KCTCS Using Agency Project Requirements for Building Automation Systems

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Revision History

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Introduction

a. The KCTCS User Agency Project Requirements for BAS is intended to communicate the KCTCS Project Requirements for Building Automation Systems (BAS) to the Design Team. These requirements are to be adapted into the project design and specifications as appropriate for the application. These do not modify the project design and contracting team's responsibility for project design, specification and construction.
b. For the purposes of maintaining the security and reporting integrity of its enterprise BAS network, KCTCS has established a BAS Standards and Compliance Team (hereafter referred to as the S/C Team). This team's primary responsibility, related to new and renovation construction projects, is to assure that the building automation systems are designed and installed consistent with the quality and performance requirements of the current Information Technology and BAS Network Standards and Policies.
c. To accomplish these objectives, KCTCS requires several changes to the traditional delineation of responsibilities in implementing Building Automation Systems. The designer is cautioned to make note of these departures from previous BAS project requirements.
d. The Designer shall make every attempt to allow competitive bidding of the BAS and Controls systems without compromising the Project Requirements defined in this document. Where adjustments are required to achieve this end, such adjustments must be approved by the DECA Project Manager and the S/C Team.

2. Definition of Terms

BACnet: a communications protocol, defined by ANSI / ASHRAE™ Standard 135-2004
BAS: Building Automation System
CEMCS: Commonwealth Energy Management and Control System
CLAN: Controls System Local Area Network
DECA: Division of Engineering and Contract Administration
DDC: Direct Digital Controls
GUI: Graphical User Interface
IPsec: Internet Protocol Security
JACE: Java Application Control Engine
KCTCS: Kentucky Community and Technical College System
WAN: KCTCS Enterprise Wide Area Network
Lon: a communications protocol, defined by EIA standard 709.1 protocol (LonTalk™), components referred to as LonMark™ or LonWorks™ compliant.
Modbus: a communications protocol, managed by the Modbus Organization
MSTP: Multiple Spanning Tree Protocol
NiCS: Niagara^{AX} Compatibility Statement
OFCI: Owner Furnished, Contractor Installed
PES: Portable Engineering Station
S/C Team: KCTCS BAS Standards and Compliance Team
SNVT: Standard Network Variables Type
TCP/IP: Transmission Control Protocol/Internet Protocol
UAPR: User Agency Project Requirements
UNC: Universal Network Controller
VPN: Virtual Private Network

3. **KCTCS BAS Standards and Compliance Team - Coordination Requirements**

The primary areas where the S/C Team's role will impact the design and construction process include but are not limited to:

a. Design Phase
   i. Design Deliverables Checklist Review
   ii. Incremental Design Reviews
   iii. Incremental Design Phase Approvals
b. Construction
   i. BAS Supplier Pre-Bid Conference
   ii. HVAC Instrumentation and Controls Scheduling Meeting
   iii. Pre-Submittal Meeting
   iv. Submittal Review
   v. Controls Standard Object Palettes for Controls Suppliers
   vi. Building and Building System Graphics Generation
   vii. Building Controls to College Server Integration
   viii. Controls Implementation & Commissioning Acceptance
   ix. Owner Proficiency Meeting
   x. Warranty Phase Operations
   xi. Warranty Transition

4. **KCTCS Building Automation System Description**

a. A typical controls system architecture in the existing KCTCS inventory is comprised of multiple tiers of communication; the most fundamental being the local equipment controller (BAS Level 1) at the bottom rung, up to the JACE network controller (BAS Level 2) which manages the multiple equipment controllers and passes information up to the server level (BAS Level 3) which manages the human interface and reporting functions. It is a KCTCS requirement that the BAS Architecture implementation and any expansion be accomplished with open protocol / open distribution components and programming, with all programming intellectual property being non-proprietary, including all software keys with full disclosure. This has been difficult to accomplish due to the complexity and proprietary nature of the many control suppliers that have been utilized at the sixteen (16) colleges and headquarters facilities.
b. To take full advantage of the existing BAS investment and avoid adding to the BAS complexity, the Niagara AX Framework is the software platform being deployed to implement the KCTCS BAS network. The intent is to accommodate the existing BAS networkswhile maintaining the ability to competitively bid construction projects without compromising the BAS standards and operations. The open nature of the Niagara AX Framework software platform will enable this plan.
c. To enable competitive bidding of construction projects, without compromising the BAS standards and operations, KCTCS will furnish Tridium Vykon JACE network controllers (BAS Level 2) to the Controls Provider as OFCI devices. Level 1 Application Specific and Custom Application Controllers and control sensing, actuation and similar devices are intended to be provided by the Control Supplier through the competitive bid process, subject to Building Automation System / Control Product Requirements (paragraph 6 below) and applicable provisions of these Agency Requirements.

d. The Enterprise BAS Architecture must also be implemented in a manner that will maintain the integrity and security of BAS and other KCTC System networks. These provisions are detailed within KCTCS reference documentation. This document is updated as technology and security developments occur; the design team should request the most current version at the concept development stage of a project.
e. The control system communications shall be transparent, meaning that the user or control programmer does not need to know the details of system architecture and operation.
f. The project design shall provide for all labor, materials, equipment programming, and service necessary for a complete and operating temperature control system, utilizing a high speed peer to peer network of interoperable Direct Digital Controls (DDC), electronic sensing and actuation devices, and Graphical User Interface (GUI) with color graphic displays available to the Enterprise network user.
g. The Controls System Local Area Network (CLAN) for dedicated controllers shall be at least 100 Mpbs Ethernet furnished by the control system supplier and shall support BACnet IP, BACnet MSTP, Lon, Modbus TCP, and Modbus Async for maximum flexibility for integration of building data with Universal Network Controllers (UNCs) to control system supplier's Application Specific Controllers, Custom Application Controllers and control devices
h. The Enterprise Ethernet (IEEE 802.3) shall utilize the WAN furnished and maintained by KCTCS.
i. The control system shall consist of an open architecture with capability to utilize EIA standard 709.1 (LonTalk™) protocol, as a common communication protocol between controllers and integral ANSI / ASHRAE™ Standard 135-2XXX (BACnet-current release) functionality to assure interoperability among all system components. Both the Lon protocol and the BACnet protocol are required to assure that the project is fully supported by the two leading HVAC open protocols to reduce future building maintenance, upgrade, and expansion costs. Where specific products are not Lon or BACnet compatible, the Modbus protocol is an acceptable communication protocol to that specific device only.
j. Where necessary or desired, Lon packets may be encapsulated into TCP/IP messages to take advantage of existing infrastructure or to increase network bandwidth. Any such encapsulation of the Lon protocol into IP datagrams shall conform to existing Lon guide-lines for such encapsulation and shall be based on industry standard protocols.
k. The products used in constructing the control system shall be LonMark™ compliant. In instances where LonMark™ devices are not available; the controls system supplier shall provide LonWorks™ devices with application source code, device resource files, and external interface definitions.
l. The software tools including cables and connectors required to manage Lon, Modbus and BACnet protocols must be provided with the system. Minimum BACnet compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet/Ethernet IP.
m. All work described in this section shall be installed, circuit tested, and calibrated by factory certified technicians qualified for this work and in the regular employment of the Control System Supplier.
n. Provide Portable Engineering Station (PES) software, and interfaces to provide uploading/downloading of Custom Application Controller and Application Specific Controllers databases, monitoring of all Lon Standard Network Variables Types (SNVTs) including display of all bound SNVTs, monitoring and overrides of all controller physical

input/output points, and editing of controller resident time schedules. PES connectivity shall be via digital wall sensor connected to controller.

5. <u>Building Automation System Design Requirements</u>

a. Design Deliverables

i. Phase A - Conceptual Design Requirements

1) Submit MEP Deliverables Checklist including BAS/Controls Design Deliverables
2) MEP System Control Description including:
    a. Preliminary Controlled Systems Sequence Descriptions
    b. Conceptual MEP Flow Schematics
    c. Preliminary Electrical Riser Diagram with sub-metering strategy to measure HVAC, Lighting, Receptacle and Instructional Power energy usage.

ii. Phase B - Design Development Requirements

1) 95% MEP System Flow schematics
2) Controls Specifications Draft
3) 95% Control Sequences and KCTCS-CEMCS compatible Points List (obtain current standard objects point list from the S/C Team or DECA Project Manager during Phase A Design).
4) 95% Controls Specification
5) 75% Entry to Distribution Panel Electrical Riser Diagram
6) Room Numbering Methodology Defined
7) BAS Standards & Compliance Team Coordination Meeting
    a. Custom Graphics Definition
    b. OFCI Component & Services Decisions
8) Phase B Design Review shall also include the:
    a. BAS Standards & Compliance Team
    b. HVAC Service Contract Provider
9) Training scope requirements will be provided to the Design Team by the BAS Standards & Compliance Team during the Phase B Design Review

iii. Phase C - Construction Documents Requirements

1) Phase C 50% Review
    a. Room Numbering Firmly Established
    b. BAS / Controls on Emergency Power
    c. Unique Equipment Identification
    d. HVAC Equipment schedules include fields which indicate system component relationships where such exist; for instance:
        i. Air Terminal Unit's to upstream Air Handling Unit
        ii. Air Handling Unit to upstream pumps
        iii. Etc.
    e. Electrical Panel schedules include fields which indicate feed source identification
    f. BAS Standards & Compliance Team Review Meeting

2) Phase C 100% Review

a. Control Sequence Set-points Defined
b. Control Sequence Schedules Defined
c. Sub-contractor's bid form listing:
    i. Identification of the Controls Provider
    ii. Identification of the Niagara AX Certified Technician
d. Materials (Equipment) bid form listing:
    i. Controls Manufacturer

b. Submittal Requirements
    i. Include manufacturer's technical literature for each control device.
    ii. Bill of materials of equipment indicating quantity, manufacturer, and model number, cross referenced to Component Tag on Plans.
    iii. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and all other control devices.
    iv. Wiring Diagrams: Power, signal, and control wiring, with wire number identification.
    v. Written description of sequence of operation, and either: 1) programming ladder logic diagrams, or 2) control logic block diagrams, fully populated with initial set-point and control values.
    vi. Schedule of dampers and valves including size, leakage, torque requirements and flow characteristics.
    vii. DDC System Hardware:
        1) Wiring diagrams for control units with termination numbers.
        2) Schematic diagrams and scaled floor plans for field sensors and control hardware.
        3) Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
        4) Points list.
    viii. Control System Software:
        1) Summary List of "Standard Objects" Graphic Palettes being utilized.
        2) Summary List of points to be displayed on each "Standard Object" Graphic.
        3) Summary List of all Custom Graphics to be developed by the KCTCS S/C Team.
            a. Floor Plans
            b. System Schematics
            c. Custom Equipment
            d. Etc.
        4) Summary list of points to be displayed on these Custom Graphics.
        5) Other Graphic Requirements as outlined in paragraph 8.b. BAS Graphics Coordination below and as defined during the Pre-Submittal meeting.
    ix. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with Lon, Modbus and BACnet standards.
    x. Qualification Data: For Installer, manufacturer and Niagara AX Certified Technician.
    xi. Project Work Schedule: Provide a Gantt or Critical Path Work Schedule developed in conjunction with the General Contractor, Divisions 23, 26, 27, and 28 Sub-contractors demonstrating the plan to have the HVAC systems installed and operational in ample time to complete functional performance tests prior to the

substantial completion deadline; and ample time between substantial and final completion for the S/C Team to complete a compliance review.

xii. Operation and Maintenance Data: For instrumentation and control system components to include in emergency, operation, and maintenance manuals. Include the following:
   1) Maintenance instructions and lists of spare parts for each type of control device and / or compressed-air station.
   2) Interconnection wiring diagrams with identified and numbered system components and devices.
   3) Keyboard illustrations and step-by-step procedures indexed for each operator function.
   4) Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   5) Calibration records and list of set points.

xiii. Field quality-control checklists.

c. Quality Assurance Requirements
   i. In addition to device listing, labeling and conformance to industry standards; the following Quality Assurance provisions are required:
   ii. Controls Provider Qualifications: The control systems provider shall be the controls manufacturer's authorized representative, who is trained and approved for installation of the system components required for this Project. The manufacturer is to be ultimately responsible for the installation quality and warranty.
      1) Bids by wholesalers and non-franchised contractors will not be acceptable.
      2) The Controls Provider shall have a minimum rated qualification of five (5) years of installation experience with the manufacturer and shall provide documentation in the submittal package verifying longevity of the installing company's relationship with the manufacturer.
      3) Supervision, calibration and checkout of the system shall be by the employees of the Controls Provider.
      4) The Controls Provider shall have a full service facility within Kentucky that is staffed with engineers/technicians trained in integrating interoperable systems and fully capable of providing Lon, Modbus and BACnet programming and instruction.
      5) The Controls Provider shall have support within 200 statute miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment to perform routine and emergency maintenance service on all system components.
      6) The Controls Provider shall utilize a Niagara AX Framework Certified Technician with a minimum of three (3) years programming experience of Niagara AX systems to program the Vykon JACE networked controllers and to configure all attributes of the controlled devices being served up to the College Level Niagara AX Supervisor. Programming shall be implemented in a manner that there are no restrictions on which brands or tools can interact with the system, with the exception of integral factory installed equipment controllers.
      7) The Controls Provider's Project Manager and the Niagara AX Framework Certified Technician shall complete a publically accessible training and

orientation session on the implementation requirements for the KCTCS Building Automation System that will be offered by the BAS S/C Team.

a. A Certification Statement will be issued upon completion of the session.
b. It is strongly encouraged but not mandatory that the Controls Provider complete this certification prior to bidding the project. It is a requirement that evidence of successful certification be presented with the BAS / Controls submittals.
c. The design team shall not approve the BAS / Controls submittals without this certification.

iii. Where DDCs are specified as factory mounted equipment, it is a requirement that the Contractor and the Controls System Supplier be responsible for coordinating all controls, actuators, valve assemblies, and sensors specified are fully compatible and shall be capable of seamless interfacing with all Lon, Modbus and BACnet protocol requirements specified.

iv. User / Operator Proficiency: The Design Team shall make provisions for a training program conducted by the Controls Provider which includes three (3) progressive levels of training based on the access permissions granted to the User / Operators of the BAS.

1) The objectives for the three (3) levels of training will be furnished by the S/C Team, as a component of the Phase B Design Review feedback, based on the complexity of the project's Building Systems, its BAS and the capabilities of the college's operating staff.
2) The three (3) levels of training will generally be organized as follows:
   a. User Access(Very Low) - designed for those needing read only access to building system information, with minimal set-point adjustment authorization.
   b. Operator Access (low to medium) - designed for those authorized to make limited write adjustments to set-points and schedules.
   c. Operator Access (medium to high) - designed for those authorized to make substantial write and invoke level adjustments to the BAS.
3) The S/C Team will recommend the duration of the training with this Phase B review feedback.

v. Controls Implementation and Commissioning Final Completion Acceptance Report

1) The S/C Team will perform a compliance review of the BAS between substantial and final completion.
2) Prior to final acceptance the S/C Team must issue an Acceptance Report confirming acceptable completion of the BAS and receipt of the following BAS related items:
   a. Software & Tools
   b. Documentation
   c. Licenses and Programming Niagara AX Compatibility Statement (NiCS).
   d. Owner Training / Proficiency Report

d. Coordination Meeting Requirements

i. BAS Pre-bid Conference: Prior to the project Pre-bid Conference, the Design Team shall schedule or advertise a BAS Pre-bid Conference (either a scheduled meeting or by web training as KCTCS develops the tool).
    1) The purpose of the BAS Pre-Bid (Web) Conference is to familiarize the Controls Provider with the provisions of the Standard Objects Palettes being utilized by KCTCS.
    2) The KCTCS – BAS Implementation Guide will be made available to the Controls Provider.
    3) An understanding of these provisions will help the Controls Provider accurately estimate the programming time savings available with these palettes and services.
    4) Attendance to the BAS Pre-bid Conference shall be optional.

ii. HVAC Instrumentation and Controls Scheduling Meeting: This meeting shall be arranged between the General Contractor, Division 23, Division 26, Division 27, Division 28 Sub-contractor, Commissioning Authority, and the Controls System Supplier to establish a Project Work Schedule. This Project Work Schedule is a requirement for Submittal Approval.

iii. Pre-submittal Meeting: This meeting shall be scheduled through the Design Team. The Control Systems Supplier representation shall include the Control System Designer, the System Programmer, and Project Supervisor. A KCTCS S/C Team representative, Design Engineer representative, and a Commissioning Authority representative shall participate in this meeting. The intent is to:
    1) Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
    2) Coordinate locations for UNC's, Ethernet communication cabling and secure open ports and TCP/IP addresses.
    3) Coordinate Point Naming, Graphics, Alarms and System Navigation with the KCTCS S/C Team.

iv. Submittal Review Meeting: At the discretion of the Engineer and/or the Commissioning Authority, the Control System Supplier's Programmer and Project Supervisor shall meet to review and/or adjust the programming or other portions of the submittal prior to approving or returning the Control System Supplier's submittals. The intent is to reconcile any uncertainties so that the control submittal(s) can be approved as a complete set rather than incrementally.

e. Ownership of Proprietary Materials
    i. Controller Software / Toolkits / Licenses – Ownership
        1) It is a requirement that the ownership of all BAS controllers, software and licenses be in the name of KCTCS.
        2) All programming intellectual property associated with the KCTCS BAS software shall be tendered to and owned by KCTCS with full disclosure.
        3) KCTCS shall be provided a copy of all tools kits required to operate, adjust and program all BAS products.
    ii. Warranties of all BAS Hardware shall be in the name of KCTCS.
    iii. KCTCS shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to KCTCS as defined by the manufacturer's

license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. All project developed software and documentation shall become the property of KCTCS. These include, but are not limited to project graphic images, record drawings, project database, project specific application programming code, and all other associated documentation.

f. BAS / IT Network Requirements
    i. KCTCS IT Standards apply to all elements of BAS installation where the BAS / Control device is networked on the KCTCS IT network.
    ii. Where sub-networks are established for communication between the networked controllers and lower level controllers or devices; the Division 26 low voltage cabling, identification, pathways, and other applicable specifications shall apply.
    iii. The coordination of IP addresses, porting and other networking requirements shall be through the KCTCS project manager or S/C Team representative as designated by the project manager.
    iv. Controls Provider Access
        1) An authorized Controls Provider Technician / Engineer will be granted VPN access only to the building(s) under contract. User Name and Password credentials will be provided to the appropriate service technicians.
        2) The Controls Provider's network must meet certain IPsec requirements, access outside this IPsec network will be denied.
        3) Password strength must meet certain minimum requirements and will be updated on a schedule per KCTCS.
        4) Access will only be available until the Contract warranty period expires.

g. Warranty and Maintenance Requirements
    i. All components, system software, and parts furnished and installed by the Control Systems Supplier shall be guaranteed against defects in materials and workmanship for one (1) year of substantial completion unless extended warranty by owner or manufacturer is greater than one (1) year. Labor to repair, re-program, or replace these components shall be furnished by the Control Systems Supplier at no charge during normal working hours during the warranty period.
    ii. Materials furnished but not installed by the Control Systems Supplier shall be covered by warranty to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation.
    iii. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks.
    iv. The Control Systems Supplier shall respond to the owner's request for warranty service within forty-eight (48) standard working hours. Emergency service shall be available within twenty-four (24) hours.
    v. Any changes made to the control system, including set-points, programming, schedules, or calibrations shall be documented on the Owner's work order to clarify the adjustments made in addition to updating user documentation.
    vi. Service Contract Provider Transition Acceptance Report: After project Final Completion, KCTCS will transition preventative maintenance responsibilities to their current Service Contract Provider (outside the project contract). Prior to acceptance of these responsibilities the Service Contract Provider will inspect the

facility and issue a Service Contract Provider Transition Acceptance Report. The design team shall review the findings of this report and work with the commissioning and contracting teams to resolve appropriate project warranty related issues.

h. Building Automation System Warranty Transition Requirements; The design team shall add the following to the project closeout provisions:
    i. The BAS Standards & Compliance Team will be provided a copy of the:
        1) Commissioning Report
        2) Design Team Final Warranty/ Closeout Report
        3) Service Contractor Transition Acceptance Report
    ii. As a provision of the project closeout, the BAS Standards & Compliance Team will issue a Project Closeout Acceptance Report indicating the BAS is performing consistent with the project requirements.

6. Building Automation Performance Requirements

a. Graphic Display: Display graphic with minimum twenty (20) dynamic points with current data within ten (10) seconds.
b. Graphic Refresh: Update graphic with minimum twenty (20) dynamic points with current data within eight (8) seconds.
c. Object Command: Reaction time of less than two (2) seconds between operator command of a binary object and device reaction.
d. Object Scan: Transmit change of state and change of analog values to control units or workstation within six (6) seconds.
e. Alarm Response Time: Annunciate alarm at workstation within forty-five (45) seconds. Multiple workstations must receive alarms within five (5) seconds of each other.
f. Program Execution Frequency: Run capability of applications as often as five (5) seconds, but selected consistent with mechanical process under control.
g. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
h. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

VARIABLE	REPORT RANGE	CONTROL RANGE
Water Temperature	+/- .5ºF (0.25ºC)	+/- 2ºF
Water Flow	+/- 2% of full scale	+/- 5% of full scale
Water Pressure	+/- 1% of full scale	+/- 2% of full scale
Space Temperature	+/- 1ºF (0.5ºC)	+/- 3ºF
Ducted Air Temperature	+/- .5ºF (0.25ºC)	+/- 1˚F – 2˚F
Outside Air Temperature	+/- 1ºF (.5ºC)	N/A
Dew Point Temperature	+/- 1ºF (.5ºC)	+/- 3ºF
Temperature Differential	+/- 0.25ºF (0.15ºC)	N/A
Relative Humidity	+/- 1%	+/- 3%
Airflow (Pressurized Spaces)	+/- 1% of full scale	+/- 3% of full scale
Airflow (Measuring Stations)	+/- 2% of full scale	+/- 5% of full scale
Airflow (Terminal)	+/- 2% of full scale	+/- 10% of full scale
Air Pressure (Space)	+/- 0.01" wg (2.5 Pa)	+/- 0.05" wg
Air Pressure (Supply Duct)	+/- 0.1" wg (25 Pa)	+/- 0.2" wg
Air Pressure (Return Duct)	+/- 0.01" wg (2.5 Pa)	+/- 0.05" wg
Electrical Power	+/- 1% of reading	N/A

7. **Building Automation System / Control Product Requirements**
    a. The following BAS / Control Product Requirements are intended to communicate the product specific BAS and Controls Project Requirements to the Design Team. These requirements are to be adapted into the project design and specifications as appropriate for the application. They do not modify the design and contracting team's responsibility for project design, specification, construction and functionality.
    b. Network Controller Standards (BAS Level 2 Field Cabinets)
        i. The BAS Network Controllers shall be an open protocol / open distribution controller.
            1) For existing buildings, the current BAS Level 2 Devices are to remain unless requiring replacement. In such cases, the Vykon JACE with an open Niagara AX Compatibility Statement (NiCS) should be used. Where existing conditions warrant an exception and with written approval from the S/C Team, an existing non-Vykon JACE may be considered.
            2) For construction projects the network controllers shall be Vykon JACEs, Owner Furnished – Contractor Installed. Programming shall include an open Niagara AX Compatibility Statement (NiCS).
    c. Custom Application Controllers
        iii. Custom Application Controllers applied to specific equipment shall include a standard open communications interface of either BACnet-IP, BACnet-MSTP, Modbus TCP, Modbus-Async (Serial), or Lon (EIA Standard 709.1) protocol.
        iv. Mechanical and Electric Equipment with integrated factory controllers shall include a standard open communications interface of either BACnet-IP, BACnet-MSTP, Modbus TCP, Modbus-Async (Serial), or Lon (EIA Standard 709.1) protocol.
        v. Modular and Custom Air Handling Unit Controls may be factory mounted as directed by the design team, but in such cases, the Custom Application Controller shall be furnished and programmed by Controls Provider and of the same manufacturer as other Custom Application Controllers and Application Specific Controllers used for the project.
        vi. Variable Frequency Drives shall include a standard open communications interface of either BACnet-IP, BACnet-MSTP, Modbus TCP, Modbus-Async (Serial), or Lon (EIA Standard 709.1) protocol.
    d. Zone Control Standards (BAS Level 1)
        i. Application Specific Controllers
            1) Application Specific Controllers shall be of the same manufacturer for a given building (mixed controls manufacturers within a given building requires written approval by the KCTCS project manager).
            2) Application Specific Controllers shall include a standard open communications interface of either BACnet-IP, BACnet-MSTP, or Lon (EIA Standard 709.1) protocol.
    e. Control Devices
        i. Sensing Devices shall be of high quality and perform to the functionality specified under Building Automation Performance Requirements.
        ii. Actuating Devices shall be of high quality and perform to the functionality specified under Building Automation Performance Requirements. With the exception of very large assemblies or devices, electronic actuation is preferred

over pneumatic. The actuators shall have torque ratings sufficient to drive the connected devices without shortening the life of the actuator.

8. <u>Building Automation System Execution Phase Requirements</u>

a. BAS Installation Requirements

i. It is intended that the HVAC Instrumentation and Controls wiring be installed and terminated in accordance with Division 26 Requirements, with the following guidelines for signal and communication cable management:

1) Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2) Install exposed cable in raceway.
3) Install concealed cable in raceway.
4) Existing building cable tray raceways may be utilized, but control cabling shall be of a different jacket color than existing cabling and shall be secured and bundled within the tray separately of other cables.
5) Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
6) Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
7) Number-code conductors for future identification and service of control system, except local individual room control cables may be color coded.
8) Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

ii. Install labels and nameplates to identify control components according to Division 26, Section Identification for Electrical Systems

b. BAS Graphics Coordination

i. BAS Graphics for KCTCS building automation systems generally fall into three (3) categories:

1) Typical Equipment types: Typical MEP equipment types have had "Standard Object" palettes developed by the S/C Team.
   a. The palettes include the graphics for this equipment.
   b. These owner furnished palettes will be provided to the Controls Provider after project award.
   c. These types include fan coils, VAV boxes, heat pumps, and similar equipment.
2) Custom Equipment types: Custom MEP equipment graphical requirements shall be coordinated during the design phase with the S/C Team.
   a. In most instances, these will be developed by the S/C Team and will be owner furnished palettes provided to the Controls Provider after project award.
   b. There may be circumstances where the design team is instructed to have these custom graphics developed by the BAS Supplier. In such cases, the BAS Supplier shall utilize widely available Tridium / Niagara workplace graphic tools (specifically the kit PxGraphics Palette) to maintain consistency with those developed in the Standard Object palettes, and must be approved by the S/C Team during the submittal process.

3) Building and Building System level graphics: Building and Building System level graphical requirements shall be coordinated during the design phase with the S/C Team.
    a. In most instances, these will be developed by the Team and will be added to the College Level Server by the Team.
    b. There may be circumstances where the design team is instructed to have these custom graphics developed by the BAS Supplier. In such cases, the BAS Supplier shall utilize widely available Tridium / Niagara workplace graphic tools (specifically the kit PxGraphics Palette) to maintain consistency with those developed in the Standard Object palettes, and must be approved by the S/C Team during the submittal process.
4) The specifications shall instruct the Controls Provider to map and integrate control points from the devices and equipment onto the graphics provided by the S/C Team.

ii. Controls Provider's BAS Graphics Responsibility
1) The Controls Provider will be responsible for linking the building-level control points to the JACE level Standard Object modules using the KCTCS Standards Objects palette. The Controls Provider will need to support the integration of the networked JACE's into the college-level Niagara AX Supervisor server. This includes, but is not limited to, responsiveness to the JACE commissioning review, communication to confirm networking, availability to review custom systems that do not meet standard configuration.

c. Calibration Requirements
i. Calibrating and adjusting.
1) Calibrate instruments.
2) Make three-point calibration test for both linearity and accuracy for each analog instrument.
3) Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4) Control system inputs and outputs:
    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5) Flow:
    a. Set differential pressure flow transmitters for 0 and 100 percent values with three-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.
6) Pressure:

a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7) Temperature:
a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
b. Calibrate temperature switches to make or break contacts.

8) Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.

9) Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.

10) Provide diagnostic and test instruments for calibration and adjustment of system.

11) Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures for review and approval before initiating startup procedures, per the Commissioning Plan.

ii. Adjust initial pressure, temperature and humidity set points.

d. Software and Firmware Operational Documentation:
i. Include the following:
1) Software operating and upgrade manuals.
2) Program Software Backup: On a magnetic media or compact disc, complete with data files.
3) Device address list.
4) Printout of software application and graphic screens.

ii. Software license required by and installed for DDC workstations and control systems, with a licensed copy left at the Campus.

iii. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

e. On-site Assistance
i. Occupancy Adjustments: Within one (1) year of date of Substantial Completion, provide up to three (3) project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual condition.

f. Training
i. The initial training session shall be scheduled and completed prior to project Final Completion date. The remaining hours allocated for training (dependent on recommendation from SC Team during Phase B review) shall be scheduled and completed at Owner designated intervals during the Warranty period.

ii. Training shall be performed in a controlled classroom environment where Owners' Representatives can access the BAS through workstations or PCs. The user service, prototypes, and permissions shall be set up prior to training to provide appropriate access and visual information to the trainees.

iii. Train the designated staff of Owner and Owner's Representatives to achieve the objectives of the User / Operator Proficiency requirements outlined in the Quality Assurance section, paragraph 5.c.iv above.

iv. Present & Document content in digital format for each level of training, in modular format:
    1) The three (3) levels of training will generally be organized around:
        a. User Access - designed for those needing read only access to building system information, with minimal set-point adjustment authorization.
        b. Operator Access (low to medium) - designed for those authorized to make limited write adjustments to set-points and schedules.
        c. Operator Access (medium to high) - designed for those authorized to make substantial write and invoke level adjustments to the BAS.
v. Make digital content accessible at the Read-Only user level through the BAS browser.

END OF SECTION