23 09 00

Direct Digital Control Systems

The Missouri University of Science & Technology Design Guideline conveys requirements design teams shall incorporate into the contract documents to achieve S&T's quality and performance expectations. The Guide does not relieve or limit the design team's professional or contractual responsibility. Submit any proposed deviations to the PM or discuss during design review meetings.

PART 1 GENERAL

1.1 SUMMARY

A. Section includes
   1. Direct Digital Controls Systems

B. Abbreviations
   1. BAS: Building Automation System
   2. JCI: Johnson Controls Inc.
   3. SNE: Supervisory Network Engine

1.2 DESIGN/PERFORMANCE REQUIREMENTS

A. General
   1. S&T uses JCI as the sole source contractor for all buildings on the S&T Campus. Interface shall be Metasys
   2. Engage JCI as a design assist partner. See Part 2 for contact information.
   3. For critical airflow systems, phoenix controls shall be specified.

B. BAS system
   1. Generally, specify BAS control for all HVAC equipment. Do not specify stand-alone controls.
   2. Do not specify a PC workstation, printer, and training unless specifically requested.
   3. Specify Metasys graphics updates with JCI for systems and buildings.

C. BAS control panels
   1. Indicate on the drawings the BAS control panel locations for AHU's, boilers, chillers and other non-terminal equipment to plan for required wall space. Indicate a dedicated 20A 120V circuit for each control panel.
   2. Locate BAS control panel near the controlled device for economical wiring installation.
   3. Confirm with JCI if a building SNE is required during the milestone review process. Indicate a dedicated 20A 120V circuit and network data drop for each SNE.
   4. Specific a permanently affixed label on the upper right corner of the panel cover with the name of the equipment served.

D. Control valves
   1. Schedule valves as a JCI product or Belimo product excluding butterfly valves.
   2. Schedule valves as a Bray product for butterfly valves.
   3. Standard design shall not use pressure independent control valves unless approved by owner for specific purposes.
   4. Specify and ensure pre-packaged equipment contains valves meeting the criteria in this section.
   5. Locate valves and actuators at locations that allow for access, maintenance, and replacement.

6. Schedule control valves on the drawings and indicate the size, CV, valve type, shut off pressure, actuator type, and fail-safe position. For projects with 20 or more terminal units, specify typical flow ranges in lieu of scheduling individual terminal units.
7. Specify valves for specific equipment as follows:
    a. Do not specify solenoid valves or zone valves for HVAC control.
    b. Terminal equipment: Characterized ball valves with proportional actuators
    c. Hydronic indoor AHU with unconditioned OA: Characterized ball valves with proportional actuators with spring return N.O.
    d. Hydronic indoor AHU without unconditioned OA: Characterized ball valves with proportional actuators without spring return N.C.
    e. Hydronic outdoor RTU air: Characterized ball valves with proportional actuators with spring return N.O.
    f. Steam loads: Globe valves with proportional actuators with spring return N.C.
8. Select control valves for modulating hydronic service for 3-5 psig pressure drop or a valve authority of at least 30%. However, main building loop ties will be line size butterfly valves.
9. Where required, specify 2-position, line size control valves. Ball valves shall be full port.
10. Typically, specify 2-way controls valves for energy conservation.
11. Typically, do not specify 3-way valves except for remote runs for maintaining temperature. Show locations on documents and use sparingly.
12. Specify butterfly valves for the following conditions:
    a. When exceeding the capacity of ball valves for large, non-modulating, 2-position hydronic valves.
    b. When exceeding the capacity of a globe valve for large, modulating hydronic valves used with a heat transfer device.
    c. When exceeding the capacity of a ball valve or for modulating hydronic valves used for flow throttling not associated with heat transfer device.
    d. Select modulating butterfly with a range from closed to 70 percent open with proportional non-spring return actuators.
    e. Request approval from the S&T PM before specifying fail safe butterfly valves which require a remote battery/capacitor. Specify valve with a lug body.
13. Actuator power
    a. Schedule power voltage for actuators as 24VAC.
    b. BAS contractor will provide 120V power supply if required due to voltage drop.
    c. Conform to BAS contractor’s determination of valve voltage requirements.

E. Control dampers and actuators
1. Schedule control dampers and actuators as a JCI product or Belimo product.
2. Specify aluminum airfoil blades with blade seals and end seals in dampers.
3. Locate dampers and actuators at locations that allow for access, maintenance, and replacement.
4. Schedule control dampers on the drawings and indicate size, blade type (parallel or opposed), actuator type, and fail-safe position.
5. Configure dampers and actuators such that one actuator control only one damper connected via damper end shaft. Don not utilize jack shafts or locate dampers in walls. Layout multi-section dampers to allow for actuator access and maintenance.
6. Specify actuator as follows:
    a. Terminal equipment: Proportional actuators without spring return
    b. Indoor AHU with unconditioned OA: Proportional actuators with spring return
    c. Indoor AHU without unconditioned OA: Proportional actuators without spring return
    d. Actuators for outdoor RTU air: Proportional actuators with spring return
    e. Specify spring return normal positions as follows:
        1) Outdoor air: Normally closed
        2) Return air: Normally open

7. Actuator power
    a. Schedule power voltage for actuators as 24VAC.
    b. BAS contractor will provide 120V power supply if required due to voltage drop.
    c. Conform to BAS contractor's determination of valve voltage requirements.

F. Hydronic sensors
1. Typical temperature sensor: JCI TE-6300 series, 1000 ohm nickel without transmitter
    a. Locate temperature sensors in thermowells. Thermowell insertion depth shall be 1/2"the inside pipe diameter but not to exceed 10".
    b. Indicate temperature sensor locations and BTU meter sensors locations on the flow diagrams.
2. Typical chilled water temperature sensor: JCI TE-6000, 1000 ohm platinum without transmitter
3. Typical differential pressure sensor: Setra model 230 wetted differential pressure sensor with 3-valve manifold
    a. Indicate sensor locations on the flow diagrams with service valve located at the connection to the piping. Typically, specify copper tubing to connect to sensor.
    b. S&T prefers sensors 4' AFF in mechanical rooms. For other conditions, locate sensors above an accessible ceiling in a common space or corridor (not an office, classrooms, lab, etc.).

G. Airside sensors
1. Typical temperature sensor: JCI TE-6000 series, 1000 ohm nickel without transmitter
    a. Specify single point sensors for duct applications.
    b. Specify flexible averaging sensors for coil leaving air temperature applications.
    c. Indicate sensor locations on the flow diagrams.
2. Typical differential pressure sensors: Setra model 264
    a. Indicate the pressure sensor locations on the airflow diagrams and the floor plans.
    b. Indicate the outdoor reference device and coordinate location with the architect.
    c. Typically, specify a single building reference located on the roof with a vertical 1/2" copper riser used as a reference on each floor.
3. Specify humidity sensors sparingly. Review specific conditions with the S&T PM.
4. Do not specify carbon dioxide sensors more than ASHRAE requirements.

H. Airflow measurement
1. S&T prefers building differential pressure sensors for control sequences in lieu of air flow measurement.
2. Specify airflow measurement sensors sparingly. Review specific conditions with the S&T PM.
3. Where approved, specify:
    a. Do not detail airflow measurement sensors in unfiltered air.
    b. Vortex shedding or thermal dispersion type sensors. Do not specify pitot tube type sensors.
    c. Design for easy maintenance access and verify upstream and downstream straight duct requirements when selecting location.

I. Zone Temperature sensors and Thermostats
1. Indicate a backbox and conduit rough-in for temperature sensor and thermostat installations.
2. Indicate temperature sensor and thermostat type number on the drawings.
3. Specify a permanently affixed label on temperature sensors and thermostats identifying the equipment they serve.
4. Thermostats shall be white in color and shall include a display. Specify sensor only with flush stainless steel wall plate for gyms or high abuse locations.

J. Refrigerant monitors
   1. Specify a hardwired interlock connecting the refrigerant monitor to the exhaust fan operation and makeup air.
   2. Indicate on the drawings the control panel location, sensor locations, and remote horn/strobe to plan for required wall space.
   3. Indicate a dedicated 20A 120V circuit.

K. Leak detection
   1. Indicate a leak detection monitor at the lowest level of the building in a wet mechanical room or other unoccupied space.

L. Metering
   1. Specify ultrasonic strap on meters for large diameter pipes and ultrasonic inline meters for small diameter pipes with BACnet MSTP for chilled and hot water applications.
   2. Specify Onicon System-20 BTU meters with F-3500 and F-4300 flow meters for building water BTU metering applications when required.
   3. Specify Leviton 3500 series with BACnet MSTP or IP card for monitoring total building electrical load.

M. Hardwired safeties
   1. Specify hardwired safeties for life safety and equipment protection.
   2. Typical applications: Refrigerant exhaust, freeze stat, high pressure safety, low pressure safety, etc.
   3. Specify freeze stats in any unit with an OA connection. Locate upstream from cooling coil and downstream from preheat coil (when so equipped).
   4. High pressure and low-pressure switches shall be:
      a. Automatic reset type
      b. SOO shall include delay start and maximum number of resets before lockout.
      c. in an easily accessible place that can be reset. This must be able to be reset without the use of a ladder, in all cases that are reasonable.
      d. Remote reset from BMS.

N. Sequences of operation
   1. S&T and JCI maintains standard sequences for common applications due to campus size.
   2. Utilize S&T and JCI standard sequences and blocks of standard routines.
   3. Review with S&T PM and JCI special applications which require non-standard sequences.
   4. ASHRAE Guideline 36 High Performance Sequences of Operation for HVAC Systems may also be used and discussed with S&T PM.

O. Interface with fire alarm system
   1. Coordinate with electrical consultant to indicate a relay module at each AHU control panel for DDC interlock to fire alarm mode.
   2. At smoke dampers and fire/smoke dampers, indicate DDC relay in series with fire alarm relay to close damper when system air is not flowing (i.e. AHU is off, in unoccupied mode, or other mode).

P. Electrical devices and relays
   1. S&T utilizes the following components on projects:
      a. Functional Devices RIB relays with hand-off-auto switch
      b. Ice cube relays with indicator light
      c. Multifunction digital type time delay relays
      d. Current transformers

Q. Raceways
   1. All conduit installed must have minimum of 20% spare area under maximum code conduit fill area for future wire pulls.

2. All abandoned control wiring, pneumatic tubing, control enclosures, conduit, sensing devices, abandoned controllers, and raceway shall be removed to its source when involved in a project.
3. S&T accepts BAS control wiring in open J-hooks in the following locations:
   a. Above 8' AFF in unfinished spaces (closets, mechanical rooms, electrical rooms)
   b. Above acoustical ceilings

R. Integration
1. Specify BACnet MS/TP integration in lieu of BACnet IP Integration for 3rd party devices to minimize data drops.

S. Phoenix Lab Controls (For critical airflow control systems such as laboratory, vivarium, isolation rooms and BSL 3 containment areas)
1. Shall be contracted through BAS contractor (Friemel Love).

T. Control wiring
1. All control wiring shall be home runs to the main controller and shall contain no splices.
2. All wires are to be labeled clearly with wrap around tags on both terminations of the wire. All junction box covers shall be labeled Controls. Cabinets are to be clearly labeled.
3. All safety circuit devices such as low temperature detectors, high pressure cut outs, and fire safety devices shall be physically wired in series with the variable frequency drive safety circuit or motor starter in such a way that the equipment will shut down without intervention from the BAS. BAS is to monitor all of these points for purpose of alarming. Multiple safety devices of the same type must also be wired in series when applied within the same system.
4. All critical equipment, as deemed so by the University Facilities Group shall be wired to fail in a system and environmentally safe position in case of loss of BAS signal. For example, exhaust fans may fail on due to a critical environment that they are serving.

PART 2 PROVIDERS & PRODUCTS

2.1 SOLE SOURCE BAS PROVIDER

A. Johnson Controls Inc. – St. Louis Office
314-569-1570
www.johnsoncontrols.com
Jack Conroy (Account Representative- Contractor Sales): jack.conroy@jci.com

B. Phoenix Controls: Friemel-Love Company
314-647-6363
www.friemellove.com

2.2 MANUFACTURERS

A. Specify products from the following manufacturers based on local representation and support.
1. BAS controls: **JCI Metasys**
2. Lab Controls: **Phoenix Controls**

PART 3 EXECUTION

3.1 SPECIFICATION REQUIREMENTS

A. Include the following text in the appropriate section of the project specifications:
   1. Contractor coordination drawings shall include BAS panel locations, sleeves required in concrete or masonry walls, and roof penetrations.
   2. Contractor shall test and adjust set point for electronic flow switches for chiller minimum flow rates or value indicated by Engineer.
   3. All controller layouts shall be physically wired such that all critical inputs and outputs shall be wired to the same controller on the network. Points for PID type control loops shall not be passed from controller to controller across the network. All control loops in a controller shall act in a standalone manner, if the network communication to that controller were lost.
   4. All major controller cabinet locations should be placed in easily accessible places in secured mechanical spaces. Room level controllers need not be placed in secured mechanical rooms, but still should be accessible for replacement and maintenance as needed.
   5. All actuators and valves must be placed in spaces that are accessible for full testing without removal. Actuators and valves should be easily remove-able and should have hand valves in place in order to easily change out actuators and control valves without shutting a section of the larger system down than is already affected by the actuator and valve itself.
   6. All room level controllers shall have adequate access to remove covers, replace and service components. This includes valves, dampers, filters, etc.
   7. Ladders should not be required to reach controllers, except in the case of room level controllers above ceilings.
   8. All equipment level controllers should leave at least 10 percent spare point capacity of a distributed variety (BI, BO, AI, and AO), specifically for each type of point provided on the controller.
   9. Each controls installation shall include a set of as built documents that are sent electronically at the time of project closeout. These documents must contain all applicable schematics, system architecture, valve schedules, product specification sheets, and sequences for how the controls are operating when the project has reached completion.
   10. All BACnet IP Instance ID's, Network ID's, and IP addresses shall be requested from University Facilities Group. All BACnet MSTP addressing shall be determined by controls contractor and follow BACnet guidelines.
   11. All building automations system submittals and as built documentation should include a quality sequence of operations section for each piece of equipment to be controlled.
   12. All projects must contain trended points that include but are not limited to the following:
       a) All associated temperatures and their set point
       b) All associated humidity and their set point
       c) All associated valve and damper positions/signals
       d) All CFM and flow values and set points
       e) All digital proofs for pumps and fans
       f) All vfd signals
       g) All pressurization values and set points
   13. The specific trending requirements of each point are dependent upon the level of criticality determined for that space. All spaces shall be categorized into 3 categories. Each category determines the level of trending required in the frequency that samples are taken, the range of values that are to be captured, and in the length of time that the data will be stored. A space may be determined during the project as requiring a specific level of trending, in order to be categorized in level 1, 2, or 3. See table below for trending level specific requirements.
   14. Historical logging is to be stored on the system server for different lengths of time specified for each category in the chart below.
   15. All BACnet installations shall use the required BBMD for their area subnet applications. This BBMD

shall come from the existing BBMD in the subnet, or from a newly supplied BBMD controller specifically included in the new installation for that newly created subnet. The BBMD shall be a controller which is a zero node controller (containing no physical I/O points) solely installed and maintained in the subnet for routing all BACnet traffic for the entire subnet.

16. All BACnet installations including 3rd party equipment shall be managed by the BAS contractor.
17. All third party equipment shall be integrated with BACnet, preferably. This may be done MS/TP or TCP/IP where it makes sense to implement either. In the event that BACnet is not available with the third party equipment then it may be implemented in Modbus RTU (RS485) or TCP/IP as appropriate.
18. All floor level or room level controllers shall be BACnet MS/TP. They shall not operate on proprietary languages.
19. All MS/TP controllers installed must be accessible from the front end software for controller level changes, such as programming, schedules, point database management, etc.

B. Equipment Submittal Process
    1. Equipment specified to provide BACnet Communications
        a. Each individual piece of equipment shall be provided with either an RS-485 port for BACnet MSTP or an Ethernet port for BACnet IP.
            i. Exceptions for specialized equipment can be submitted and approved. All protocols shall be "certified" by the governing authority (ie BTL Listing for BacNet). Use of non-certified protocols is not allowed. Packaged HVAC equipment. Equipment specifically not considered specialized HVAC equipment is as follows, but not limited to, RTU, AHU, Chiller, Boiler, ERU, Heat Pump
            ii. BACnet MSTP interface shall be available operating speed of 38.4 Kbps.
            iii. All BACnet connections shall be proven factory tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:
                a. Data Sharing – Read Property – B.
                b. Data Sharing – Write Property – B.
                c. Device Management – Dynamic Device Binding (Who-Is; I-AM).
                d. Device Management – Dynamic Object Binding (Who-Has; I-Have).
                e. Device Management – Communication Control – B.

        b. Communication capabilities shall include, but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, common setpoint adjustments. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote fault reset shall be possible.

C. Equipment Install Process
    1. Manufacture to provide points list for each specific build of equipment the given piece of equipment. Table shall include:
        a. Point name
        b. Point description
        c. Point type (analog vs binary; input vs output; etc)
        d. Value range or possible outcomes (sensing range for temperature sensor, possible states for multistate value, etc.
        e. Read or write capability

2. Provide manufacturer's trained representative to provide onsite field installation support for devices shipped loose with equipment. Manufacturer's representative shall direct installing contractors on what components are to be field installed, how they are to be installed, and where they are to be installed. The install contractor may deem that offsite coordination or documentation instructions alone may not be sufficient and request a site visit by owners manufacture prior to manufacture equipment startup. This will vary by complexity of the equipment.

D. Equipment Startup

1. Manufacturer's software trained representative shall:

a. Verify control device address and communication speed.
b. Start up and check out the controls provided with the equipment.
c. Confirm unit operation per the Sequence of operation as provided by the engineer of record.
d. Document any additional sequence of operation detail as not defined in the EOR provide as-built SOO.
e. Verify integration of equipment controls with BAS.
    i. BAS contractor to provide equipment supplier with list of discoverable points.
    ii. Equipment supplier to evaluate points list by documenting non-pertinent points, providing accurate/extended descriptions. This evaluated points list shall be returned to the BAS contractor.
    iii. BAS contractor shall implement changes to the BAS based on the evaluated points list.
    iv. A final review of the points list shall be done as part of the owner training by the equipment supplier.
f. verify one (1) and one (1) binary readable input point is reading correctly through the integration to the BAS.
g. verify one (1) analog and one (1) binary writeable output point is changing correctly through the integration to the BAS.

PART 4 REFERENCES

4.1 23 09 93 SEQUENCES OF OPERATION

A. Refer to the flow control diagram, points list and sequence of operation for the following 3 conditions:
1. 23 09 93 CHW Bypass Flow Control – Non-Plant Bldg (S&T)
2. 23 09 93 HW Bypass Flow Control – Non-Plant Bldg (S&T)
3. 23 09 93 CHW Flow Control – Regular Duty Chiller (S&T)