuous capacitance type level transmitter with adjustable span and zero.
  - 2. Output: 4-20 mA.
  - 3. Probe: Fluoropolymer coated stainless steel rod or cable. Provide cable probe with end attachment hardware or weight.
  - 4. Electrical Enclosure: NEMA 4 (indoor application), NEMA 6 (outdoor application).
  - 5. Approvals: UL or CSA.
  - 6. Accuracy:  $\pm 1\%$  of calibrated span.
  - 7. Process Connection: MPT or ANSI Flange as required.
- B. Ultrasonic Type
  - 1. Provide a non-contacting, temperature compensating, narrow beam, ultrasonic type level transmitter with adjustable span and zero.
  - 2. Output: 4-20 mA.
  - 3. Transducer Materials: PC/ABS, Polypropylene, PVC and/or Teflon.
  - 4. Electrical Enclosure: NEMA-4X, Type 6.
  - 5. Approvals: UL, CE or CSA.
  - 6. Accuracy:  $\pm .5\%$  of calibrated span.

## 2.12 INSERTION TYPE TURBINE METER FOR WATER SERVICE

- A. Turbine Insertion Flow Meter sensing method shall be impedance sensing (iron magnetic and non-photoelectric), with volumetric accuracy of +/- 2% of reading over the entire operating range.



- B. Turbine Insertion Flow Meter shall have maximum operating pressure of 400 psi and maximum operating temperature of 200°F continuous (220°F peak).
- C. All wetted metal parts shall be constructed of 316-stainless steel.
- D. Flow meter shall meet or exceed the accuracy, head loss, flow limits, pressure and material requirements of the AWWA standard C704-70 for the respective pipe or tube size.
- E. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 V, and current output of 4-20 mA.
  - 1. Install in water systems with a minimum of straight length unobstructed flow per manufacturer's requirements.

#### 2.13 ULTRASONIC WATER SERVICE FLOW METER

- A. Clamp-On Ultrasonic Flow Meter: The ultrasonic flow meter shall be a transit-time non-invasive clamp-on type in which transducers clamp on the exterior surface of the pipe. The flow meter shall use Time-Domain Expansion Technology that allows for extremely accurate measurement of upstream and downstream arrival time differentials. The achievable field accuracy shall be 1% of rate or better. The repeatability of the flow meter shall be 0.5% of rate. The flow meter shall be able to measure bi-directional velocities.

#### 2.14 VORTEX SHEDDING FLOW METER FOR LIQUID AND GAS SERVICE:

- A. Output: 4-20 mA, 0-10 VDC, 0-5 VDC
- B. Maximum Fluid Temperature: 800 °F (427 °C)
- C. Wetted Parts: Stainless Steel
- D. Housing: NEMA 4 (indoor applications), NEMA 6 (outdoor applications)
- E. Turndown: 10:1 minimum.
- F. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for gases.
- G. Body: Wafer style or ANSI flanged to match piping specification.

#### 2.15 AIRFLOW MEASURING STATIONS (AFMS)

- A. Pitot Tube Grids: Provide an array of velocity pressure sensing elements with averaging manifolds and air straightening vanes packaged in a sheet metal casing. Distribute sensing elements in accordance with ASHRAE for traversing ducts. Provide taps to connect tubing from instrumentation. Label AFM with drawing number designation, design flow, velocity pressure, and pressure drop. Application of pitot grids shall be allowed only where minimum expected flow is greater than 30% or maximum flow
- B. Vortex Shedding Grid: Provide an array of vortex shedding elements designed to produce stable vortices that are linear with air velocity. Provide the electronics to totalize the pulses and output average velocity proportional to an output signal of 4-20ma.



1. Sensor Accuracy:  $\pm 2\%$
2. Electronics Accuracy:  $\pm 0.5\%$
3. Range: Select minimum range to accommodate the expected flow range of the project
4. Temperature Limits: 20-140°F
5. Acceptable Manufacturer: Tek-Air Vortek VT series. Substitutions shall be allowed per Division 01.

#### 2.16 AIR VELOCITY PRESSURE SENSORS (INSERTION TYPE)

- A. Single or Multi-Point Averaging (as indicated): Sensing tip shall be for insertion into duct with mounting flange and push on tube connections. Material shall be suitable to the application.

#### 2.17 CO<sub>2</sub> SENSORS/TRANSMITTERS (CO<sub>2</sub>)

- A. CO<sub>2</sub> sensors shall use silicon based, diffusion aspirated, infrared single beam, dual-wavelength sensor.
- B. Accuracy:  $\pm 2\%$  full scale to 1400 ppm.
- C. Stability: 5% over 5 years.
- D. Output: 4-20 mA, 0-10 VDC or relay.
- E. Mounting: Duct or Wall as indicated.

#### 2.18 ELECTRIC CONTROL COMPONENTS

- A. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.

1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
  - a) AC coil pull-in voltage range of +10%, -15% or nominal voltage.
  - b) Coil sealed Volt-Amperes (VA) not greater than four (4) VA.
  - c) Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
  - d) LED pilot light indication of power-to-coil and coil retainer clips.
  - e) Coil rated for 50 and 60 Hz service.
  - f) Acceptable Manufacturers: Relays shall be IDEC or Functional Devices RIB. Substitutions shall be allowed per Division 01.
2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC or Functional Devices RIB. Substitutions shall be allowed per Division 01. Whatever spec/code is required, maybe list 150% requirement (more money typ).
3. Relays used for stop/start control shall have low voltage coils (30 VAC or less) and shall be provided with transient and surge suppression devices at the controller interface.

- B. Control Transformers: Furnish and install control transformers as required.



Control transformers shall be machine tool type and shall be US and CSA listed. Primary and secondary sides shall be fused in accordance with the NEC. The transformer shall be of proper size for application not to exceed 100VA and mounted in minimum NEMA-1 enclosure.

- C. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type and rated for minimum 120 VAC operation.
- D. Electric Selector Switch (SS): Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 VAC operation.
- E. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1 enclosure. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley. Substitutions shall be allowed per Division 01.
- F. Low Temperature Detector ('Freezestat') (FZ): Low temperature detector shall consist of a 'cold spot' element which responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8" x 20' (3.2mm x 6.1m), junction box for wiring connections and gasket to prevent air leakage or vibration noise, DPST (4 wire, 2 circuit) with manual reset. Temperature range 15 to 55°F (-9.4 to 12.8°C), factory set at 38°F. Provide one thermostat for every 20 square feet of coil surface.
- G. Manual Time Switch: Switch shall be spring wound, manually set time switch for the control of electrical current. Contacts shall be rated for minimum 120 VAC operation.
- H. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC.
- I. Surface-Mounted Thermostat: Surface-mounted thermostat shall consist of SPDT contacts, operating temperature range of 50 to 150° F (10 to 65°C), and a minimum 10°F fixed setpoint differential.

## 2.19 REFRIGERANT MONITOR

- A. General: Contractor shall provide a refrigerant sensitive infrared-based stationary refrigerant gas leak monitor system designed to continuously measure refrigerants. The alarm system shall comply with ANSI/ASHRAE 15 and local code requirements. Device start-up and calibration shall be performed by certified factory/manufacturer's representative.
- B. The refrigerant monitor shall be capable of monitoring multiple refrigerant gas compounds at multiple locations. Accuracy shall be maintained within ambient environmental ranges of 0°C. through 50°C., (32°F. through 122°F.) and 5% through 90% relative humidity, non-condensing.
- C. The refrigerant monitor shall automatically and continuously monitor the



areas through a sample draw type tubular pick up system with an internal pump and filter. The installation of the monitoring control and the tubing shall be in strict accordance with the manufacturer's instructions. The location, routing, and final position of the sample tubes shall be submitted to the engineer with all necessary shop drawings and monitor specifications and installation instructions. Each of the sampling tubes shall have end of line filters.

- D. Factory certification of the calibrations shall be provided with the O&M manuals.
- E. The monitor shall continuously display the refrigerant concentration level and alarm status.
- F. The monitor shall have a gasketed, hinged front cover. Conduits and tube connections shall be located on the bottom of the enclosure. The enclosure shall have a rust and corrosion resistant finish.
- G. All alarm conditions shall be reported to the BAS.
- H. The refrigerant monitor shall be powered by an Emergency Power Circuit.

#### 2.20 ROOM STATIC PRESSURE MONITOR AND PROBE

- A. Provide flush or wall mounted room pressure monitor with room and reference pressure fittings to a remote pressure transducer with a 1 percent accuracy, 4-20ma analog output with a resolution of 0.001 inch w.c., red and green LEDs to alert operating personnel to the room pressure status and audible alarm horn with local silence button. Locate as shown on contract drawings. Alternates may include more descriptive display screens.
- B. Provide factory calibration to NIST procedures with documentation.

#### 2.21 CONTROL TRANSFORMERS

- A. UL-listed, class II with 120 VAC primary and 24 VAC secondary. Provide with integral manual reset circuit breaker.

#### 2.22 OXYGEN DEPRIVATION, CARBON DIOXIDE, CARBON MONOXIDE OR NITROGEN DIOXIDE (DIESEL) MONITOR:

- A. General: Wall mounted, polycarbonate enclosure, UL Classified and CSA certified with multi-channel microprocessor-based controller gas monitoring system.
- B. Provide visual three-digit display of concentration on front of sensor panel. Alarm shall be silenced by pressing button on wall in vicinity of room. Provide a single calibration kit.
- C. Performance:
  - 1. Sensor Power 17 – 27 Vac, 20 – 38Vdc.
  - 2. Relay Output 1 DPDT relay, 5A @ 250Vac; 5A @ 30Vdc.
  - 3. Accuracy: +/-3% of full scale.
  - 4. Range: as required for application. Review with vendor (By Volume).



5. Sensor Life Two Year minimum.

D. Communications: RS485 Modbus; BACnet MS-TP master.

#### 2.23 HIGH STATIC PRESSURE SWITCH:

- A. Diaphragm operated to actuate a single pole, double throw, snap action switch.
- B. Motion of diaphragm shall be restrained by a calibrated spring that can be adjusted to set exact pressure differential at which electrical switch will be actuated.
- C. Set Point Adjustment: Screw type with set point indicated on a visual scale.
- D. Select pressure switch range for specific fan application.
- E. Provide switch with a manual reset function.

#### 2.24 UNINTERRUPTIBLE POWER SOURCE

- A. Manufacturer: Eaton 3S 550. Substitutions shall be allowed per Division 01.
- B. Provide at each stand-alone controller where indicated by control drawings.
- C. Provide protection from power surges, spikes, blackouts and brownouts.
- D. Provide immunity from electrical sags, surges, transients, noise, and outages.
- E. Performance:
  - 1. Output Voltage Regulation: Plus or minus 10 percent.
  - 2. Output Frequency Regulation: 0.1 Hz.
  - 3. Output Overload Capability: 125 percent for 1 second causes shutdown without hardware damage.
  - 4. Transient Suppression: Tested to IEEE 587.
  - 5. Battery Reserve: 15 minute typical at full load for controllers; 10-15 minutes with a typical PC load for Supervisory Stations.
  - 6. EMI/RFI: Complies with FCC Part 15J, Class A.
- F. Electrical:
  - 1. Input Voltage: Single Phase, two-wire plus ground.
  - 2. Input Frequency: 50/60 Hz auto select.
  - 3. For Supervisory Stations, provide UPS with quantity of outlets for CPU, Monitor, and printers.
- G. Environmental:
  - 1. Operating Temperature: 32 to 95 degrees F
  - 2. Relative Humidity: 0 to 90 percent non-condensing.
- H. Battery: Internal, sealed, captive electrolyte, non-corrosive, no flammable gases.
- I. Provided contacts for Low Battery and Trouble conditions signal to BAS.
- J. Provide a manual bypass switch permitting scheduled maintenance or UPS



replacement without power disruption.

## 2.25 VICONICS ROOM CONTROLLER

- A. Manufacturer: Viconics Technologies, Inc.
- B. All provided Viconics devices must interface with the BAS through a BACnet/MSTP connection. The connection must allow read/write access to all sensor values and set points.
- C. Provide all hardware and software necessary to backup and restore all Viconic parameters.

## EXECUTION

### 3.01 INSTALLATION OF CONTROL DEVICES:

- A. General: Install systems and materials in accordance with manufacturer's instructions, details shown on drawings, and all applicable codes defined in design documents. Locate sensors in positions that most accurately represent the sensed medium. Ensure that single point sensors are positioned in a well-mixed medium position. Ensure that flow sensors are located in areas with minimal turbulence. Ensure that temperature and humidity sensors are located in a position that is remote from humidifiers and sufficiently downstream to ensure full moisture absorption.
- B. Averaging Temperature Sensors: Provide one linear foot of averaging sensor per square foot of coil face installed in serpentine fashion across entire face of coil.
- C. Airflow Measuring Stations: The Contractor is to coordinate the installation with the relevant mechanical duct installer or unit manufacturer according to the AFMS manufacturer's recommendations in an unobstructed straight length of duct (except those installations specifically designed for installation in fan inlet). For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFMS manufacturer.
- D. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current.
- E. Flow Switches: Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications.
- F. Fluid Flow Sensors: The Contractor is to coordinate the installation with the relevant mechanical pipe subcontractor to install per manufacturer's recommendations in an unobstructed straight length of pipe.
- G. Low Temperature Detectors (Freezestats): Install LTDs in a serpentine fashion where shown on drawing. Provide one foot of element for each square foot of coil face area. Where coil face area exceeds required length of element, provide multiple devices, wired in parallel for normally open close on trip application. Adequately support with coil clips that will not conduct temperature from the mounting surface to the element.
- H. Phase-Voltage-Frequency Monitor: Contractor shall install with coordination



required by the BAS Contractor.

- I. Pipe Surface Mount Temperature Sensor: Install with thermally conductive paste at pipe contact point. Pipe insulation shall be replaced in kind and adequately joined to existing undisturbed insulation. Maintain vapor barrier and finish to match. These should be temporary applications only, until a well may be installed for proper inflow measurement of temperature.
- J. Refrigerant Monitors: Install them in accordance with the manufacturer's instructions. Place sensing tips in locations to maximize effectiveness. Hard wire interlocks the emergency ventilation and shutdown of combustion devices.
- K. Relative Humidity Sensors: Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.
- L. Space Temperature Sensors: Sensors shall be located:
  - 1. Mount non-adjustable sensors with centerline 60" above finished floor. Sensors with adjustable setpoints and/or override switches must be mounted 48" above the finished floor.
  - 2. Coordinate location of sensor with work of other trades so sensor does not conflict with or is obstructed by such items as blackboards, bleachers, bookcases, etc.
  - 3. Conceal all control wiring to sensors located in new-finished spaces; the use of wire-mold is prohibited unless specified.
  - 4. Thermostats located in Bathrooms, Locker Rooms, Common Rooms, Storerooms, and Corridors shall be flush mounted type.
- M. Supply Duct Pressure Transmitters:
  - 1. General: Install pressure tips with at least 4 'round equivalent' duct diameters of straight duct with no takeoffs upstream. Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions. Locate the transmitter at an accessible location to facilitate calibration.
  - 2. VAV System 'Down-Duct' Transmitters: Locate pressure tips approximately 2/3 of the hydraulic distance to the most remote terminal in the air system. AE must approve the final location.
- N. Test Ports: Provide test ports in ductwork at each temperature and humidity sensor location to facilitate sensor calibration. Test ports shall be 3/4" diameter minimum and accessible via a 2" x 4" junction box with insulated cover. Provide a test port for all pressure points in pipe work.
- O. Valve Bypass for Differential Pressure Sensors: Provide a five-valve bypass kit for protection of DP sensors where the static pressure on the pipe can potentially over-pressure one port with the other at atmospheric pressure. Kit shall include high and low pressure isolation valves, high and low pressure vent valves (five valve kit) and a bypass valve contained in a NEMA-1 enclosure. Enclosure shall be mounted no higher than 6 feet AFF.

END OF SECTION



## 25 35 19 CONTROL VALVES

### GENERAL

#### 1.01 SECTION INCLUDES:

- A. Description of Work
- B. Control Valve Requirements

#### 1.02 DESCRIPTION OF WORK:

- A. Furnish and Install DDC instrumentation and control devices required supporting specified building automation system functions as detailed herein and Section 25 35 00.

### PRODUCTS

#### 2.01 CONTROL VALVES

- A. General:
  - 1. Provide factory fabricated control valves of type, body material and pressure class indicated. Valves shall be two-way or three-way type for two-position or modulating service as scheduled, shown on drawings, or as specified in Sequence of Operations.
- B. Close-Off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
  - 1. Water Valves: Shutoff at 150% of total system (pump) head.
- C. Water Valves:
  - 1. Body and trim style and materials shall be per manufacturer's recommendations for design conditions and service shown.
  - 2. Sizing Criteria:
    - i. Two-position service: Full port line size.
    - ii. Two-way modulating service: Pressure drop across the valve in a wide-open position, with full flow through the valve, shall be equal to 50% of the available pressure differential between the mains, with a minimum of 4 psi.
    - iii. Three-way Modulating Service: Pressure drop across the valve in a wide-open position, with full flow through the valve, shall be equal to twice the pressure drop through the heat exchanger (load), with a 3-psi minimum. 3-way valves shall have linear flow characteristics.
    - iv. 1-1/2 inch valves and smaller shall have screwed ends. 2 inch and larger shall have flanged or welded ends.
  - 3. Construction Type:  
Segmented or Characterized Ball Type:
    - 1) Body: Carbon Steel; Seat: Reinforced Teflon (PTFE); Ball: Stainless Steel; Stem: Stainless Steel



- 2) Port: Segmented design with equal-percentage characteristic
- 3) Cold Service Pressure: 200 psi WOG

Plug-Type Globe Pattern:

Body: Bronze, screwed, 250 psi max (1/2" to 2"); Cast Iron, flanged, 125 psi max (2-1/2" and larger)

Stem: Stainless Steel; Seat: Brass; Plug: Brass, Bronze, or Stainless Steel

Butterfly Type:

1) Body: Extended neck epoxy coated cast or ductile iron with full lug pattern; Seat: EPDM; Disc: Bronze or Stainless Steel, pinned or mechanically locked to shaft; Bearings: Bronze or Stainless Steel; Shaft: Stainless Steel

2) Cold Service Pressure: 175 psi

3) Close Off: Bubble-Tight shutoff to 150 psi

Ball Type:

1) Body: Brass or Bronze, threaded ends; Seat: Reinforced Teflon; Ball: Stainless Steel; Stem: Stainless Steel

2) Port: Standard or 'V' style

3) Cold Service Pressure: 600 psi WOG

4. Water valves shall fail as specified in the Control Sequences.

5. Evaporative Cooler Drain and Fill Valves:

Valve normal position shall be as shown on the drawings.

6. For systems containing fluids other than water, provide documentation that the valve components in contact with the fluid are compatible with it.

## EXECUTION

### 3.01 GENERAL:

A. Refer to Section 25 5500 for general requirements.

### 3.02 INSTALLATION OF CONTROL VALVES:

A. Refer to Section 25 55 00 for general installation requirements for all mechanical, electrical and controls work.

B. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down. Always refer to manufacturer's recommended installation best practices prior to installation.

END OF SECTION



## 25 55 00 CONTROL OF HVAC

### GENERAL

#### 1.01 SECTION INCLUDES

- A. Related Documents
- B. Approved Control Systems
- C. Contractor Responsibilities
- D. Description of Work
- E. Procurement
- F. BAS Quality Assurance and Performance Parameters
- G. Definitions and Functional Intent
- H. Submittal and Record Document Requirements
- I. System Architecture
- J. Warranty, Storage and Material Handling
- K. Construction Coordination Requirements
- L. Field Workmanship and Quality Control
- M. Wiring and Electrical Requirements
- N. Control Panels/Quantity and Location
- O. Demolition and Reuse of Existing Materials and Equipment
- P. Sequence of Work for Existing Systems Conversions

#### 1.02 DEFINITIONS

- A. Accuracy: Accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis. See other Division 25 Sections for details specific to devices and applications.
- B. Advanced Application Controller (AAC): A device with limited resources relative to the Building Controller (BC). It may support a level of programming and may also be intended for application specific applications.
- C. American University (AU): Owner of all facilities and systems.
- D. Application Protocol Data Unit (APDU): A unit of data specified in an application protocol consisting of application protocol control information and possible application user data (ISO 9545).
- E. Application Specific Controller (ASC): A device with limited resources relative to the Advanced Application Controller (AAC). It may support a level of programming and may also be intended for application-specific applications. .
- F. BAS Contractor: Contractor responsible for the installation, programming,



- commissioning, training, and warranty service of the new building automation system.
- G. Binding: In the general sense, binding refers to the associations or mappings of the sources network variable and their intended or required destinations.
  - H. Building Automation System (BAS): The entire integrated management and control system
  - I. Building Controller (BC): A fully programmable device capable of carrying out a number of tasks including control and monitoring via direct digital control (DDC) of specific systems, acting as a communications router between the LAN backbone and sub-LANs, and data storage for trend information, time schedules, and alarm data.
  - J. Change of Value (COV): An event that occurs when a measured or calculated analog value changes by a predefined amount (ASHRAE/ANSI 135).
  - K. Client: A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.
  - L. Continuous Monitoring: A sampling and recording of a variable based on time or change of state (e.g. trending an analog value, monitoring a binary change of state).
  - M. Contractor: Within this specification, all references to “Contractor” shall mean the contractor that holds the construction contract that incorporates the BAS. This contractor would normally be called the General Contractor, or Construction Management contractor, but ultimately, it is the contractor that is responsible for and owns the construction contract.
  - N. Controller or Control Unit (CU): Intelligent stand-alone control panel. Controller is a generic reference and shall include BCs, AACs, and ASCs as appropriate.
  - O. Control Systems Server (CSS): This shall be a computer (or computers) that maintain the systems configuration and programming database. This may double as an operator workstation.
  - P. Direct Digital Control (DDC): Microprocessor-based control including Analog/Digital conversion and program logic.
  - Q. Ethernet: Reference to the campus Information Technology network, used for normal business-related e-mail and Internet communication. IEEE 802.3 based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser or client installed software.
  - R. Functional Profile: A collection of variables required to define the key parameters for a standard application. As this applies to the HVAC industry, this would include applications like VAV terminal, fan coil units, and the like.
  - S. Gateway (GTWY): A device, which contains two or more dissimilar networks/protocols, permitting information exchange between them



(ASHRAE/ANSI 135).

- T. Handheld Device (HHD): Manufacturer's microprocessor based device for direct connection to a Controller.
- U. LAN Interface Device (LANID): Device or function used to facilitate communication and sharing of data throughout the BAS
- V. Local Area Network (LAN): General term for a network segment within the architecture. Various types and functions of LANs are defined herein.
- W. Local Supervisory LAN: Ethernet-based LAN connecting Primary Controller LANs with each other and OWSs and CSSs. See System Architecture below. This LAN can function as the Primary Controlling LAN.
- X. Master-Slave/Token Passing (MS/TP): Data link protocol as defined by the BACnet standard. (ASHRAE/ANSI 135).
- Y. MMBTU (IT) / hour: One million international British thermal units per hour for energy use calculations in this Section.
- Z. Open Database Connectivity (ODBC): An open standard application-programming interface (API) for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data.
- AA. Operator Interface (OI): A device used by the operator to manage the BAS including OWSs, POTs, and HHDs.
- AA. Operator Workstation (OWS): The user's interface with the BAS system. As the BAS network devices are stand-alone, the OWS is not required for communications to occur.
- BB. Point-to-Point (PTP): Serial communication as defined in the BACnet standard.
- CC. Portable Operators Terminal (POT): Laptop PC used both for direct connection to a controller and for remote dial up connection.
- DD. Primary Controlling LAN: High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.
- EE. Router: A device that connects two or more networks at the network layer.
- FF. Secondary Controlling LAN: Subordinate LAN connecting AACs and ASCs to the Primary Controlling LAN. Refer to System Architecture below.
- GG. Server: A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.
- HH. SQL: Standardized Query Language, a standardized means for requesting information from a database.
- II. Smart Device (SD): A control I/O device such as a sensor or actuator that can directly communicate with the controller network to which it is connected. This differs from an ASC in that it typically deals only with one variable.

### 1.03 PROCUREMENT



- A. The following are approved control system suppliers, manufacturers, and product lines:
  - 1. Siemens Desigo
  - 2. ALC WebCTRL

#### 1.04 RESPONSIBILITIES

- A. BAS Contractor shall coordinate, manage and comply with all contract requirements to furnish and install a direct digital control Building Automation System (BAS).
- B. All BAS related interconnecting cabling, wiring, conduit, and associated support structures that would normally be installed to support the conduit, cabling, wire and BAS Field Enclosures shall be installed by the BAS Contractor.
- C. The BAS Contractor shall be responsible for the installation of all devices that comprise the BAS system and all wiring terminations as required to complete the installation of the BAS system.
- D. The BAS Contractor shall provide all drawings and details, to properly wire and terminate the BAS.
- E. The BAS Contractor shall assist the Owner and Engineer as needed with LEED credit qualification including utility metering trends, IAQ, and outside air delivery monitoring.

#### 1.05 DESCRIPTION OF WORK

- A. The new BAS shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves as referred to in the sequence of operations to perform control sequences and functions specified. Refer also to control drawings, sequences of operation, and point lists.
- B. The distributed digital control (DDC) and building automation system (BAS) defined in this specification shall interface with an Ethernet network. Contractor shall provide all specified objects and services and have them configured/mapped as applicable.
- C. All control work shall be installed by the BAS contractor, unless specified otherwise. Certain building systems including but not limited to, electrical equipment, plumbing equipment, security systems, mechanical equipment and special systems are equipped with manufacturer furnished controls that must be integrated into the BAS for monitoring and control. All labor, materials, equipment, software, and services necessary for the installation of a complete integrated system shall be provided with the exception as noted in this specification.
- D. The proposed system must be entirely compatible with the existing building BAS. This includes open source BACnet compliant controllers and devices. No system, even if supplied by the same manufacturer, may be installed as sole source if gateways or other means are required to interface with the existing system.



## 1.06 PERFORMANCE PARAMETERS:

- A. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall reconfigure LAN and programming as necessary to accomplish these performance requirements (see Integrated Automation Software for Control and Monitoring Networks Section for alarm definitions):
1. 5 seconds between a Level 1 (critical) alarm occurrence and enunciation at operator workstation.
  2. 10 seconds between a Level 2 alarm occurrence and enunciation at operator workstation.
  3. 20 seconds between and a Level 3-5 alarm occurrence and enunciation at operator workstation.
  4. 3 seconds between an operator command via an operator interface to change a setpoint and the subsequent change in the controller.
  5. 3 seconds between an operator command via an operator interface to start/stop a device and the subsequent command to be received at the controller.
  6. 10 seconds between a change of value or state of an input and it being updated on an operator interface.
  7. 10 seconds between an operator selection of a graphic and it completely painting the screen and updating at least 10 points.
  8. 2 seconds for any point being used across the LAN for control between 2 Field Panels at any level of the architecture.
  9. Programmable Controllers: Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.
  10. Multiple Alarm Annunciations: Each workstation on the network shall receive alarms within 5 sec of other workstations.
  11. Reporting Accuracy: System shall report values with minimum end-to-end accuracy listed in Table 1.
  12. Control Stability and Accuracy: Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.



Table 1  
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5°C (±1°F)
Ducted Air	±0.5°C (±1°F)
Outside Air	±1.0°C (±2°F)
Dew Point	±1.5°C (±3°F)
Water Temperature	±0.5°C (±1°F)
Delta-T	±0.15°C (±0.25°F)
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO <sub>2</sub> )	±50 ppm

Note 1: Accuracy applies to 10% - 100% of scale

Note 2: For both absolute and differential pressure

Note 3: Not including utility-supplied meters



Table 2  
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.)	50 Pa -1.5 kPa (0.2-6 in. w.g.)
	±0.25% of Full Scale (Devices for Setpoint Control BSL and LAB)	±63 Pa around setpoint (±0.25 in. w.g.)
	±50 Pa (±0.2 in. w.g.)	-1.5 kPa - -50 Pa (-6.0 to -0.2 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0°C (±2.0°F)	
Duct Temperature	±1.5°C (±2.0°F)	
Humidity	±5% RH(Office) ±2% RH(Lab, BSL)	
Fluid Pressure	±10 kPa (±1.5 psi)	MPa (1-150 psi)
	±250 Pa (±1.0 in. w.g.)	0-12.5 kPa (0-50 in. w.g.) differential

### 1.10 SUBMITTALS

- A. Design engineer shall concurrently review all submittals along with the Owner's Engineering/IT/Facilities Departments and incorporate all comments into a final review document. All submittals shall comply with all Cx requirements.
- B. Electronic Submittals: Control submittals and O&M information shall be provided electronically in Adobe PDF format. Control drawings shall be electronically provided in Adobe PDF in a size no less than 11"x17". Documents will be developed in a preferred format or converted from their native electronic format directly to a preferred format. Any documents scanned as images must be converted to a searchable text format using OCR (Optical Character Recognition) and reduced in size prior to submission. O&M manual shall include electronic versions of the project Mechanical and Electrical design drawings.
- C. Product Data: Submit manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics including compliance with grounding and power conditioning requirements, and material finishes. Also include installation and start-up instructions.
- D. Shop Drawings: Submit shop drawings for each control system, including a complete drawing for each air handling unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Each shop drawing shall be provided in PDF & AutoCAD format and contain:



1. System Architecture, System Layout, Risers:
  - a) One-line diagram indicating schematic locations of all control units, workstations, LAN interface devices, gateways, etc. Indicate network number, device ID, drawing reference number, and controller type for each control unit. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the diagram. Indicate relevant communication protocol on each network segment.
  - b) Indicate device instance and MAC address for each CU. Indicate media, protocol, and type of each LAN.
  - c) Provide floor plans locating all control units, LAN interface devices, gateways, etc. Include all WAN and LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Wiring routing as-built conditions shall be maintained accurately throughout the construction period and the drawing shall be updated to accurately reflect accurate, actual installed conditions.
  - d) Indicate network number, device ID, address, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans.
  - e) For renovation projects, the system diagram should clearly show all new and modified connections to existing networks and controllers.
2. PI&D Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include narrative description of sequence of operation, as it will be applied by the proposed control system (providing verbatim copy of contract documents is not acceptable). Indicate which items will be installed by others. Where applicable, provide a diagram for factory-controlled equipment detailing the BAS interface.
3. All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.

With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number).
5. Label each control device with set point and range of adjustable control.
6. Label each controller input and output with the appropriate range.
7. Label each control device with the relevant detail drawing number.
8. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.



9. Provide a Control Valve Schedule listing valve and actuator information including: size,  $C_v$ , design flow, design pressure drop, manufacturer, model number, close off rating, control signal, line size, line pressure, ANSI class rating, tag number, system service, valve type, material construction of body, stem, disc, etc. Indicate normal positions of automatic return valves.
  10. Provide a Control Damper Schedule listing damper and actuator information including: size, material, blade arrangement, manufacturer, model number, control signal, close off rating, etc. Indicate normal positions of automatic return dampers.
  11. Provide an Air Flow Monitoring Station Schedule listing the following information: size, material, manufacturer, model number, control signal, CFM, velocity, etc.
  12. Provide a Metering Device Schedule listing the following information: Flow range, fluid type, mechanical input type (magnetic, wheel, ultrasonic), Manufacturer, Model, Purpose, Location.
  13. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Clearly differentiate between portions of wiring which are existing, factory- installed and portions to be field-installed.
  14. Provide details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations and allocated service clearances. Provide panel layout drawing including power supply, control unit(s) and wiring terminals.
  15. Sheets shall be consecutively numbered.
  16. Each sheet shall have a title indicating the type of information included and the system controlled.
  17. A Table of Contents shall list sheet titles and sheet numbers followed by a symbol legend and list of abbreviations.
  18. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.
- E. Control Logic Documentation
1. Submit control logic program listings to document the control software of all control units.  
Include written description of each control sequence.
- F. Operation and Maintenance Materials:
1. Documents shall be provided electronically as described for electronic submittals.
  2. Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessory.



3. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual. Only include sections for equipment and software used on this project. Do not provide entire catalog of product data with extraneous information, cross out or draw a single line thru non-related data.
  4. Submit BAS User's Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripherals.
  5. Submit BAS advanced Programming Manuals for each controller type and for all workstation software.
- G. Schedule
1. Schedule of work provided within two weeks of contract award, indicating.
    - a) Intended sequence of work items
    - b) Start date of each work item
    - c) Duration of each work item
    - d) Planned delivery dates for ordered material and equipment and expected lead times
    - e) Milestones indicating possible restraints on work by other trades or situations
  2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.
- H. Panel Control Drawings
- Provide laminated control drawings within each control panel for the CUs and devices controlled from that panel. System control schematics shall be mounted adjacent to key pieces of equipment for that system. Panel termination drawings shall be mounted in or adjacent to respective panels.
- I. System Conversion Planning
1. Submit schedule of work with respect to equipment outages and/or occupancy/work schedules.
  2. Provide details of control panels, including controls and instruments impacted. Provide scale panel layout drawing including power supply, control unit(s) and wiring terminals impacted.
  3. Provide details of additional power source connections required beyond those provided in the existing system.
- J. Controls contractor shall provide Owner with all product line technical manuals and technical bulletins, to include new and upgraded products, by the same distribution channel as to dealers or branches throughout the warranty period of the project.



- K. Manufacturers Certificates: For all listed and/or labeled products, provide a certificate of conformance.
- L. Product Warranty Certificates: Coordinate and submit manufacturers product warranty certificates covering the hardware provided once approved by the Owner. List the local offices and the representatives to perform routine and emergency maintenance on system components.
- M. Re-Submittals: Include cover letter that specifically responds to all previous submittal comments and explains how they are addressed in the current re-submittal.

#### 1.07 PROJECT RECORD DOCUMENTS

- A. Documentation shall be provided electronically
- B. As-Built copies of product data and control shop drawings updated to reflect the final installed condition.
- C. As-Built copies of approved control logic programming and database uploaded and stored on the project BAS server. Accurately record actual setpoints and settings of controls, final sequence of operation, including changes to programs made after submission and approval of shop drawings and including changes to programs made during specified testing.
- D. As-Built copies of approved project specific graphic software stored on the Owner's BAS server.
- E. As-Built copies shall include individual floor plans with controller locations with all interconnecting wiring routing including space sensors, LAN wiring, power wiring, low voltage power wiring.
- F. As-Built copies shall include the final riser diagram showing the location of all controllers.
- G. As-Built copies shall include ALL control drawings revision history to reflect the As-Built date. No drawing, Document nor database shall be provided without the final As-Built revision date and comment attached.
- H. All As-Built documents shall be provided electronically and copied to the BAS CSS. Links to this documentation shall be provided on each equipment graphic for access to the as-built shop drawings, point lists, and sequences of operation.
- I. Confirm AU BAS Supervisor can access all record documentation once uploaded to CSS.

#### 1.08 SYSTEM ARCHITECTURE

- A. The system provided shall incorporate hardware resources sufficient to meet the functional requirements of this project. The Contractor shall include all items not specifically itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these contract documents.
- B. The system shall be configured as a distributed processing network(s) capable of expansion.



- C. The system architecture shall consist of an Ethernet-based, wide area network (WAN), a single Local Area Network (LAN) or multi-levelled LANs that support BCs, AACs, ASCs, Operator Workstations (OWS), Smart Devices (SD), and Remote Communication Devices (RCDs) as applicable. The BAS network shall be able to seamlessly communicate using the standard protocols, MODBUS and BACnet, at all network levels. The following is a functional description of the BAS structure.
1. WAN: Internet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser. This is an existing infrastructure and the contractor is not required to configure any components of this WAN. Refer to Section 25 11 16 for requirements.
  2. Local Supervisory LAN: The Local Supervisory LAN is an extension of the WAN. Contractor will be provided specific ports dedicated for control module/interface device connectivity. Contractor may not extend this network without prior approval from the Owner. Power-line carrier communication shall not be acceptable for communications.
    - a. The Contractor is responsible for the installation of a temporary Ethernet network that will serve the purpose of the Local Supervisory LAN until such time as the permanent Local Supervisory LAN is available. Should the temporary network be required, the BAS Contractor is responsible for the coordination and implementation of the Local Supervisory LAN to conform to the eventual permanent LAN's settings and addresses for the BAS.
  3. Primary Controller LAN ('Primary LAN'): High-speed, peer-to-peer communicating LAN used to connect Building Controllers (BCs) and communicate control information.
  4. Secondary Controller LAN ('Secondary LAN'): Network used to connect AACs, ASCs or SDs. These can be BACnet MS/TP or MODBUS, in addition to those allowed for Primary Controller LANs. Network speed versus the number of controllers on the LAN shall be dictated by the response time and trending requirements (see the Integrated Automation Remote Control Panels Section).
- D. Dynamic Data Access: Any data throughout any level of the network shall be available to and accessible by all other devices, Controllers and OWS, whether directly connected or connected remotely.
- E. Communication Interruptions: Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, separate networks shall be formed and communications within each network shall continue uninterrupted.
- F. Communication Devices: All line drivers, signal boosters, and signal conditioners etc. shall be provided as necessary for proper data communication (see also Network Bandwidth Management).
- G. Control Systems Server (CSS): The CSS is a virtual machine that maintains the systems configuration, programming database, and historical trend data. The BAS software shall be platform independent and



capable of residing on Owner's specific operating system with virtualization software. It shall hold backup files of information downloaded into the individual controllers and as such support uploading and downloading that information directly to/from the controllers. It shall also act as a control information server to non-control system based programs. It shall allow secure multiple-user access to the control information. Refer to Section 25 1113 – Integrated Automation Network Servers for its requirements.

1. Operator Interfaces shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, and remote monitoring. Refer to Section 25 1113 – Integrated Automation Network Servers.
  2. During construction and prior to acceptance by the Owner new BAS projects will reside on their respective QA (Quality Assurance) server. This server operates separately from the primary CSS to prevent construction phase work from impacting existing systems. The CSS QA will be configured to match the primary CSS capability and allow testing of all CSS functions including historical trending and alarm reporting.
- H. Field Panel Independence: The BCs, AACs, ASCs, and SDs shall monitor, control, and provide the field interface for all points specified. Each BC, AAC, or ASC shall be capable of performing all specified energy management functions, and all DDC functions, independent of other BCs, AACs, or ASCs and operator interface devices as more fully specified in Section 25 1413 - Integrated Automation Remote Control Panels.

#### 1.09 WARRANTY MAINTENANCE

- A. All references to the term 'Contractor' shall mean both the BAS Contractor and contractors providing installation services.
- B. The contractor shall warrant all BAS products and labor for a period of two years after substantial completion.
- C. The Owner reserves the right to make changes to the BAS during the warranty period. Such changes do not constitute a waiver of warranty. The Contractor shall warrant parts and installation work regardless of any such changes made by the owner.
- D. Maintenance Services: During the warranty period, the Contractor shall provide maintenance services for software and hardware components as specified below, at no additional cost. The AU BAS department will be the Owner's authorized representative for all service requests:
  1. Maintenance services shall be provided for all devices and hardware supplied by the BAS Contractor. Service all equipment per the manufacturer's recommendations. All devices shall be calibrated within the last month of the warranty period. An update to the points

Information Block detail of the points definition in the CSS shall be added indicating the date of calibration and initials of the technician performing calibration.

2. Emergency Service: Any malfunction, failure, or defect in any hardware



component or failure of any control programming that would result in customer impact, property damage or loss of comfort control shall be corrected and repaired following notification by the Owner to the Contractor.

- a. If the malfunction, failure, or defect is not corrected through remote communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the Owner's site.
3. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following notification by the Owner to the Contractor.
  - a. If the malfunction, failure, or defect is not corrected through remote communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the Owner's site on the next available business day.
4. Technical Support: Contractor shall provide remote technical support throughout the warranty period.
5. Preventive Maintenance: Preventive maintenance shall be provided throughout the warranty period in accordance with the hardware component manufacturer's requirements.
6. Product Updates: Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. Do not install updates or upgrades without Owner's written authorization.

#### 1.10 DELIVERY, STORAGE, AND HANDLING

- A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials indoors, within manufacturer's specified environmental conditions and protect from construction work, weather and theft.

#### 1.11 LISTING AND LABELING

- A. The BAS and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.
- B. Portions of the BAS utilized for fire/smoke management, stairwell pressurization controls and monitoring shall be listed by Underwriters Laboratories (UUKL 864).

#### 1.12 OWNERSHIP OF PROPRIETARY MATERIAL

- A. Project specific software and documentation shall become the Owner's property. This includes, and is not limited to:
  1. System database structure project files.



2. System custom code project files.
3. System graphic project files.
4. Record Drawings of all file types, including the Design File Format of all project drawings.
5. Documentation

## PRODUCTS

### 2.01 MATERIALS AND EQUIPMENT

- A. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where drawings or specifications specifically allow existing materials to remain in place or be reinstalled.
- B. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.
- C. No product lines or materials should be used that are listed on an end-of-life or sunset schedule from the manufacturer. Product documentation of product line and/or materials production status to the Owner if requested.

### 2.02 UNIFORMITY

- A. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same OEM manufacturer.

### 2.03 PRODUCTS NOT FURNISHED NOR INSTALLED BUT INTEGRATED WITH WORK OF THIS SECTION

- A. Coordination Meetings: The Contractor shall coordinate meetings between the BAS Contractor and the Installers(s) furnishing each of the following products to coordinate the details of the interface between these products and the DDC network. The Owner or his representative shall be present at every coordination meeting. Submittals for these products shall not be approved prior to the completion of this meeting. Any issues identified during these meetings must also be resolved satisfactorily and with agreement between the BAS Contractor and the Installer(s) prior to the submittal being approved. Each Installer shall provide the Owner and BAS Contractor and all other Installers with the details of the proposed interface including the following.
  1. BACnet PICS
  2. Point List
  3. Wiring Requirements
  4. Communication Specifications for speed, type etc.
  5. Required Network Accessories
  6. (3) Past Examples of Integration to the proposed BAS at the Field Panel (BC) communication Level of the Architecture.



7. Network Identifiers
  - B. Communications with Third Party or Factory Controlled Equipment:
    1. Any additional integral control systems included with the products integrated with the work of this section shall be furnished with an interface for integration into the Direct Digital Control system described in this section.
    2. The integration shall be of the following methods determined during the coordination meetings:
      - a) Hardwired connection such as relay, 0-10VDC, or 4-20mA
      - b) BACnet/IP network connection. (Only for panel level)
      - c) MODBUS network connection. (Only for utility)
      - d) BACnet MS/TP network connection
  - C. Decentralized HVAC Equipment
    1. Unit Ventilators, Unit Heaters, Fan Coils, etc.: Unit ventilators, unit heaters, fan coils, cabinet heaters, convective or fin tube heaters, zone reheat, and similar terminal units. These units shall be furnished and configured to accept control inputs from an external building automation system controller.
  - D. Variable Frequency Drives
    1. Variable Frequency Drives: The variable frequency drive (VFD) vendor shall furnish all VFDs with an interface to the BAS. The specified interface points shall be the minimum acceptable interface to the VFD. The connection to these points shall be of the following methods determined during the coordination meetings:
      - a) Hardwired connection such as relay, 0-10VDC, or 4-20mA
      - b) BACnet/IP network connection
      - c) BACnet MS/TP network connection

## EXECUTION

### 3.01 INSPECTION

- A. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.

### 3.02 CONSTRUCTION COORDINATION

- A. Test and Balance:
  1. BAS Contractor Support:
    - a) The BAS Contractor shall provide the Test and Balance Contractor with access to the control system for testing and balancing.
    - b) The BAS Contractor shall train the Test and Balance Contractor as necessary.
- B. Electrical Coordination:
  1. The BAS Contractor shall coordinate all facets of the BAS installation.



2. The BAS Contractor shall validate the accuracy, fit and finish of all installed BAS Electrical work results in comparison to the BAS Design documents, during the project.
- C. Third Party Coordination:
1. The BAS Contractor shall be the systems integrator for all third-party control systems that must interface with the BAS.
  2. Each supplier shall comply with the communication media, software and equipment as specified in Section 25 5500.
  3. Each supplier of a control product shall configure, program, start up, and test that product to meet the sequences of operation regardless of where within the contract documents those products are described.
  4. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
  5. BAS Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

### 3.03 WIRING

- A. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26, and manufacturer's recommendations.
- B. NEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.
- C. Install wiring in raceways subject to mechanical damage and at levels below 3 m (10ft) in mechanical, electrical, or service rooms.
- D. Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.
- E. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.
- F. Include one pull string in each raceway 1.8 cm (3/4 in.) or larger.
- G. Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.
- H. Conceal raceways except within mechanical, electrical, or service rooms.
- I. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Do not use flexible metal raceway less than 1/2 in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.
- J. Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions.



- K. Make terminations in boxes with fittings. Do not make terminations in boxes with bushings.
- L. Do not make splices in plenum wire.
- M. All splices made shall be placed within a box or enclosure and labeled as a BAS splice on the cover.
- N. All raceways will be labeled as BAS.

### 3.04 COMMUNICATION WIRING

- A. Install communication wiring in separate raceways and enclosures from other wiring.
- B. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.
- C. Label communication wiring to indicate origination and destination.
- D. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:
  - 1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot).
  - 2. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
  - 3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard.
  - 4. An MS/TP EIA-485 network shall have no T connections.
- E. AU will provide all BC's and Third Party Integration Devices (e.g. All BACnet/IP devices) with an Ethernet connection point.

### 3.05 WARNING LABELS

- A. Affix permanent warning labels to equipment that can be automatically started by the control system.
  - 1. Labels shall use white lettering (12-point type or larger) on a red background.
  - 2. Warning labels shall read as follows:

**CAUTION**

This equipment is operating under automatic control and may start or stop at any time without warning.

Switch disconnect to "Off" position before servicing.

- B. Affix permanent warning labels to motor starters and control panels that



- are connected to multiple power sources utilizing separate disconnects.
1. Labels shall use white lettering (12-point type or larger) on a red background.
  2. Warning labels shall read as follows:

**CAUTION**  
This equipment is fed from more than one power source with separate disconnects.  
Disconnect all power sources before servicing.

### 3.06 IDENTIFICATION OF HARWARE AND WIRING

- A. Label wiring and cabling, with control system identification information, at each end within 5 cm (2 in.) of termination.
- B. Permanently label or code each point of field terminal strips to show instrument or item served.
- C. Label control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.
- D. Label each control component with a permanent label. Label plug-in components such as label remains stationary during component replacement.
- E. Label room sensors related to terminal boxes or valves with nameplates. Ensure the nameplate is aesthetically pleasing and unobtrusive to the room sensors functionality or design.
- F. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.
- G. Label identifiers shall match record documents.

### 3.10 CONTROL PANELS, CONTROLLER QUANTITY AND LOCATION

- A. Control panels shall consist of one or multiple controllers to meet the requirements of this specification. Control panels shall be wall mounted within mechanical equipment rooms. Electrical equipment rooms may be used with prior Owner approval. In no case shall panels, other than terminal unit controllers, be located above ceilings.
- B. Restrictions in applying controllers are specified in Section 25 14 13 - Integrated Automation Remote Control Panels. If the BAS contractor wishes to further distribute panels to other locations, the Contractor is responsible for extending power to that location also. Furthermore, the Contractor is responsible for ensuring adequate locations for the panels that do not interfere with other requirements of the project and maintain adequate clearance for maintenance access.



- C. It is the BAS Contractor's responsibility to provide enough controllers to adequately accomplish the sequence of operations and the required point lists plus an added 20% of each of the available point types, AI, AO, BI, BO. No controller installed shall exceed 80% of the point capacity of each of the four point types, AI, AO, BI, BO. This does not apply to those controllers on the Secondary Controller LAN.
- D. Point expansion modules shall be considered an extension of the controller they are connected to and as such are integral to that controller. Point expansion modules shall comply with the same installation rules as the controller they are connected to regardless of the actual LAN they are communicating upon.
- E. Controllers for terminal equipment:
  - 1. For equipment located in the conditioned space, controllers shall be mounted inside the unit enclosure. Where sufficient mounting space is not available inside the unit enclosure, a control panel shall be installed above the ceiling, inside the room, as close to the room space sensor as possible with the exception of spaces with impenetrable hard ceilings, in which case the controller shall be mounted above the ceiling in an adjacent hallway as close to the equipment served as possible. Coordinate with the AE and Owner to clarify acceptable mounting locations.
  - 2. For equipment located above drop ceilings, controllers shall be unit mounted within a plenum rated enclosure. Provide adhesive backed ceiling labels, affixed to ceiling grid below all ceiling concealed controllers, affix to ceiling panel access door for solid ceilings.

### 3.11 CONTROL POWER SOURCE AND SUPPLY

- A. Contractor shall extend all power source wiring required for operation of all equipment and devices included within the BAS.
- B. General requirements for obtaining power include the following:
  - 1. All control panels shall be served by dedicated power circuits. BC control panels served by stand-by power circuits shall additionally be provided with one of the following.
    - a) As Primary selection, a dedicated available UPS circuit from the buildings UPS system to meet the requirements for BC power failure operation in Section 25 1413 - Integrated Automation Remote Control Panels.
    - b) As Secondary selection, an external UPS power supply to meet the requirements for BC power failure operation in Section 25 14 13 - Integrated Automation Remote Control Panels. Control panel shall be labeled with electrical panel name & circuit number.
  - 2. Where a controller controls multiple systems with varying levels of power reliability (normal, stand-by, and/or interruptible), the controller shall be powered by the highest level of reliability taking into account the space restrictions mentioned above.



3. For all controlled equipment operating with an available stand-by generator the control panel must be powered from the same power source including the same automatic transfer switch for normal or stand-by power.
  4. Standalone Functionality: Refer to Section 25 14 13 - Integrated Automation Remote Control Panels.
  5. Obtain power from a source that feeds the equipment being controlled such that both the control component and the equipment are powered from the same MCC or panel. Where equipment is powered from a 460V source, obtain power from the electrically most proximate 120 VAC source fed from a common origin.
  6. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment's control transformer is large enough and of the correct voltage to supply the controls it may be used. If the equipment's control transformer is not large enough or of the correct voltage to supply the controls provide separate transformer.
- C. Power Supplies: Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

### 3.12 SURGE PROTECTION

- A. The Contractor shall furnish and install any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BCs, AAC/ASCS operator interfaces, routers, gateways and other hardware and interface devices. All equipment shall be capable of handling voltage variations 10% above or below measured nominal value, with no effect on hardware, software, communications, and data storage. CUs and panels shall have suppressors to protect against lightning damage, induced voltage from other equipment, and RF interference as applicable.

### 3.13 DEMOLITION AND REUSE OF EXISTING MATERIALS AND EQUIPMENT

- A. Existing control modules that will be replaced as part of this project are to be turned over to AU BAS department. All other existing control devices and panels that will not be reused are to be removed from the site.
- B. Existing electrical service to control panels or devices that will not be reused must be properly terminated and secured per NEC requirements. Label wire with the panel and circuit breaker.
- C. Existing valves and dampers and their operators shall be reused, except where noted to be removed or provided as new. The contractor shall lubricate all damper linkages of dampers being controlled under this project.
- D. Other materials and equipment not specifically mentioned herein may be reused only if specifically allowed by indications on the drawings.
- E. Where existing wall mounted devices are removed in finished spaces,



comply with the requirements of Division 01.

- F. Removed materials and equipment shall be subject to the requirements of Division 01.
- G. For systems with existing workstation graphics, the existing graphic must be entirely removed from the system including all links and references and replaced with a new graphic meeting all requirements of these BAS Sections. If renovation is only partial, graphics for existing equipment to remain shall have links to changed or removed equipment updated.
- H. Existing system points shall be released. Partial system renovations shall not be split between old and new points. All points shall be created or recreated to meet the requirements of these BAS guidelines.

### 3.14 SEQUENCE OF WORK

- A. General: All work involving changeover of control functions from existing systems to the new BAS shall be performed in accordance with the following sequence to minimize the duration of equipment outages. The following descriptions are intended to indicate the sequence in which the work shall be performed, not to define fully the scope of the work.
- B. Install construction server, operator's terminal, peripherals, graphic software, and LAN prior to placing any equipment under the control of the new BAS.
- C. Work which requires shutting down a pump motor, fan motor, or chiller shall be considered a utility shutdown and shall be subject to the restrictions specified in Division 01.
- D. The following sequence applies to an individually controlled HVAC subsystem, such as an air handling unit. Only one such system shall be placed under manual control (as described below) at any given time.
  - 1. Install CUs adjacent to (or within) existing control panel. Programming shall be complete (except for loading and debugging) prior to installation. Install all field devices which do not require interruption of the existing system.
  - 2. Install all conduit and wiring which does not require interruption of the existing system.
  - 3. Remove existing controls including wiring and conduit (except materials to be reused in accordance with provisions specified elsewhere) which must be removed to facilitate installation of new BAS materials and equipment.
  - 4. Remove existing digital points. Install and calibrate the remainder of new BAS materials and equipment for this subsystem. Load CU software. Connect CU(s) to LAN.
  - 5. Perform all field testing and calibration that does not require connection of permanent outputs.
  - 6. Notify the contracting officer prior to this step. Place the system under the control of the new BAS equipment. Conclude field testing and submit field-testing report prior to placing the next subsystem under control.



7. Remove remaining existing materials and equipment (except materials to be reused in accordance with provisions specified elsewhere). All existing equipment for those subsystems that have not yet been converted shall remain intact, on-line, and fully functional.

3.15 BAS START UP, COMMISSIONING AND TRAINING

- A. Refer to Commissioning requirement guidelines.

3.16 SEQUENCE OF OPERATION

- A. Refer to Project Manual and Drawings for specific requirements.

END OF SECTION



## 25 55 00.13 CONTROL OF HVAC OBJECT NAMING CONVENTION

### GENERAL

#### 1.01 SECTION INCLUDES:

- A. Outline of the naming requirements for all BAS objects.

#### 1.02 DEFINITIONS

- A. Object: Any named software or hardware component contained in the BAS.
- B. Object Descriptor: A 16-character free text attribute of a BAS object.

### PRODUCTS

#### 2.01 GENERAL:

- A. This object naming convention is to be applied to the project BAS and all integrated systems.
- B. Its design and modifications are wholly owned and approved by the Owner.
- C. The object naming convention applies to those objects with unique naming requirements within the BAS and any integrated system. The BAS contractor is always the systems integrator for third party control systems and as such owns the responsibility to ensure all objects conform to the naming convention prior to implementation.
- D. The naming of objects shall be consistent in the project documents, drawings, specifications, equipment labeling and graphics.
- E. Any variance as required to perform a particular function with any project application shall be reviewed and approved during that projects BAS review period.
- F. The BAS Contractor should submit periodic proposals for updates to include new system and device names as they may apply to any project.

#### 2.02 OBJECT NAMING CONVENTION

##### A. General:

1. All objects shall conform to the following convention:
  - a) BUILDING.MACROLEVELSYSTEM.SUBSYSTEM.DEVICEDESC  
RIPTOR
2. Each object name segment shall conform to the specific requirements defined herein.
3. The maximum character limit is 30 characters including all period (.) characters.
4. All object names shall be defined using all capital characters.
5. Only the period (.) character shall be used to delimit the segments of the object name.



## 2.03 CHANGE CONTROL

### A. General:

1. When adding new list objects to this standard object naming convention the standard format in the list is:
  - a) OBJECTLISTITEMTEXT; Description
  - b) The semi-colon is not part of the object list item text.
2. Update the Revision Number at the beginning of this document by one for each new version of the document published to the Standards Library.
3. All modifications shall be placed in alphabetically correct order.

## 2.04 OBJECT NAME SEGMENTS

### A. CAMPUS Segment:

1. The first segment of the object name.
2. This should not be more than 3 characters in length.

### B. BUILDING Segment:

1. The second segment of the object name
2. This segment should not be more than 3 characters in length.
3. There shall be no period (.) character contained within the BUILDING segment.
4. This segment shall not be more than 5 characters in length, including a trailing period (.) character

### C. MACROLEVELSYSTEM Segment:

1. The second segment of the object name
2. This segment is to describe the system containing the devices in the building.
3. This segment should not be more than 10 characters in length, including a trailing period (.) character providing consideration for overall object naming consistency.
4. Only MACROLEVELSYSTEMS contained in the MACROLEVELSYSTEMS List are permitted.
5. Any MACROLEVELSYSTEM can be succeeded by a numeral to indicate the sequence number for the system being given the name. The numeral is not delimited with a period (.).

### D. SUBSYSTEM Segment:

1. The third segment of the object name
2. This segment is to describe the subsystems within the MACROLEVELSYSTEM segment in the building.
3. This segment should not be more than 8 characters in length, including a trailing period (.) character providing consideration for overall object naming consistency.
4. Only SUBSYSTEMS contained in the SUBSYSTEMS List are



permitted.

5. Any SUBSYSTEM can be succeeded by a numeral to indicate the sequence number for the system being given the name. The numeral is not delimited with a period (.).

E. DEVIDEDESCRIPTOR Segment:

1. The fourth and last segment of the object name
2. This segment is to describe the devices that are contained within a MACROLEVEL system in the building.
3. This segment should not be more than 8 characters in length providing consideration for overall object naming consistency.
4. Only DEVIDEDESCRIPTORS contained in the DEVIDEDESCRIPTORS List are permitted.
5. Any DEVIDEDESCRIPTOR can be succeeded by a numeral to indicate the sequence number for the system being given the name. The numeral is not delimited with a period (.).
6. Combining multiple DEVIDEDESCRIPTORS is permitted and shall not be delimited with a period (.) character.
7. When combining DEVIDEDESCRIPTORS it is expected the order of combining be dictated by the actual real English Language pronunciation of the device. Approve all device names during project application of the object naming convention and prior to any implementation.

## 2.05 CAMPUSNAME LIST

1. MC; Main Campus
2. WCL; Washington College of Law
3. EC; East Campus
4. CONN; 4401 Connecticut Ave.

## 2.06 BUILDING NAME LIST

3301 NEW MEXICO – 3301 New Mexico Avenue  
3244 NEBRASKA AVE – 3244 Nebraska Avenue  
4124 WARREN – 4124 Warren Street  
4401 CONN – 4401 Connecticut Avenue  
4545 42ND ST – 4545 42<sup>nd</sup> Street  
45TH STREET – 45<sup>th</sup> Street Field  
4621 ROCKWOOD – 4621 Rockwood Parkway  
4625 ROCKWOOD – 4625 Rockwood Parkway  
4629 ROCKWOOD – 4629 Rockwood Parkway  
4633 ROCKWOOD – 4633 Rockwood Parkway



4810 ROCKWOOD – 4810 Rockwood Parkway  
AH – Anderson Hall  
ASB – Asbury Building  
BCC – Media Production Center  
BE – Beeghly Building  
BL – Bender Library  
BP – Butler Pavilion & Arcade  
BT – Battelle-Tompkins  
CA – Cassell Hall  
CDC – Child Development Center  
CH – Capital Hall  
CK – Clark Hall  
CN – Centennial Hall  
CNST – Constitution Building  
DBR – Duber Hall  
DH – Dunblane House  
DMTIB – Don Meyers Technology & Innovation Building  
FDRL – Federal Hall  
GB – Greenberg Theatre  
GR – Gray Hall  
HA – Hamilton Building  
HF – Hockey Field  
HH – Hughes Hall  
HOS – Hall of Science  
HU – Hurst Hall  
ISB – School of International Services  
KA – Katzen Arts Center  
KH – Kerwin Hall  
KB – Kogod School of Business  
KR – Kreeger Hall  
KS – Kay Spiritual Life Center  
LFS – Jack Childs Language & Foreign Studies  
LTH – Letts Hall  
LH – Leonard Hall  
MCB – McCabe Hall  
MGC – Mary Graydon Center



MH – McDowell Hall  
MK – McKinley  
MPF – Multi-Purpose Field  
MS – Washington College of Law Maintenance Shop  
NH – Nebraska Hall  
NMA – New Mexico Avenue  
OS – Osborn Building  
PB – President’s Office Building  
PG – East Campus Parking Garage  
PR – President’s Residence  
RB – Rockwood Building  
RH – Roper Hall  
SC – Sports Center/Bender Arena  
SCA – Sports Center Annex  
SCLOT – Sports Center Parking Garage  
SV – Spring Valley Building  
TB – Transmitter Building  
VM – Vehicle Maintenance Shop  
WA – Watkins  
WB – Warren Building  
WCLPG – Washington College of Law Parking Garage  
WIS – 4200 Wisconsin Avenue  
WS – Wesley Seminary  
YH – Yuma Hall

## 2.07 MACROLEVELNAME LIST

1. AHU#; Air Handling Units
2. ALN#; Automation Level Network
3. ATS#; Transfer Switch Systems
4. BLDG#; Building Systems
5. BLN#; Building Level Network
6. BLR#; Boiler Systems
7. CABHT; Cabinet Heaters
8. CAS#; Control Air Systems
9. CHLR#; Chiller Systems
10. CHP#; Chilled Water Pump
11. CHW#; Chilled Water Systems



12. CDP#; Condenser Water Pump
13. CDW#; Condenser Water Systems
14. CHM#; Chemical Treatment Systems
15. CPS#; Condensate Pump Systems
16. CRU#; Computer Room Unit
17. CT#; Cooling Tower System
18. CUH#; Cabinet Unit Heater
19. CW#; Condenser Water System
20. DCW#; Domestic Cold Water Systems
21. DHW#; Domestic Hot Water Systems
22. DWP#; Domestic Hot Water Pump
23. DX#; Direct Expansion Systems
24. EDH#; Electric Duct Heater
25. EF#; Exhaust Fan Systems
26. FAN#; Miscellaneous and General Purpose Fan Systems
27. FA#; Fire Alarm Systems
28. FCW#; Fan Coil Units with water coil
29. FCX#; Fan Coil Units with DX cooling
30. FLH#; Floor Heating System
31. FLN#; Floor Level Network
32. FTR#; Fin Tube Radiator
33. GEN#; Emergency Generator
34. HRC#; Heat Recovery Systems
35. HX#; Heat Exchanger System
36. HWP#; Hot Water Pump
37. HWS#; Hot Water Systems
38. KW#; Electric and Electric Metering Systems
39. LT#; Lighting
40. LP#; Lighting Panel
41. MAU#; Make-up Air Systems
42. MER#; Mechanical Equipment Room Systems
43. REF#; Relief Fan
44. RF#; Return Fan
45. RM#; Room Objects (Where # is the room number)
46. SC#; Security
47. SDP#; Sand Pump
48. SF#; Supply Fan



- 49. SPR#; Sprinkler Room
- 50. SUMP#; Sump Pump Systems
- 51. TNK#; Tank Systems
- 52. UH#; Unit Heaters
- 53. ZN#; Zone Systems

## 2.08 DEVICEDESRIPTOR LIST

### A. General List

- 1. #; NUMBERS
- 2. AC; AIR COMPRESSOR
- 3. AFM#; AIR FLOW METERING DEVICES
- 4. ALM#; ALARM
- 5. ALN#; AUTOMATION LEVEL NETWORK
- 6. AVG#; AVERAGE
- 7. BLN#; BUILDING LEVEL NETWORK
- 8. BPV#; BYPASS VALVE
- 9. BSP#; BUILDING STATIC PRESSURE
- 10. BTU; BRITISH THERMAL UNIT
- 11. CAD#; COMBUSTION AIR DAMPER
- 12. CAV#; Constant Air Volume Terminal Box Control Systems
- 13. CCV#; COOLING VALVE
- 14. CDD#; COLDDECK DAMPER
- 15. CLS#; CLOSE
- 16. CMD#; COMMAND
- 17. CO#; CARBON MONOXIDE
- 18. CO2#; CARBON DIOXIDE
- 19. CUR#; AMPS
- 20. CW#; CONDENSER WATER DEVICES
- 21. DEW; DEWPOINT
- 22. DIV#; DIVERTING VALVE
- 23. DLK#; MAGNETIC DOOR LOCK
- 24. DP#; DIFFERENTIAL PRESSURE DEVICES
- 25. DPV#; DIFFERENTIAL PRESSURE VALVE
- 26. DSP#; DIFFERENTIAL PRESSURE SWITCH
- 27. DXS#; DX COOLING STAGE
- 28. EAD#; EXHAUST AIR DAMPER
- 29. ECON#; ECONOMIZER DEVICES
- 30. EMS#; EMERGENCY STOP SWITCH



31. ENB#; ENABLE/DISABLE COMMAND
32. ENTH#; ENTHALPY
33. EPO#; EMERGENCY POWER OFF BUTTON
34. ESW#; END SWITCH
35. FBD#; FACE BYPASS DAMPER
36. FC; FREE COOLING STATUS
37. FCV#; FLOW CONTROL VALVE
38. FF#; FLAME FAILURE
39. FIL#; FILTER STATUS (use State Text)
40. FIRE#; FIRE ALARM
41. FLN#; FLOOR LEVEL NETWORK
42. FLOW#; WATER OR AIR FLOW
43. GPM#; GALLONS PER MINUTE
44. H2#; HYDROGEN
45. HCV#; HEATING COIL VALVE
46. HDD#; HOTDECK DAMPER
47. HDP; HEAD PRESSURE
48. HLS#; HIGH/LOW SPEED COMMAND WITH FEEDBACK
49. HOA#; HAND-OFF-AUTO (Use state text)
50. HOUR#; TIME HOURS
51. HSP#; HIGH STATIC PRESSURE CUTOUT
52. HTS#; HEAT STAGE
53. HUV#; HUMIDITY VALVE
54. ILV#; INLET VANE
55. ISD#; ISOLATION DAMPER
56. ISV#; ISOLATION VALVE
57. L#; ADDITIONAL LEVEL INDICATOR
58. LGT#; LIGHTS
59. LL#; LEAD/LAG TOGGLE (Use enumerator)
60. LSP#; LOW STATIC PRESSURE CUTOUT
61. LTD#; LOW TEMPERATURE DETECTOR
62. LVL#; LEVEL SENSOR
63. LWT; LEAVING WATER TEMPERATURE
64. MAD#; MIXED AIR DAMPER
65. MAH#; MIXED AIR HUMIDITY
66. MAT; MIXED AIR TEMPERATURE
67. METR#; METERS (FLOW, KW)
68. MOIST#; MOISTURE SENSOR



69. MOT#; MOTION SENSOR
70. MXV#; MIXING VALVE
71. N2#; NITROGEN
72. NG#; NATURAL GAS
73. O2#; OXYGEN
74. OAD#; OUTSIDE AIR DAMPER
75. OAE#; OUTSIDE AIR ENTHALPY
76. OAH; OUTSIDE AIR HUMIDITY
77. OAT; OUTSIDE AIR TEMPERATURE
78. OPN; OPEN
79. PHO#; PHOTOCELL
80. PNT; PAN TEMPERATURE
81. PPM#; PARTS PER MILLION
82. PRF#; PROOF
83. PWR#; POWER
84. PWRFAIL#; ON POWER RETURN POWERFAIL POINT FOR PANELS
85. RAD#; RETURN AIR DAMPER
86. RAE; RETURN AIR ENTHALPY
87. RAH; RETURN AIR HUMIDITY
88. RAT; RETURN AIR TEMPERATURE
89. RCD#; RETURN AIR CARBON DIOXIDE
90. REF#; REFRIGERANT
91. RF#; RETURN (AIR) FAN
92. RMT; ROOM TEMPERATURE
93. RSD#; RETURN SMOKE DETECTOR
94. RSP#; ROOM STATIC PRESSURE
95. RWH#; ROOM HUMIDITY
96. RWT#; RETURN WATER TEMPERATURE
97. SAD#; SUPPLY AIR DAMPER
98. SAT#; SUPPLY AIR TEMPERATURE
99. SCD#; SUPPLY AIR CARBON DIOXIDE
100. SET#; SETPOINT
101. SF#; SUPPLY FAN
102. SFD#; SMOKE/FIRE DAMPER
103. SLT#; SLAB TEMPERATURE
104. SSP#; SUPPLY STATIC PRESSURE (Where # is for multiple sensors)
105. SS#; START/STOP



- 106. SSD#; SUPPLY SMOKE DETECTOR
- 107. START#; START (COMMAND ONLY)
- 108. STATUS#; STATUS
- 109. STB#; STROBE
- 110. SW#; SWITCH
- 111. SWT; SUPPLY WATER TEMPERATURE
- 112. TEC#; TERMINAL EQUIPMENT CONTROLLER
- 113. TECUP#; TEC UPDATE TRIGGER (used with Field Panel system name)
- 114. VAV#; Variable Air Volume Terminal Box Control Systems
- 115. VEP#; VELOCITY PRESSURE
- 116. VSD#; VARIABLE FREQUENCY DRIVE
  - a.) ALM; DRIVE FAULT/ALARM
  - b.) SPD; SPEED COMMAND (%)
  - c.) FBK; SPEED FEEDBACK (Hz)
  - d.) SS; START/STOP WITH STATUS
  - e.) PRF; RUN STATUS
- 117. ZCD#; ZONE CARBON DIOXIDE
- 118. ZN#; ZONE

## 2.09 SPECIAL CASES

- A. Usernames: Username assignment shall be based upon the requirements of a tenant. Approved and/or acceptable variations to the object naming standard shall be approved by the Owner prior to implementation.
- B. Siemens Program (PPCL) Naming Convention
  - 1. PPCL naming shall STRICTLY follow the object naming.
  - 2. All PPCL names shall be of the format convention;
    - a) PANELNAME.PPCL
    - b) PANELNAME is defined below and will be strictly adhered to.
- C. Field Panel Naming Convention
  - 1. Field Panels shall always be Ethernet connected devices to the FCE provided WAN/LAN.
  - 2. The Hostname and IP parameters of the device on the TCP/IP network shall be provided by the FCE IT Department. See the General BAS Specification for details.
  - 3. The Siemens System Name for the Field Panel shall follow the object naming standard as follows with the except of limited to 25 characters;
    - a) CAMPUSNAME.BUILDINGNAME.RM#.PNL#
    - b) RM# can also be MER# if the panel is located in a Mechanical Space as opposed to a Room with a number.



- D. Terminal Equipment Controllers Naming Convention
  - 1. All TEC equipment types (air boxes, fume hoods, lab controllers, etc. essentially all devices that reside on a floor level network) shall follow the object naming convention as detailed herein.
- E. Graphic Naming Convention
  - 1. All graphic names shall follow the object naming convention.
  - 2. SYSTEMNAME is equal to the SYSTEMNAME used by the majority of the objects the graphic contains.
  - 3. All background graphic files shall be named as follows;
    - a) CAMPUSNAME.BUILDINGNAME.SYSTEMNAME.dsf
  - 4. All Dynamic Graphics shall be named as follows, where (?) is variable;
    - a) CAMPUSNAME.BUILDINGNAME.SYSTEMNAME.?.GRA
  - 5. It is worthy to note here; the name of the graphic is not the name that Siemens would necessarily use when linking to the graphic as defined in the graphic specification of the Master BAS Specification. Graphic linking shall be descriptive and easily navigated.
- F. Report Naming Convention
  - 1. All reports created by Siemens shall follow the object naming convention
  - 2. All reports shall be named as follows, where (?) is variable;
    - a) CAMPUSNAME.BUILDINGNAME.SYSTEMNAME.?.RPT
- G. Network Naming Conventions
  - 1. All Networks shall have a full English Language description at the CSS.
- H. CU Naming Convention
  - 1. The HostName and IP parameters of the device on the TCP/IP network shall be provided by the Owner. See the General BAS Specification for details.
- I. Zone and Event Naming Convention
  - 1. All zones and events shall be named as follows;
    - a) CAMPUS.BUILDING.MACROLEVELNAME.ZN#
    - b) CAMPUS.BUILDING.MACROLEVELNAME.EV#

## EXECUTION

### 3.01 EXAMPLES

- A. Point Names;
  - 1. Anderson, Air Handling Unit 3, Discharge Air Sensor.
    - a) System Name: MAN.AH.AHU03.SAT
  - 2. McKinley, Air Handling Unit 2, down duct static sensor
    - a) System Name: MAN.MK.AHU02.SSP



3. Kerwin, cooling tower 3 fan speed feedback.
  - a) System Name: MAN.KE.CT03.VFD.FBK
4. Hughes, boiler system 2, pump 4 start/stop.
  - a) System Name: MAN.HH.BLR02.HWP04.SS
5. Gray, building differential pressure sensor.
  - a) System Name: MAN.GR.BDP
6. Clark, exhaust fan 4, start/stop.
  - a) System Name: MAN.CK.EF04.SS

END OF SECTION



## 25 95 00 CONTROL SEQUENCES FOR HVAC

### GENERAL

#### 1.01 SECTION INCLUDES

- A. Description of Work
- B. Control Sequences General Requirements
- C. System Specific Control Sequences

#### 1.02 DESCRIPTION OF WORK

- A. This Section defines the manner and method by which controls operate and sequence the controlled equipment.
- B. Included in this section are general requirements and logic strategies that supplement the specific sequences shown on the drawings and included in this Section and its sub-sections.
- C. Refer to the control drawings for specific sequences for individual systems.

#### 1.03 GENERAL REQUIREMENTS

- A. Sequences specified herein indicate the functional intent of the systems operation and may not fully detail every aspect of the programming that may be required to obtain the indicated operation. The contractor shall provide all programming necessary to obtain the sequences/system operation indicated.
- B. Refer to the control drawings for system and application specific sequences.

#### 1.04 PROGRAMMING REQUIREMENTS

- A. Unless specified otherwise, throttling ranges, proportional bands, and cycle differentials shall be centered on the associated setpoint. All modulating feedback control loops shall include the capability of having proportional, integral, and derivative action. Unless the loop is specified "proportional only" or "P+I", Contractor shall apply appropriate elements of integral and derivative gain to each control loop which shall result in stable operation, minimum settling time, and shall maintain the primary variable within the specified maximum allowable variance.
- B. All timing devices, alarm set points and control set points shall be adjustable. Set points listed herein for duct/room static pressure control, differential pressure control for discharge/intake isolation dampers, outside airflow control, return fan airflow tracking volume, and static pressure safeties are initial starting values.
- C. There are several control parameters (e.g., temperature, humidity, etc.) which are required to be maintained within a specified control tolerance. All specified control tolerances shall be met or exceeded.



- D. See Sections 25 55 00 for Control Accuracy and Reporting Performance Parameters for alarming configuration unless this Section provides specific values for any particular alarmable point.
- E. Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the BAS start commands shall be staggered by 5 second (adj.) intervals to minimize inrush current.
- F. Alarm messages specified throughout the sequences are assigned to discrete priority levels. Priority levels dictate the handling and destination of alarm reports and are defined in Section 25 15 16.
- G. Wherever a value is indicated as adjustable (adj.), it shall be modifiable, with the proper password level, from the operator interface or via a function block menu. For these points, it is unacceptable to have to modify programming statements to change the setpoint.
- H. All initial setpoints, ranges, flow coefficients and variables shall be written into the programming for each control system zone as comments and placed on the relevant graphic.
- I. All analog control values regardless of physical range, i.e., 0-10V, 4-20mA, etc., shall be configured to present a value between 0-100% where 0% is always closed and 100% is always open. AU requests the graphic show 0% open for a closed damper and 100% open for a fully open damper.
- J. All values that represent a number less than zero shall be represented with a minus sign in front of the number. An example, all exhaust static setpoints and pressures shall be negative.
- K. Whenever the BAS system senses the status of an operating component, whether the command is initiated or not, for instance if a drive is commanded to hand locally, the BAS shall operate all control loops.
- L. Wherever a value is indicated to be dependent on another value (i.e.: setpoint plus 5°F) BAS shall use that equation to determine the value. Simply providing a virtual point that the operator must set is unacceptable. In this case three virtual points shall be provided. One to store the parameter (5°F), one to store the setpoint, and one to store the value which is the result of the equation.
- M. All calculations that require establishing the state of a static pressure sensor shall perform the following:
  - 1. A failed sensor shall indicate as zero in the calculation.
  - 2. If multiple sensors are measuring a common system duct, the calculation shall not include the failed sensor.
  - 3. Failed sensor(s) shall be an alarm condition.
  - 4. A virtual point definition shall exist in the controller that requires the static status, not the controller providing the status. For example, an exhaust status point shall be defined in the supply controller and the programming setting its value shall reside in the exhaust controller.



- N. All variable geometry discharge dampers (VGDD's) shall be programmed per the following logic. All parameters to calculate and validate airflows shall be available, adjustable and initial settings hard coded in programming. The calculation to determine the proper control shall be as follows;
1. Loop Input: Fan Flow in CFM \* Current Discharge Opening in square feet.
  2. Loop Output: VGDD signal, scaled to 0-100% where zero is minimum.
  3. Loop Setpoint: EF Discharge Stack Flow Setpoint, initial value of 3500 feet per minute.
- O. To calculate the points required for proper chiller staging, use the following formulas;
1. Excess Capacity: This is equal to the rated tonnage of all online chillers minus the actual plant tonnage. The actual plant tonnage is equal to the sum of each chillers actual tonnage.
  2. Chiller Actual Tonnage: Chiller Tonnage Nameplate Rating\*Chiller Current Load Value. The Chiller Current Load Value is determined by the chiller control panel and provided to the BAS via the hard-wired Chiller Load point. This value is received and displayed as a percentage, but for this calculation, it shall be converted to a decimal.
- P. Sensor Control: The required standards for programming to address a sensors ability to be disabled from control while in maintenance mode or failed shall be as follows;
1. Virtual AI = (Sensor Status)\*(Sensor Maintenance Mode)\*(Sensor Actual Value)
    - a) Virtual AI is the virtual analog input value used for any calculation or input control. In some cases, for example exhaust static sensors, the minimum of a number of these values would be used as the input for control.
    - b) Maintenance Mode is a Virtual BO so its value is always zero or one.
    - c) Sensor Status is always either Failed (value = 0) or Normal (value = 1).
- Q. Access Control to Laboratories, Vivarium and Museums Variables:
1. All setpoints, operational mode points, control points shall be placed on the zone/space parameters graphic and protected from change by the highest level of operator access control.

#### 1.05 SCHEDULING TERMINOLOGY

- A. When a control system is scheduled throughout the day, the following defines the terminology used:

Occupied Period: The period when the area served by the specific control system or zone is in use and occupied. Coordinate the initial occupied schedule with AU. Generally, systems will be fully operational throughout



this period and ventilation air shall be continuously introduced. Initial space temperature setpoints shall be applied per the American University Temperature Policy. Request the current AU Temperature Policy parameters from the AU BAS Department prior to entering set points.

2. Unoccupied period: The period when the area served by the specific control system or zone is not in use and unoccupied. By default, all Federal holidays (see AU website for list of observed Federal holidays) shall be unoccupied periods with the capability to modify in the future.
3. Preoccupancy Period: A time span prior to the Occupied period. Examples are AHU warm-up and cool-down. AHU Economizers will function normally. The duration and start time of this period shall be determined by an optimum start strategy unless otherwise specified.
4. Setback Period: This period will typically start with the end of the occupied period and end with the start of the preoccupancy period; however, it shall be provided with its own schedule. Generally, systems will be off except to maintain a “setback” temperature.
5. Demand Response Period: This period is available during all other periods. When activated the control system is placed into a shutdown mode in order to reduce energy consumed.

#### 1.06 RESET STRATEGIES

- A. Where reset action is specified in a sequence of operation, but a reset schedule is not indicated on the drawings, one of the following methods shall be employed:
  1. The contractor shall determine a fixed reset schedule that shall result in stable operation and shall maintain the primary variable within the specified maximum allowable variance.
  2. A floating reset algorithm shall be used which increments the secondary variable setpoint (setpoint of control loop being reset) on a periodic basis to maintain primary variable setpoint. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance.
- B. Where a supply air temperature setpoint is specified to be reset by the space temperature of the zones calling for the most cooling/heating, the following method shall be employed:
  1. A floating reset algorithm shall be used which increments the secondary variable, supply air temperature setpoint, on a periodic basis to maintain primary variable (e.g. space temperature) setpoint. The reset increment shall be determined by the quantity of “need heat” or “need cool” requests from individual Terminal Control Units. A TCU’s “need heat” virtual point shall activate whenever the zone’s space temperature falls below the currently applicable (occupied or unoccupied) heating setpoint throttling range. A TCU’s “need cool” virtual point shall activate whenever the zone’s space temperature rises above the currently



applicable (occupied, unoccupied, or economy) cooling setpoint throttling range. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. Reset range maximum and minimum values shall limit the setpoint range.

- C. Where a duct pressure, or differential water pressure setpoint is specified to be reset by valve or damper position of the zone or zones calling for the most cooling/heating, the following method shall be employed:
  - 1. A floating reset algorithm shall be used which increments the secondary variable (e.g., pipe or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. cooling valve, heating valve, damper position) setpoint of 85% open. The reset increment shall be calculated based on the average position of the quantity of the worst (most open valve/damper) zone(s) as specified. The recalculation time, reset increment and control device position influence shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. The BAS analog output value shall be acceptable as indicating the position of the control device.
  - 2. Alternatively, to continuously calculating the average of the quantity of worst valve/damper positions, a method similar to the one described above may be employed whereby the “need heat” or “need cool” virtual point shall increment by one unit each time a zone’s valve/damper position rises to greater than 95%. The quantity of “need heat” or “need cool” points shall then be the basis for reset.

## 1.07 PROOF STRATEGIES

- A. Where “prove operation” of a device (generally controlled by a digital output) is indicated in the sequence, it shall require the BAS, after an adjustable time delay after the device is commanded to operate (feedback delay), confirm that the device is operational via the status input.
- B. If the status point does not confirm operation after the time delay or anytime thereafter for an adjustable time delay (chatter delay) while the device is commanded to run, an alarm shall be enunciated audibly and via an alarm message at the operator interface and print at the alarm printers. A descriptive message shall be attached to the alarm message indicating the nature of the alarm and actions to be taken. The contractor shall provide messages to meet this intent.
- C. Upon failure, the run command shall be removed, and the device shall be locked out in software until the alarm is manually acknowledged unless specified otherwise.



## PRODUCTS

### 2.01 NOT USED

## EXECUTION

### 3.01 PROJECT SYSTEM NAMING

- A. All objects contained within the BAS shall use the Object Naming specification. See Section 25 5500.13 for details.

### 3.02 GENERAL

- A. Emergency Shutdown is a special software switch that when activated must command all air moving equipment OFF and exterior dampers (outside air, exhaust air, relief air) CLOSED. Coordinate integration of this network point with all fans and dampers under BAS control for this project.

Provide building level software button for all systems to shutdown per building, and campus level software button for all system on campus to shut down. Integrate manual shutdown button in central plant with campus level shutdown sequence.

- B. Outside air sensor backup programming: Whenever the local building outside air sensor is determined to have failed or be unreliable by the BAS the BAS shall automatically connect to a remote outside air sensor for outside air data.
- C. Winter Break Setback is a special software switch that when activated sets all zone level terminal units and single zone space control equipment to a heating setback temperature setpoint of 53 degrees F (adj.). The Winter Break Setback switch shall automatically revert to normal temperature setpoints at the end of the Winter Break scheduled period.
- D. Zone temperature adjustment: Provide a means for the BAS operator to adjust space temperature set points per space, per floor, or per building. For example, there shall be a means for the BAS operator to change all of the space temperature set points in a building from a single operation and not require the operator to change the set point at each space separately.

### 3.03 AIR HANDLER UNITS

- A. When an air handling unit is not in operation, control devices shall remain in their "off" positions. "Off" positions may differ from the "normal" (meaning failed) position. Except as specified otherwise, "off" and "normal" positions of control devices shall be as follows:



Device	“Off” Position	“Normal” Position
Heating Coil Valves	Closed/Controlling	Open
Cooling Coil Valves	Closed	Closed
Outside Air Damper	Closed	Closed
Return Air Damper	Open	Open
Exhaust Air Damper	Closed	Closed
Var. Freq. Drive	Off	Min. Speed

B. Logic Strategies: The BAS shall fully control the air handlers. Generally, the BAS shall energize the AHU (start the fans and activate control loops) as dictated for each air handler. The following indicates when and how the BAS shall energize the AHUs and control various common aspects of them:

1. Scheduled Occupancy: BAS shall determine the occupancy periods (occupied, unoccupied, preoccupancy, and setback) as defined above. The following details the common control aspects related to the scheduled occupancy.
  - a) Occupied Period: BAS shall energize the AHU during all occupied periods. Note that the beginning of the occupancy period shall be set sufficiently before the actual start of occupancy to obtain the required building component of ventilation per ASHREA 62. Minimum OA flow setpoint shall be as scheduled on the drawings. “Normal” setpoints shall apply.
  - b) Unoccupied Period: Minimum OA flow shall be 0 CFM or the minimum OA damper position shall be 0%. If during the unoccupied period there is a request for occupancy override, the occupancy mode shall become active for an adjustable period. The unoccupied period and the preoccupancy period will typically overlap.
  - c) Setback Period: the BAS shall deenergize the unit except as required to maintain a setback temperature as indicated in the individual sequences with a 5°F cycle differential. Generally, where setback temperatures apply in multiple zones, the worst zone shall control the system. Setback setpoints generally apply except during preoccupancy [and night purge]. If during the unoccupied period there is a request for occupancy override, the occupancy mode shall become active for an adjustable period.
  - d) Preoccupancy: BAS shall energize the AH continuously during the preoccupancy period. Minimum OA flow shall be 0 CFM or the minimum OA damper position shall be 0%. “Normal” setpoints shall apply. Preoccupancy duration shall be one of the following as specified by reference:
    - 1) Fixed: The duration of the preoccupancy period shall be fixed



as scheduled by the operator.

- 2) Optimum: The duration of the morning warm-up period shall vary according to outside air temperature and space temperature such that the space temperature rises to occupied period heating setpoint at the beginning of, but not before, the scheduled occupied period. The duration of the cool-down period shall vary according to outside air temperature and space temperature such that the space temperature falls to the occupied period cooling setpoint at the beginning of, but not before, the scheduled occupied period
2. Minimum OA Control: BAS shall maintain minimum ventilation during the occupied period. The following strategies may apply:
    - a) Balanced Position: During the occupied period, applicable mixing and OA dampers shall never be positioned less than the position set for the required minimum OA ventilation rate. If the air handler has a single OA damper that is capable of economizer, the minimum position output shall be determined by the balancer. If the AH has a two-position minimum OA damper, that position shall be fully open to its balanced position. This logic strategy is only applicable to constant volume AHs.
    - b) Reset Balanced Position: During the occupied period, applicable mixing and OA dampers shall never be positioned less than the minimum position. The minimum position shall be reset between limits of a position delivering system exhaust make-up air CFM and the design minimum position delivering design minimum CFM to maintain a CO<sub>2</sub> setpoint of 400 ppm (adj.) above the outdoor air CO<sub>2</sub> level. Loop shall be a “sample and bump” or dynamic proportional only loop tuned for the slow response. The balancer shall determine the minimum position outputs at both extreme points. This logic strategy is only applicable to constant volume AHUs.
    - c) Damper Controlled Fixed: During the occupied period, applicable mixing dampers shall be modulated to maintain an OA flow rate of no less than the minimum ventilation requirement (MVR) as dictated in the design and required by code. Setpoint flow rates shall be provided by the A/E.
    - d) Damper Controlled Reset: During the occupied period, applicable mixing dampers shall be modulated to maintain an OA flow rate setpoint. Setpoint shall be reset between limits of system exhaust make-up air CFM and the design minimum CFM to maintain an RA CO<sub>2</sub> setpoint of 900 ppm (adj.). Loop shall be a “sample and bump” or dynamic proportional only loop tuned for the slow response. Setpoint flow rates shall be provided by the A/E.
    - e) Mixed Air Temperature Control: Minimum position of the OA damper shall be set to obtain the design required minimum OA. This balanced minimum position shall remain fixed.



Whenever the minimum loop is active BAS shall control the dampers to maintain a mixed air temperature setpoint that will be 2°F below AHU discharge air temperature cooling setpoint (adj.).

3. VAV Return Fan Capacity Control: BAS shall control the output of the return fan as follows:
  - a) Flow Tracking: The return air fan shall run to maintain a return flow setpoint of the supply flow minus an offset value. The offset value shall be determined as follows.
    - 1) Fixed Differential: It shall be fixed at the design minimum OA value.
    - 2) Differential Reset from RA CO<sub>2</sub>: It shall be reset between limits of system exhaust make-up air CFM and the design minimum CFM to maintain an RA CO<sub>2</sub> setpoint of 900 ppm (adj.). Loop shall be a “sample and bump” or dynamic proportional only loop tuned for the slow response. Setpoint flow rates shall be provided by the A/E.
    - 3) Differential Reset From Measured OA to Maintain Fixed OA: It shall be reset to maintain the measured minimum OA flow at the design value any time the economizer mode is inactive. Whenever it is inactive, it shall be set to the value that existed when the unit became active.
    - 4) Differential Reset From Measured OA to Maintain Reset OA: When the economizer mode is inactive, it shall be reset to maintain the measured OA flow setpoint. The OA setpoint shall be reset between limits of system exhaust make-up air CFM and the design minimum CFM to maintain a CO<sub>2</sub> setpoint of 900 ppm (adj.). Loop shall be a “sample and bump” or dynamic proportional only loop tuned for the slow response. Setpoint flow rates shall be provided by the A/E. Whenever the economizer is active, it shall be set to the value that existed when the unit became active.
  - b) Rescaled Output Capacity Control: The output for the return fan capacity control shall be rescaled from the output of the to the supply device such that the design minimum OA flow is maintained at both maximum and 50% flow conditions. The balancing contractor shall determine the coordinated output.
4. Airside Economizer: BAS shall modulate the mixing dampers to provide “free cooling” when conditions merit. The free cooling shall generally be staged before any mechanical cooling. While conditions merit, dampers shall be modulated in a DA PID loop to maintain mixed air temperature at a setpoint as specified for the individual unit. Economizer logic shall remain enabled during setback cooling where applicable. The following strategy shall be used to enable the economizer mode:
  - a) Dry Bulb Switch: Economizer mode shall be active while the unit is



energized AND when outside air temperature falls below the switching setpoint of 55°F (adj.) (with 5°F cycle differential). Economizer mode shall be inactive when outside air temperature rises above switching setpoint, dampers shall return to their scheduled minimum positions as specified above.

5. Sequenced Heating and Cooling: BAS shall control the heating and cooling coils and air side economizer as detailed for the AH. Program logic shall directly prohibit the heating and cooling valves as well as the heating valve and economizer damper to be open (or above minimum) simultaneously. This does not apply to cooling and reheat valves that are used simultaneously for dehumidification.
6. Mixed Air Low Limit Override: BAS shall override the signal to the OA damper via a proportional only loop to maintain a minimum mixed air temperature of 45°F (adj.) (loop shall output 0% at 45°F which shall be passed to the output via a low selector).
7. Freeze Safety: Upon operation of a Freezestat the following sequence shall occur:
  - a) The unit fans shall be deenergized. Typically supply and return fans where applicable shall be deenergized via a hardwired interlock, and an indication of the operation shall be displayed by the BAS.
  - b) All hot water valves and chilled water valves will be commanded to 100% open. Steam preheat valves shall modulate to maintain minimum preheat/mixed air plenum temperature.
  - c) All hot water coil pumps and chilled water coil pumps will be commanded to run.
  - d) Outside air dampers shall fully close and return air dampers shall fully open.
  - e) BAS shall enunciate appropriate alarm and remove and lock out the start command, which shall initiate "fan failure" alarms.
8. Smoke Safety: Upon indication of smoke by a smoke detector, FAC shall override all AH control. FAC shall not rely on BAS for implementation of smoke control sequences unless specifically approved. Smoke detector shall notify the fire alarm system and BAS, shut down the fans, and close the smoke dampers via hard-wired interlock.
9. Smoke Pressurization Cycle: When pressurization is commanded by the interface to the fire alarm system, the supply fan shall start and deliver 100% outside air to the space. Return fan shall remain off. Hardwired interlock from safeties may still interrupt fan operation. (See damper and heating valve sequences for additional sequences associated with pressurization.)
10. Smoke Exhaust Cycle: when exhaust is commanded by the interface to the fire alarm system, the return fan shall start and shall exhaust 100% return air from the space. Supply fan shall remain off. (See damper and



heating valve sequences for additional sequences associated with pressurization.)

11. High or Low Pressure Safety: Upon activation of a high or low pressure safety switch, AH shall be deenergized, fans shall be deenergized via a hard wired interlock, and an indication of the operation shall be sensed by the BAS. BAS shall enunciate appropriate alarm and remove and lock out the start command, which shall initiate "fan failure" alarms.
  12. Vibration Safety (Applicable To Units >50,000 cfm): Upon activation of a vibration safety switch, respective fan shall be deenergized, fan shall be deenergized via a hard wired interlock and an indication of the operation shall be sensed by the BAS. BAS shall enunciate appropriate alarm and remove and lock out the start command.
- C. The detailed "logic strategies" above shall be required by reference to them in each of the individual sequences specified.

### 3.04 AIR HANDLING UNIT DIAGNOSTICS

- A. Diagnostic Strategies: In addition to the standard alarm limits specified for all sensed variables the BAS monitor and diagnose anomalies in the operation of the air handlers. The following "diagnostic strategies" shall be included by reference with each air handler with any specific clarifications required:
1. Run Time Limit: BAS shall accumulate the runtime of the status of associated rotating equipment and enunciate an alarm to indicate that the unit is in need of service.
  2. Filter Monitoring: BAS shall monitor the differential pressure transmitter across the filter bank(s). An alarm shall be reported when pressure drop exceeds the transmitter's setting.
  3. Start Monitoring: BAS shall accumulate the starts of cycling equipment. BAS shall further enunciate an alarm when the number of starts exceeds the specified value within the specified time period. (ie: more than 3 starts in a 30 min period).

### 3.05 ENERGY CURTAILMENT CONTROL

- A. BAS shall monitor kW demand over a 15-minute sliding period.
- B. The operator (with appropriate password level) at the OWS shall manually enable demand limiting. Demand limiting shall remain enabled until manually disabled by the operator at the OWS.
- C. On a rise in kW to within 200 kW (adj.) of setpoint, a Level 4 alarm shall be enunciated and BAS shall begin to make one "load shed" command every 10 minutes (adj.). On a fall in kW to 200 kW less than the demand setpoint, BAS shall begin to broadcast one "load restore" command every 5 (adj.) minutes on a first shed, first restored basis.

Automatic load shedding shall be limited to a maximum of two (adj.) load



shed commands. Once the maximum automated load shed has been reached and demand still exceeds the demand, setpoint the operator will be notified via Level 3 alarm that additional load shedding will require manual intervention.

Operators with required user access shall be able to manually initiate additional load shed commands.

- D. Coordinate which loads are available for shedding with the Owner.
- E. Load shedding commands priority:
  - 1. The first load shed command shall reset terminal level equipment space temperature set points to their set back values over a [5] minute (adj.) period.
  - 2. The second load shed command shall reset VAV air handler down duct static set points to their minimum value over a [10] minute (adj.) period.
  - 3. The third load shed command shall reset central plant equipment to their minimum capacity set points over a [30] minute (adj.) period.
- F. On a rise in kW to within 50 kW (adj.) of setpoint, a Level 3 and Level 4 alarm shall be enunciated.

### 3.06 GENERAL PRIMARY/SECONDARY CHW SYSTEMS CONTROL

- A. All Chiller Start/Stop sequences and design elements are to be reviewed by the Owner prior to approval.
- B. General: BAS shall fully control the chilled water systems and equipment and shall provide monitoring and diagnostic information for management purposes. The following logic strategies are referenced in the individual sequences and expand on the requirements:
- C. Cooling Enable: As indicated on the drawings for the specific system.
- D. Chilled Water Load Determination:
  - 1. Chilled water load shall be calculated instantaneously from the flow and temperature difference of the following loops:
    - a) Primary loop total.
    - b) Individual chiller circuits.
    - c) Individual secondary circuits (as applicable)
  - 2. Chilled water load for the purposes of the staging of the chillers shall be calculated as the 10 min average of the secondary circuit loads.
- E. Chiller Staging: Chiller shall be staged as specified below.
- F. Proof of Chiller Operation: BAS shall prove the operation of the chillers via chiller status and alarm points. When a chiller is assessed as failed, the run command shall be locked out and shall require manual acknowledgment at the operator interface before it is restarted. BAS shall then start the next chiller in rotation. The following conditions shall result in the assessment that the chiller has failed:
  - 1. Loss of chiller status for more than 15s (adj.) while it is requested.



2. Closure of chiller failure input.
  3. Leaving chilled water temperature exceeds chiller setpoint plus 8°F for 10 min. continuously.
  4. Chiller environment is unacceptable for 10 min. as specified below.
- G. Chiller Environment Monitoring: BAS shall monitor the “environment” of all active (not starting or stopping) chillers and remove the run command when the environment is assessed as unacceptable. An unacceptable environment will include any of the following:
1. Loss of status on the associated primary pump (pump proof debounce time shall not apply).
  2. Condenser water entering temperature below CHW supply plus 12°F or above 100°F.
  3. Condenser water flow below a minimum setpoint GPM where such flow is measured.
  4. Chilled water flow below a minimum setpoint GPM.
- H. When the environment is assessed as unacceptable, the BAS shall enunciate an alarm, remove chiller run command (not the chiller request; all supporting equipment shall continue to operate) and start a timer. If the environment is still unacceptable after 10 min. (adj.), fail the chiller.
- I. Chiller Request: A chiller request is the request for a chiller and the associated equipment. A chiller request is issued before the actual run command to the chiller, which is the closure of the physical point that enables the chiller.
- J. Chilled Water Temperature Control: The chilled water temperature shall be controlled as specified below.

### 3.07 CHILLER STAGING (T ON L OFF)

- A. BAS shall control the starting and stopping of chillers to meet the demands of the secondary chilled water systems (SCHW). Whenever cooling is requested, a minimum of one chiller shall be requested. Chillers shall be started per the chiller start sequence and stopped per the chiller stop sequence specified below. Once the conditions merit starting or stopping a chiller, BAS shall complete the starting or stopping sequence regardless of temperature fluctuations during the sequence. Additional chillers shall be started based on SCHW supply temperature as follows:
1. For the purposes of chiller staging control, a virtual point called “average secondary chilled water supply temperature” (ASCHWST) shall be continuously calculated and displayed. This value shall be the 10-minute average of the instantaneously sensed secondary chilled water supply temperature.
  2. An additional chiller shall be requested and started per the chiller start sequence specified below when:



- a) The ASCHWST rises more than 4°F above the secondary chilled water supply setpoint for 5 min. (adj.) continuously, AND
  - b) More than 30 min. (adj.) has elapsed since the start of the last chiller.
3. Chillers shall be stopped, per the chiller stop sequence specified below, based on the averaged cooling load as follows:
- a) One chiller shall be stopped when the load falls below (Total Nominal Capacity-(Nominal Capacity of Last Chiller) \* 1.2), AND
  - b) A minimum of 15 min. has elapsed since a chiller has been stopped, AND
  - c) A minimum of 30 min. has elapsed since this chiller has been started.

### 3.08 CHILLER STAGING (LOAD)

- A. BAS shall control the starting and stopping of chillers to meet the demands of the [secondary] chilled water systems. Whenever cooling is requested, a minimum of one chiller shall be requested. Chillers shall be started per the chiller start sequence and stopped per the chiller stop sequence specified below.

Once the conditions merit starting or stopping a chiller, BAS shall complete the starting or stopping sequence regardless of temperature fluctuations during the sequence. Additional chillers shall be started based on SCHW load as follows:

1. An additional chiller shall be requested and started per the chiller start sequence specified below when:
  - a) The average cooling load rises above 90% of the nominal capacity of the active chillers for 5 min. (adj.) continuously, AND
  - b) More than 30 min. (adj.) has elapsed since the start of the last chiller.
2. Chillers shall be stopped, per the chiller stop sequence specified below, based on the averaged cooling load as follows:
  - a) One chiller shall be stopped when the load falls below (Total Nominal Capacity-(Nominal Capacity of Last Chiller) \* 1.2), AND
  - b) A minimum of 15 min. has elapsed since a chiller has been stopped, AND
  - c) A minimum of 30 min. has elapsed since this chiller has been started.

### 3.09 CHILLER STAGING (CHILLER AMPS)

- A. BAS shall control the starting and stopping of chillers to meet the demands of the secondary chilled water systems. Whenever cooling is requested, a minimum of one chiller shall be requested. Chillers shall be started per the chiller start sequence and stopped per the chiller stop sequence specified



below.

Once the conditions merit starting or stopping a chiller, BAS shall complete the starting or stopping sequence regardless of temperature fluctuations during the sequence. Additional chillers shall be started based the amperage drawn by the chiller as follows:

1. An additional chiller shall be requested and started per the chiller start sequence specified below when:
  - a) The average percent amperage drawn by the active chillers rises above 95% of the nominal full load amperage of the active chillers for 5 min. (adj.) continuously, AND
  - b) More than 30 min. (adj.) has elapsed since the start of the last chiller.
2. Chillers shall be stopped, per the chiller stop sequence specified below, based on the averaged cooling load as follows:
  - a) One chiller shall be stopped when the load falls below (Total Nominal Amperage-(Nominal Amperage of Last Chiller) \* 1.2), AND
  - b) A minimum of 15 min. has elapsed since a chiller has been stopped, AND
  - c) A minimum of 30 min. has elapsed since this chiller has been started.

### 3.10 PRIMARY CHW PUMP CONTROL (ONE PUMP/CHILLER)

- A. Primary pumps shall be started to serve their respective chiller when it is requested to run per the chiller start and stop sequences specified below. Pumps shall run continuously when the respective chiller is requested. BAS shall prove operation of the pump.

### 3.11 SECONDARY CHW PUMP (WITH VFD) CONTROL

- A. Secondary pumps shall run continuously whenever cooling is requested from the system it is serving or when system is enabled by the operator. BAS shall prove operation of the pump. BAS shall vary the speed of the pumps to maintain the lowest differential pressure setpoint across any of the applicable differential pressure sensors. The differential pressure setpoint shall either be fixed at 10 psi (adj.) or reset between 5 psi (adj.) and 15 psi (adj.) based on one of the following as indicated specifically on the drawing sequences:
  1. Valve position, OR
  2. Cooling requests from the applicable secondary terminals.

### 3.12 CONDENSER WATER PUMP CONTROL (ONE PUMP/CHILLER)

- A. Pumps shall be started per the chiller start and stop sequences specified below to serve their respective chiller when the chiller is requested to run. Pumps shall run continuously when their chiller is requested. BAS shall



prove operation of the pumps.

### 3.13 COOLING TOWER BYPASS VALVE CONTROL

- A. BAS shall control the bypass valve via a PID control loop to maintain a minimum mixed condenser water temperature of 65°F when systems are in mechanical cooling mode.

### 3.14 CHILLER PRIORITY SELECTION (EQUAL SIZE AND EFFICIENCY CHILLERS)

- A. BAS shall automatically prioritize the chillers for starting order. One of the following methods shall be employed to rotate and re-prioritize the chillers:
  1. The chiller with the least run time shall be started first and the chiller with the greatest runtime shall be stopped first.
  2. The BAS shall provide a graphic screen to support the manual selection of chiller priorities.
  3. The chiller priorities shall be rotated based on a predetermined schedule. Owner shall dictate a regular schedule for the priorities to be switched.
- B. Operators shall be able to lock out chillers in "Maintenance Mode. This means that the requests for this chiller and associated appurtenances shall be bypassed. This shall be done through a graphic icon associated with a virtual point indicating whether the maintenance mode is active or via a property associated with the chiller icon.

### 3.15 CHILLER START SEQUENCE

- A. On a request for a chiller to start as specified above under "Chiller Staging," the following sequence shall occur:
  1. Wait thirty seconds (adj.).
  2. Enable additional cooling towers as specified above (if applicable). This shall enable the bypass valve control loop if it is not already enabled. Then command the isolation valves to open. The travel rate of the tower isolation valves shall be limited to ease the shock on the tower water system leaving temperature during cold weather. For systems that allow tower piping to drain when the system is off, upon start up fully close bypass valve for 30 seconds (adj.) to prime the system and eject air when the system is first started.
  3. Gradually reset the demand limit to all active chillers from 100% to 50% (adj.) of maximum amps.
  4. Request the start of the applicable condenser water pump and prove operation.
  5. After condenser pump operation is proven, BAS shall start the applicable primary chilled water pump and prove operation. Concurrently with the starting of the chilled water pumps, BAS shall open the chiller isolation valve (if applicable) at a limited rate of travel



to minimize the shock to other operational chillers.

6. Wait a maximum of 5 min. after the command to start the condenser pump for the chiller environment as specified above to be acceptable. As soon as the environment is assessed as acceptable, continue the start sequence. If after 5 min. the environment is not acceptable, fail the chiller and start the next chiller.
7. Command the chiller to start under its own control.
8. Monitor chiller status and prove operation. If status is not indicated within 3 minutes (adj.) of a command to start, announce an alarm, disable and lock out chiller.
9. After status is proven, gradually reset current limit to all active chillers to 100%.

### 3.16 CHILLER STOP SEQUENCE

- A. When a chiller is no longer needed as specified in chiller staging, the following sequence shall occur:
  1. Remove chiller run command.
  2. Wait for status to clear and for the chiller to stop under control.
  3. Wait 1 min. (adj.). Then, where applicable, begin to modulate closed the isolation valve. At mid-stroke stop associated PCHW pump.
  4. Where applicable, begin to stroke the condenser isolation valve closed and at mid stroke, stop the condenser pump.
  5. Close applicable tower isolation valves and, if this is the last chiller running on the circuit, close the applicable bypass valve.

### 3.17 GENERAL HEATING WATER SYSTEMS CONTROL

- A. General: BAS shall fully control the hot water systems and equipment and provide monitoring and diagnostic information for management purposes. The following logic strategies are referenced in the individual sequences and expand on the requirements.
- B. Heating Enable: Heating shall be enabled as indicated on the drawing sequence.
- C. Hot Water Load Determination
  1. Hot water load shall be calculated instantaneously from the flow and temperature difference of the following loops:
    - a) Primary loop total.
    - b) Individual boiler circuits.
    - c) Individual secondary circuits.
  2. Hot water load for the purposes of the staging of the chillers shall be calculated as the 10 min average of the secondary circuit loads.



### 3.18 CENTRAL PLANT MONITORING AND MANAGEMENT

- A. General: The BAS shall monitor various aspects of the heating and cooling systems and calculate parameters as specified below to facilitate plant operations and management.
- B. Trending: The BAS shall continuously monitor, calculate, and display the following parameters at the intervals indicated. These values shall be stored initially in the buffer of the controlling control unit, and then be uploaded periodically and stored on a specified hard disc. Contractor shall format reports from this data to support one of the following data formats:
  - 1. Quote (text strings) and Comma delimited.
  - 2. Microsoft EXCEL.
  - 3. Microsoft ACCESS.
- C. Parameters to be Trended:
  - 1. Load on the secondary systems in MMBTU (IT) / hr per the following equation:  $(\text{Return Temp} - \text{Supply Temp}) * (\text{GPM}) / .5$ . This shows cooling as a positive heat load and heating as a negative heat load. This value shall be trended and stored every two hours.
  - 2. All temperature sensors at 15-minute intervals.
  - 3. All relative humidity sensors at 15-minute intervals.
  - 4. All pressure sensors at 15-minute intervals.
  - 5. All run requests and statuses on a change in value.
  - 6. All analog loop outputs on 15-minute intervals.
  - 7. Calculated enthalpies in 2-hour intervals.
  - 8. Summed cooling and heating requests on 2-hour intervals.

### 3.19 VARIABLE FREQUENCY DRIVES

- A. Coordinate the following requirements with the VFD vendor:
  - 1. All drives shall include network and hardwired BAS interface options.
  - 2. Drive shall be configured for auto-restart on power return when the run command is indicated.
  - 3. Drive shall be configured to start into a forward or backward rotating fan wheel when the run command is indicated. Drive shall catch the wheel at its speed and accelerate directly to the indicated reference speed.
  - 4. Drive shall be configured to stop the fan at the fastest, mechanically safest possible rate to assure as low a static pressure as possible during the turndown period.
  - 5. Drive shall be configured such that upon loss of BAS speed reference



signal the drive shall stop.

6. Preset speed signal shall be set up to limit the operating speed of the drive to an adjustable parameter (typically 25 Hz) when there is an open contact across it. This value shall be adjusted during Cx to ensure smooth transitions into an operating header and a safe pressure against the dead head of the dampers.
7. Drive shall be configured to stop when any load side disconnect switch is placed in the OPEN position. The drive shall be allowed to return with normal operations when all load side disconnect switches are placed in the CLOSED position.
8. Drive shall be configured to initiate a common alarm to the BAS whenever there is a fault detected.
9. All TAB established drive programming shall be included on a BAS CSS Graphic for informational purposes. Each value shall include the default value and the custom programming value with a brief description of the customization's purpose.
10. Each VFD shall open all AHU dampers in parallel in accordance with the following:
  - a) In VFD Mode: Upon a run command from the BAS, the drive shall start the fan into closed dampers. It shall start at 0 Hz and accelerate per drive settings (typically 1 Hz per second). When the drive speed exceeds an adjustable speed threshold (typically 20 Hz) the drive shall issue an open command to the fans OA damper and the supply discharge damper via a "drive running" output. The drive shall limit the speed of the fan to the safe preset speed (programmed in the drive) until all dampers are proven open. Once the damper end switches prove open dampers, the drive shall allow the fan to accelerate at the controlled rate to the BAS drive reference signal that is sent via hard-wired interface from the BAS.
  - b) In HAND Mode: The same logic shall apply as VFD Mode when the drive speed signal is in HAND mode and manually controlled through the VFD panel. Preset speed limit shall apply whenever the Inverter is active.

END OF SECTION  
END OF DIVISION 25