Construction Management

University of Missouri-Columbia

Planning, Design & Construction
Campus Facilities

117 General Services Building
Columbia, MO 65211-3200

PHONE (573) 882-1133
FAX (573) 882-1175

PROJECT:

BAS CHECKLIST

Date:

BAS Construction Checklist

Project:	

Date:	
Building:	
Location:	

Submittal / Approvals

Submittal. The above equipment and systems integral to them are complete and ready for functional testing. The checklist items are complete and have been checked off only by parties having direct knowledge of the event, as marked below, respective to each responsible contractor. This construction checklist is submitted for approval, subject to an attached list of outstanding items yet to be completed. A Statement of Correction will be submitted upon completion of any outstanding areas. None of the outstanding items preclude safe and reliable functional tests being performed. ___ **List attached.**

Mechanical Contractor	Date	Controls Contractor	Date
Electrical Contractor	Date	Sheet Metal Contractor	Date
TAB Contractor	Date	General Contractor	Date

Construction checklist items are to be completed as part of startup & initial checkout, preparatory to performing test procedures.

- This checklist does not take the place of the manufacturer's recommended checkout and startup procedures or report.
- If this form is not used for documenting, one of similar rigor shall be used.
- Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

Approvals. This filled-out checklist has been reviewed. Its completion is approved with the exceptions noted below.

PROJECT:

BAS CHECKLIST

Date:

Commissioning Authority	Date	Owner's Representative	Date

Equipment Verification.

	As Specified	As Submitted	As Installed
Manufacturer			
Model No.			
Serial No.			
CPU			
Monitor			
Other primary features:			

	As Specified	As Submitted	As Installed
Manufacturer			
Model No.			
Serial No.			
CPU			
Monitor			
Other primary features:			

Requested documentation submitted	Rec'd	Comments
Manufacturer's cut sheets	☐	
Installation and startup manual and plan	☐	
O&M manuals	☐	
Sequences and control strategies	☐	
Sequences and list of all control strategies	☐	
Completed control drawings	☐	
List of all control parameters, settings and setpoints	☐	
Point-to-point checks	☐	
Comments:		

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Installation Checks			
Check if acceptable, provide comment if unacceptable		**NA**	**Comment**
Terminal Interface and Sub-Panel Checks			
General appearance good, no apparent damage	☐	☐	
Equipment labels affixed	☐	☐	
Layout and location of control panels match drawings	☐	☐	
Areas or equipment panels served clear in control drawings	☐	☐	
Wiring labeled inside panels (to controlled components)	☐	☐	
Controlled components labeled/tagged	☐	☐	
BAS connection made to labeled terminal(s) as shown on drawings	☐	☐	
Shielded wiring used on electronic sensors	☐	☐	
110 volt AC power available to panel	☐	☐	
Compressed air available to panel (if applicable)	☐	☐	
Battery backup in place and operable	☐	☐	
Surge suppression in place and operable	☐	☐	
Panels properly grounded	☐	☐	
Environmental conditions according to manufacturer's requirements	☐	☐	
System date and time correct	☐	☐	

Comments:

PROJECT:

BAS CHECKLIST

Date:

Device and Point to Point Checkout (Static Testing)

The following procedures are required to be performed and documented for each and every point in the control system. The following procedures are minimum requirements. The control contractor is encouraged to identify more comprehensive checkout procedures in greater detail in their submitted plan. These procedures are not a substitute for the manufacturer's recommended start-up and checkout procedures but are to be combined with them, as applicable. The documentation may be provided on the vendor's stock form, as long as all the information in the sample table below can be clearly documented on the form.

Similar checkout and calibration requirements are found on the equipment construction checklists. Redundant documentation is not required. Cross reference, by name and form number, to other forms that contain documentation left blank on the current form (attached below).

Procedures:

1. [Wire] Verify that the wiring is correct to each point.
2. [Actu] If the device is or has an actuator, verify full free movement through its full range.
3. [Addr] Verify that the software address is correct.
4. [Load] For devices with a controller, verify that current software program with proper setpoints has been downloaded.
5. [DevCal] Device stroke/range calibration. This applies to all controlled valves, dampers, fans, pumps, actuators, etc. Simulate maximum and minimum transmitter signal values, verify minimum and maximum controller output values, and positively verify each and every control device minimum and maximum stroke and capacity range. Follow procedure below.
6. [SensLoc] Verify that all sensor locations are appropriate and away from causes of erratic operation.
7. [SensCal] Sensor calibration. Calibrate or verify calibration of all sensors and thermostats, including temperature, pressure, flow, current, kW, rpm, Hertz, etc. Verify that the sensor readings in the control system are within the sensor accuracies specified in this section, using hand-held or other external measuring instruments. Follow procedure below.
8. [OperCk] For controlled devices (dampers, valves, actuators, VAV boxes, etc.), after mechanical equipment control becomes operational, perform an operational test of each control loop. Follow procedure below. Operational checks are preparatory to the later *test procedures*.

Other Abbreviations:

[BAS] .....Building automation system or gage-read value.
[Instru].....Instrument (calibrated) read value.
[Ofset].....Offset programmed into the point to correct the calibration.

Device and Point by Point Checkout (Dynamic Testing)

The following procedures are required to be performed and documented for each and every point in the control system. The following procedures are minimum requirements. The control contractor is encouraged to identify better and more comprehensive checkout procedures in their submitted plan. These procedures are not a substitute for the manufacturer's recommended start-up and checkout procedures, but are to be combined with them, as applicable. The documentation may be provided on the vendor's stock form, as long as all the information in the sample table below can be clearly documented on the form.

Similar checkout and calibration requirements are found on the equipment construction checklists. Redundant documentation is not required. Cross reference, by name and form number, to other forms that contain documentation left blank on the current form.

PROJECT:

BAS CHECKLIST

Date:

Procedures:

Each control point will be verified to be commanding, reporting and controlling according to their intended purpose.

Every analog and digital input and output in the central control system shall be verified to be functioning properly. Points within and controlled by packaged equipment controllers do not require a point-by-point checkout except for actuator positions or other points listed in the specifications or manufacturer's start-up and checkout procedures. For each output, commands will be initiated and verified to be functioning by visually observing and documenting the status of the controlled device (e.g., command cooling coil valve to full open, or command heating water pump off). For each input, the system or conditions will be perturbed to initiate the input response being tested and the response in the control system observed and recorded (e.g., high duct static pressure alarm). Sensors and actuators will also be calibrated according to the sections below.

Sensor Calibration Methods:

All Sensors. Verify that all sensor locations are appropriate and away from causes of erratic operation (in stratified air flow, touching coils, etc.). Verify that sensors with shielded cable, are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading, of each other, for pressure. Tolerances for critical applications may be tighter. Hand-held instrument readings should be taken at five or more locations for mixed air temperatures and three or more locations for hot and cold deck temperatures to ensure a good average value to check against the BAS reading.

A. Sensors Without Transmitters--Standard Application. Make a one-point reading within the normal expected range of operation of the sensor with a calibrated test instrument, having an accuracy per table below, within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS) is within the tolerances in the table below of the instrument-measured value. If not, install offset in BAS, calibrate or replace sensor.
B. Sensors With Transmitters--Standard Application. Make a two point calibration. Check the calibration at a condition near the low end and near the high end of expected operating values (temperature, pressure, etc.) using the procedure in (A). If sensor is not within tolerances, calibrate: Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum expected temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature expected matching 20 mA to the potentiometer span or maximum and verify at the BAS. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS) is within the tolerances in the table below of the instrument-measured value. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

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BAS CHECKLIST

Date:

C. Critical Applications. For critical applications (process, manufacturing, etc.) more rigorous calibration techniques may be required for selected sensors, such as making multiple point readings throughout the expected range of sensor operation. Describe any such methods used on an attached sheet.
D. Terminal Unit Flow Sensors. Flow sensors in air terminal units shall be calibrated during testing, adjusting and balancing using NEBB or AABC approved procedures.

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BAS CHECKLIST

Date:

Required Instrument Accuracy and Calibration Tolerances – Standard Applications

Sensor	Required Calibrating Instrument Accuracy (+/-)	Required Calibration Tolerance (+/-)
Cooling coil, chilled and condenser water temps	0.25F	0.4F
AHU wet bulb or dew point	1.0F	2.0F
Hot water coil and boiler water temp	1.0F	1.5F
Outside air, space air, duct air temps	0.25F	0.4F
Combustion flue temps	2.0F	5.0F
Relative humidity	2% RH	5% RH
Watthour, voltage & amperage	2% of reading	1% of design
Pressures, air, water and gas	2% of reading	3% of design
Building differential pressure	1% of full span	0.01 in. WC
Variable frequency drive	2 Hz	2 Hz
Flow rates, water	4% of reading	4% of design
CO_2 monitor	5% of reading	50 ppm
CO monitor	3% of span	0.6 ppm / deg C
Natural gas & oil flow rate	2% of reading	1% of design
Steam flow rate	2% of reading	3% of design
Flow rates, air	3% of reading	10% of design[1]
Air velocity rates	3% of reading	10% of design

Relative Sensor Calibration. This procedure makes sure that sensors are accurate relative to each other in a given piece of equipment. Sensors calibrated in this way, do not need separate calibration as given in Procedures A-D. For example, for a heating water system all the sensors in the fluid stream would be checked at one time, e.g., boiler entering and leaving temperatures, bypass, building supply and return temperatures. This would include building automation sensors, equipment panel readouts and gages. For an air handler it may include the return air temperature, coil temperatures and supply air temperatures. Calibrating sensors with this method is preferable to calibrating them each separately.

The procedure is as follows. 1) Record all current sensor calibration offsets. 2) Remove all sensor calibration offsets. 3) Put the system in a mode that will offer constant flow of water or air past the sensors, e.g., turn off boilers; turn on pumps, or turn on air handler and close outside air dampers and heating and cooling coil valves, etc. 4) Check with the reference instrument that the temperatures across coils and dampers are equal indicating that there is no leak-by. 5) With the reference instrument record the temperature rise across fans. 6) Use the entering fluid temperature to the system as a reference by inserting a reference measuring instrument there. 7) Compare the sensor readings with the reference reading. Take into account temperature rises across fans and pumps. 8) Install offsets or replace sensors and gages as required so sensor readings, compared to the reference, are within the tolerances given in Section E above. 9) Record all conditions, readings and offsets and submit. 10) Return systems to normal.

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BAS CHECKLIST

Date:

Valve and Damper Stroke Setup and Check

A. Actuator Arrangement. Verify that the actuator is using its full stroke to move the damper or valve through its full range of motion without sacrificing kinematics. Verify that linked or paired actuators are arranged the same. Verify that the linkages and ball joints are lubricated and that linkage rods are not binding or bent.

B. Spring Returns. For valves and dampers with spring returns, apply or remove power to the actuator and see that it moves to the correct position and that the spring has enough torque to fully close or open valve or damper.

C. BAS Readout and Stroke. For all valve and damper actuator positions checked, verify BAS address and the actual position against the BAS readout and verify that the valve or damper strokes fully and that "normal" position is correct.

Set pumps or fans to normal operating mode. Command valve or damper closed, visually verify that valve or damper is closed and adjust output zero signal as required. Dampers shall be adjusted to provide a tight positive closure. Command valve or damper open, verify position is full open and adjust output signal as required. Command valve or damper to a few intermediate positions. If actual valve or damper position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics). Remove the control signal to the valve or actuator from the BAS. Observe that the failure mode (current position, open, closed) is as per specifications.

D. Closure for heating coil valves (NO): Set heating setpoint 20°F above room temperature. Observe valve open. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Then, for pneumatic actuators only: Set heating setpoint to 20°F below room temperature. Observe the valve close. Override in the BAS, increase pressure to valve by 3 psi (do not exceed actuator pressure rating) and verify valve stem and actuator position does not change. Restore to normal.

E. Closure for cooling coil valves (NC): Set cooling setpoint 20°F above room temperature. Observe the valve close. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. For pneumatic actuators only: Set cooling setpoint to 20°F below room temperature. Observe valve open. Override the BAS, increase pressure to valve by 3 psi (do not exceed actuator pressure rating) and verify valve stem and actuator position does not change. Restore to normal.

Coil Valve Leak Check

A. Method 1--Water Temperature With 2- or 3-Way Valve. Calibrate water temperature sensors on each side of coil to be within 0.2°F of each other.

Option 1. Test Across Coil--for valves that are tight against AHU cabinet or valves that are away from the cabinet. Turn off air handler fans, close OSA dampers; keep pump running and valve open. Fix the supply water temperature setpoint. Place one sensor in moving supply water stream P/T plug or use existing thermometer, else strap-on sensor and insulate. Place one sensor on the return side of the coil, but not in the

main return stream from other coils, ideally in a P/T plug, or strap-on and insulate. Sensor on the valve side of the coil must be on the far side of the valve from the coil. Verify that temperatures on both sides of the coil read the same. If not the same, record differences and compensate in the next part of the test.

Close the valve by software command. After 10 minutes observe water delta-T across coil or valve. If delta-T is not greater than 2°F, leakage is probably occurring. If leaking, reset valve stroke to close tighter. Repeat test until in compliance.

Option 2. Test Just Across Valve—for valves more than 4 feet from the coil. Command the valve closed and measure the temperature difference with one sensor in the moving water stream on one side of the valve and one in the dead water at least 3 ft. from both the valve or the coil if the fan is on, if the fan is not on it can be closer to the coil than 3 ft. After 10 minutes observe water delta T across valve. If it is not greater than 2°F, leakage is probably occurring.

B. Method 2--Air Temperature With 2 or 3-Way Valve. Calibrate air temperature sensors on each side of coil to be within 0.2°F of each other. Change mixed or discharge air setpoint, override values or bleed or squeeze bulb pneumatic controller to cause the valve to close. Air handler fans should be on. After 5 minutes observe air delta T across coil. If it is greater than 1°F, leakage is probably occurring. Reset valve stroke to close tighter. Repeat test until compliance. Water leak-by less than 10% will likely not be detected with this method.

C. Method 3--Coil Drain Down for Terminal Units (not for 3-way valves). Put systems in normal mode. If cooling coil valve, remove all call for cooling or if heating coil valve put system in full cooling. Close isolation valve on supply side of coil, open air bleed cap, open drain-down cock and drain water from coil. Water should stop draining, else there may be a leak through the control valve. Return all to normal when done.

Isolation Valve or System Valve Leak Check (for valves not by coils)

A. Method 1--Ultra-sonic flow meter. With full pressure in the system, command valve closed. Use an ultra-sonic flow meter to detect flow or leakage.

END OF CHECKLIST
(See documentation forms on following pages)

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BAS Point to Point Verification Sample Form

(Static Testing) Duplicate form as necessary

Project:	

Date:	
Building:	
Location:	

Point	Type	Description	Point to Point	Sensor Calibration	Initials/Date

Comments:

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Point	Type	Description	Point to Point	Sensor Calibration	Initials/Date

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Sensor Calibration Documentation (sample form)

Sensor and Actuator Calibration

All field-installed sensors and gages, and all actuators (dampers and valves) on this piece of equipment shall be calibrated in accordance with Specification Section 01810. All test instruments shall have had a certified calibration within the last 12 months: **Y/N_____.** Sensors installed *in* the unit at the factory with calibration certification provided need not be field calibrated.

Sensor or Actuator Tag & Location	**Location OK**	**1st Gage or BAS Value**	**Instrument Measured Value**	***Final* Gage or BAS Value**	**Pass Y / N**

Valve and Damper Actuator Check Documentation

VALVES, DAMPERS and STATES							
Procedure #→	A;B	C					D;E
Name and Location	Link-age OK?	Initial BAS Value	Initial Visual Observa-tion	Final Visual Observa-tion	OK Y/N	Nor-mal OK?	Clos-ure OK?
		Open ☐ Closed ☐					
		Open ☐ Closed ☐					
		Open ☐ Closed ☐					
		Open ☐ Closed ☐					
		Open ☐ Closed ☐					
		Open ☐ Closed ☐					
		Open ☐ Closed ☐					

VALVE LEAK-BY TESTS	
A; B or C	
State Leak-By method used (A, B or C) and results, (final dT, etc.)	OK Y/N

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VALVES, DAMPERS and STATES								**VALVE LEAK-BY TESTS**	
Procedure #→	A;B	C					D;E	A; B or C	
Name and Location	Link-age OK?	Initial BAS Value	Initial Visual Observa-tion	Final Visual Observa-tion	OK Y/N	Nor-mal OK?	Clos-ure OK?	State Leak-By method used (A, B or C) and results, (final dT, etc.)	OK Y/N
		Open ☐ Closed ☐							
		Open ☐ Closed ☐							
		Open ☐ Closed ☐							
		Open ☐ Closed ☐							
		Open ☐ Closed ☐							
		Open ☐ Closed ☐							
		Open ☐ Closed ☐							

CCV = cooling coil valve, HCV = heating

***Fill out all form fields before signing!**

Name **Organization** **Title** **Signature**

University of Missouri Commissioning Authority

(Place Digital Locking Stamp Here)