SECTION 250804

BUILDING AUTOMATION SYSTEM (BAS) COMMISSIONING

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**NOTE TO SPECIFIER**

*Use this Specification Section for Mail Processing Facilities.*

***This is a Type 1 Specification with completely editable text; therefore, any portion of the text can be modified by the A/E preparing the Solicitation Package to suit the project.***

*For Design/Build projects, do not delete the Notes to Specifier in this Section so that they may be available to Design/Build entity when preparing the Construction Documents.*

*For the Design/Build entity, this specification is intended as a guide for the Architect/Engineer preparing the Construction Documents.*

*The MPF specifications may also be used for Design/Bid/Build projects. In either case, it is the responsibility of the design professional to edit the Specifications Sections as appropriate for the project.*

*Text shown in brackets must be modified as needed for project specific requirements.* *See the “Using the USPS Guide Specifications” document in Folder C for more information.*

*The last date that USPS revised this standard specification section occurs in two places, at the end of this section and in the Table of Contents. If the date in this section matches the date in the Table of Contents, then you are using the latest version. Do not delete or revise the “last revised” date at the end of the section during the development of the Project Manual.*

*The footer in this section should be edited to replace the text, “USPS MPF SPECIFICATION” with the project name, and the blank date in the center should be replaced with the submission date, for interim design reviews, or the issue date of the completed Project Manual.*

Use this specification section for projects where commissioning services will be provided. This specification is intended as a guide to the Architect/Engineer preparing the Construction Documents. The degree of commissioning that will be required for the project shall be specified by the COR. Refer to Handbook AS-503 Standard Design Criteria for more information about when commissioning is required.

The USPS uses prequalified Commissioning Agents for commissioning services. Commissioning services cannot be provided through the A/E, the Design/Build Entity (DBE), or the General Contractor (GC).

The purpose of this section is to inform the GC or DBE of the extent of the commissioning that will be required for the project prior to contract award because the GC or DBE is also responsible for providing the required assistance from their subcontractors to complete the Commissioning Plan. To that end, this section, and the other sections in Divisions 1, 22, 23, 25, and 26, must be closely coordinated with the Commissioning Agent and the Commissioning Plan.

This specification section, like all sections, are directed to the GC or DBE; do not include instructions to the A/E or the Commissioning Agent in the specifications.

This section includes commissioning requirements that are specific to Building Automation Systems. General requirements are included in Section 019113 - General Commissioning Requirements. Plumbing and electrical work are to be included in Section 220800 - Commissioning of Plumbing and Section 260800 - Commissioning of Electrical Systems.

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1. GENERAL
	1. SUMMARY
		1. The Postal Service has retained an independent Commissioning Authority to provide Commissioning Services and a Commissioning Plan to confirm that the functionality of new equipment and systems meets the original design intent, operates efficiently, and demonstrates that all the required features of the new system are functioning as specified in the design documents.
		2. This Section and other Sections in the Project Manual detail the Contractor’s responsibilities relative to the Commissioning process.
		3. Work included:
			1. Building Automation System and equipment testing and start-up.
			2. Validation of proper and thorough installation of BAS and equipment.
			3. Functional testing of control systems.
			4. Documentation of tests, procedures, and installations.
			5. Coordination of BAS training.
			6. Documentation of BAS Operation and Maintenance materials.

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NOTE TO SPECIFIER

Edit the RELATED REQUIREMENTS and REFERENCE STANDARDS paragraphs below to suit project requirements. The Commissioning Plan must be included in the Project Manual and listed in the Table of Contents; however, it is not a part of the Construction Contract. Also list the other sections in Divisions 22, 23, 25, and 26 that will include specific commissioning requirements related to the BAS.

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* 1. RELATED REQUIREMENTS
		1. Commissioning Plan: Available for reference.
		2. Section 013200 - Construction Progress Documentation.
		3. Section 013300 - Submittal Procedures.
		4. Section 017704 - Closeout Procedures and Training.
		5. Section 019113 - General Commissioning Requirements.
		6. Section 220800 - Commissioning of Plumbing.
		7. Section 230800 - Commissioning of HVAC.
		8. Section 260800 - Commissioning of Electrical Systems.
	2. REFERENCE STANDARDS
		1. ASHRAE Guideline 0-2005, "Guideline for Commissioning HVAC Systems"
		2. ASHRAE Guideline, “Preparation of Operating and Maintenance Documentation for Building Systems”
		3. NEBB - Procedural Standards for Building Systems Commissioning

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***NOTE TO SPECIFIER***

*Edit SUBMITTALS below to match the requirements in the Commissioning Plan.*

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* 1. SUBMITTALS
		1. Start-Up Procedures: Provide quality assurance procedures, checklists, and manufacturer’s installation and start-up procedures for all equipment and systems to be commissioned.
		2. Field Testing Agency Reports: Prior to the Acceptance Phase, provide all documentation from independent testing agencies required by the contract.
		3. Test Kits: Provide prior to the Acceptance Phase.
		4. Equipment Warranties. Provide prior to the start of the Acceptance Phase.
	2. QUALITY ASSURANCE
		1. Testing Equipment and Instrumentation: Provide all instrumentation necessary to accomplish the testing indicated in the Commissioning Plan. Quality and accuracy to be sufficient to test and measure system performance with the tolerances specified. Calibrate all equipment according to the manufacturer’s recommended intervals. Calibration tags to be affixed or certificates readily available.
			1. Test Kits: Provide new, previously used test kits are unacceptable.
			2. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of + or - 0.1°F.
			3. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
			4. All equipment shall be calibrated according to the manufacturer’s recommended intervals. Calibration tags shall be affixed or certificates readily available. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6 month period. Certificates of calibration shall be submitted to the CxA prior to start-up of the BAS.
			5. Functional Performance Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems will be provided by CxA.
			6. Special Tools: Provide special equipment, tools and instruments only available from vendor, specific to a piece of equipment, required for testing equipment.
			7. Provide digital indication of temperature and pressure with associated sensors to work with the P/T test ports.
			8. Provide companion readout kit with fittings, for calibrated balancing valve with ranges as required by all devices.
1. PRODUCTS

not used

1. EXECUTION

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***NOTE TO SPECIFIER***

*Edit the requirements below to suit project requirements in accordance with the Commissioning Plan.*

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* 1. General bas commissioning requirements
		1. Assist CxA in verification and performance testing. Assistance will generally include the following:
			1. Establish trend logs of system operation as specified herein
			2. Manipulate systems and equipment to facilitate functional performance testing as outlined in Section 019113.
			3. Provide POTs or operator workstations in locations convenient to testing activities as specified below
			4. Provide CxA with appropriate passwords, keys, and access to control panels and workstations.
			5. Where control systems do not allow a test mode or the overriding of physical input values for testing, program an interim virtual point for all inputs that can be used to represent the point and be overridden for testing.

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**NOTE TO SPECIFIER**

The following software optimization assistance time needs to be customized and/or selected for each project. For example, larger projects may use up to 24 hours whereas smaller projects may use 8 hours. Select the applicable system and submit to USPS Project Manager.

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* + 1. Provide a Control technician to work at the direction of Commissioning Authority for software optimization assistance for a minimum of [\_\_] hours.
		2. Train USPS Representatives in systems operations, control equipment use, operation, maintenance and repair.
		3. Compensate the USPS for site time necessitated by incompleteness of systems or equipment at time of functional performance testing. All testing failures, which require on-site time for retesting, will be considered actual damages to USPS. All parties under contract with USPS who are affected by the retesting may be included in the contract modification.
	1. TAB & COMMISSIONING Portable operators terminal
		1. Provide the CxA with all software, connection devices, licenses, passwords, etc. to facilitate connection to the BAS throughout the building. Provide a license to graphic software, and all operating software necessary for testing and configuration of all control elements at all levels. License may be a temporary license that will expire after the completion of the Warranty Period.

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**NOTE TO SPECIFIER**

Modify the below paragraph to suit the project requirements.

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* + 1. Provide the CxA with:
			1. A laptop computer for dedicated use by the CxA throughout the Construction and Acceptance Phases. Turn over laptop to USPS at the end of the Acceptance Phase.
			2. Browser access to the full graphic software. Set up the laptop to successfully connect.
			3. Licensed Client Software to be installed and ensure it is functional.
			4. Terminal Services session access to a Graphic server with required CALs to allow use of all required software. Configure the CxA computer to connect to the terminal session.

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**NOTE TO SPECIFIER**

As an alternative to 1 and 2 below: Access to the graphic server relating to terminal controls can be provided to the CxA through a connection port in the space such as a connection to a jack on the temperature sensor (basically what is required by TAB specified below). This does not apply to mechanical rooms as full graphic access is required in mechanical rooms.

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* + 1. Access to the BAS must be provided throughout the building as follows:
			1. Full wireless connection to the graphic server throughout the building will be adequate.
			2. Network connection for full access to the graphic server within 50 feet of any point in the building
		2. Provide software required by TAB to calibrate all flow sensors. TAB will provide computer to be used as a portable operator’s terminal. Provide manufacturer specific hardware such as connection cables, converters, hand held devices, etc.
		3. Provide local connections to the device being calibrated. For example, for VAV boxes, connection of the operator’s terminal shall be either at the sensor as well as at the box. Otherwise a wireless system shall be provided to facilitate this local functionality.
	1. COMMISSIONING CONSTRUCTION PHASE
		1. Provide assistance from [list contractors as needed] during the start-up process to confirm that the functionality of the new equipment meets the original design intent, operates efficiently, and demonstrates that all of the required features of the new system are functioning as specified in the design documents.
		2. Start-up requirements for systems and equipment:
			1. Submit Product data and Shop Drawings and receive approval.
			2. Submit Control Logic Documentation and receive approval.
			3. Submit project-specific graphics for each “unique” system and receive approval
			4. Submit electronic record copy of approved submittals.
			5. Review and return Pre-Commissioning checklists, drafted by the CxA, incorporating manufacture specific start-up procedures accompanied by manufacturers pre-printed start up procedures for all equipment.
			6. Install controls.
			7. Submit BAS O&Ms for review.
			8. Receive BAS Pre-Commissioning checklists approval.
			9. Submit Training Plan
			10. Place systems under BAS control.
			11. Prepare and initiate Trend Log data storage and format trend graphs.
			12. Perform BAS start up.
			13. Submit completed BAS Pre-Commissioning Checklists.
			14. Submit Commissioning BAS Software and provide password access to USPS and commissioning agent. Access level must provide for the manual override of all inputs, outputs and setpoints for the systems.
			15. Receive BAS Pre-Commissioning Report approval and approval to schedule Commissioning Demonstrations.
			16. Receive Demonstration approval and approval to schedule Acceptance Phase.
			17. Perform Functional Performance Testing and demonstrate systems to Commissioning Agent and USPS. Submit trend logs in format specified
			18. Train USPS Representatives on control system operation and maintenance.
			19. [List additional specific requirements as needed]
	2. COMMISSIONING ACCEPTANCE PHASE
		1. Provide assistance in functional performance testing from [list other contractors as needed] to:
			1. Manipulate systems to facilitate functional performance testing.
			2. [List requirements as needed]
		2. Functional performance testing requirements for systems and equipment:
			1. Two week Operational Test.
			2. Receive Operational Test approval which enables start of Functional Testing.
			3. Receive Acceptance Period approval which is Functional Completion for the BAS.
			4. Substantial Completion
			5. [List requirements as needed]
	3. COMMISSIONING WARRANTY PHASE
		1. Provide assistance in functional performance testing from [list other contractors as needed] to:
			1. Participate as required in seasonal testing.
			2. Train USPS on final Sequences and modes of operation.
			3. Update facility manual content with any changes.
			4. Update record drawings.
			5. Install Framed Control Drawings.
			6. Final Completion.
			7. Provide administrator access password access to USPS.
			8. Revise and Re-Submit Record drawings and O&M manuals.
			9. Schedule and begin Opposite Season Operational Test and Functional Performance Testing.
			10. Receive Opposite Season Operational Test and FPT approval.
			11. Submit As-Built drawings and O&M manuals.
			12. Update Framed Control Drawings.
			13. Complete USPS training.
			14. [List other requirements as needed]
	4. BAS Start-Up TESTING, ADJUSTING, CALIBRATION
		1. Work and/or systems installed under this Division shall be fully functioning prior to Demonstration and Acceptance Phase. Start, test, adjust, and calibrate all work and/or systems under this Contract, 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 and amperages, and verify that all circuits are free from faults.
			3. Verify integrity/safety of all electrical connections.
			4. [For AHUs that use a throttled outside air damper position when minimum outside air is required, mark existing minimum outside air damper position to allow replication by new controls.]
			5. Coordinate with TAB installer to obtain [and CxA] to fine tune control settings that are determined from balancing procedures. Record the following control settings as obtained from TAB installer , and note any TAB deficiencies in the BAS Start-Up Report including but not limited to the following:
				1. Optimum duct static pressure setpoints for VAV air handling units
				2. Minimum outside air damper settings for air handling units
				3. Optimum differential pressure setpoints for variable speed pumping systems

### Calibration factors for all flow meters, flow stations, demand meters, consumption meters, etc.

Provide hand held device (HHD) as a minimum to the TAB and CxA to facilitate calibration. Connection for any given device shall be local to it (i.e.: at the VAV box or at the thermostat). HHD or POT shall allow querying and editing of parameters required for proper calibration and start up.

* + - * 1. Calibration parameters for venturi valves
			1. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BAS display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the BAS Start up Report.
			2. Check and set zero and span adjustments for all transducers and transmitters.
			3. For dampers and valves:
				1. Check for adequate installation including free travel throughout range and adequate seal.
				2. Where loops are sequenced, check for proper control without overlap
			4. For actuators:
				1. Check to insure that device seals tightly when the appropriate signal is applied to the operator.
				2. Check for appropriate fail position, and that the stroke and range is as required and coordinated with the programmed ranges when it is operating under normal conditions.
				3. For pneumatic operators, adjust the operator spring compression as required to achieve close off. If positioner or volume booster is installed on the operator, calibrate per manufacturer’s procedure to achieve spring range indicated. Check split range positioners to verify proper operation. Record settings for each device.
				4. Check the stroke and range under actual loading conditions and validate that they correlate with programmed values
				5. For sequenced electronic actuators, calibrate per manufacturer’s instructions to required ranges.
			5. 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 OI display. Record the results for each device.
			6. For outputs to reset other manufacturers devices (VFDs) and feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.
			7. Verify proper sequences by using the approved checklists to record results. Verify proper sequence and operation of all specified functions.
			8. Verify that all safety devices trip at appropriate conditions. Adjust setpoints accordingly.
			9. 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 BAS Start up Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):
				1. Duct air temperature: ±1°F.
				2. Space Temperature: ±2°F
				3. Chilled Water: ±.5°F
				4. Hot water temperature: ±2°F.
				5. Duct pressure: ± 0.25” w.g.
				6. Water pressure: ±1 psid
				7. Steam Pressure: ±1 psid
				8. Duct or space Humidity: ±5%
				9. Air flow control: ±5% of setpoint velocity.
				10. Space Pressurization (on active control systems): ±0.05” wg with no door or window movements
			10. For communication interfaces and DDC control panels:
				1. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the record drawings.
				2. Ensure that terminations are safe, secure and labeled in accordance with the record drawings.
				3. Check power supplies for proper voltage ranges and loading.
				4. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
				5. Check for adequate signal strength and acceptable bandwidth utilization on communication networks.
				6. Check for stand alone performance of controllers by disconnecting the controller from the local area network (LAN). Verify the event is annunciated at OIs. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
				7. Ensure that all outputs and devices fail to their proper positions/states.
				8. Ensure that buffered and/or volatile information is held through power outage
				9. With all system and communications operating normally and all trends functioning, sample and record update/annunciation times for critical alarms fed from the panel to the OI.
				10. Check for adequate grounding of all DDC panels and devices.
				11. Run self diagnostic routines and ensure they are functional
				12. Check the memory allocation and loading to ensure adequate and excess capacity is available and that it will not affect control functionality.
			11. Coordinate desired initial alarm strategies with USPS Operators. Set all required alarms and document the initial settings in the start up documentation
			12. Coordinate all initial setpoints with USPS Operators. Ensure those setpoints are active
			13. For Operator Interfaces/Servers:
				1. 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.
				2. Output all specified BAS reports for review and approval.
				3. Verify that the alarm printing and logging is functional and per requirements.
				4. Verify that trend archiving to disk and provide a sample to the CxA for review.
				5. Verify alarm enunciation functionality. Time delay from actual occurrence to the time updated or enunciated on the screen. Ensure it is per the specified requirements.
				6. Verify that real time and historical trends are accessible and viewable in graph format.
				7. Verify that paging/dial out alarm annunciation is functional.
				8. Verify the functionality of remote OIs and that a robust connection can be established consistently.
				9. Verify that required third party software applications required with the bid are installed and are functional.
				10. Demonstrate open protocol and custom third party interfaces reliably communicate and check response time.
				11. Verify response times and screen update and refresh times are per the requirements.
				12. Verify that all custom programs are editable from the OI. Check upload, download, back up and restore capabilities of system configuration information as well as custom programs.
				13. Verify schedules are set up and working.
				14. Verify USPS stipulated security and permissions is set up and functional.
				15. In concert with the Building Power Outage test, validate that critical GUI installations are properly powered by UPS and emergency outlets to keep it functional during a power outage. Validate that the space has adequate lighting to manage the building in the event of an outage.
			14. Start up and check out control air compressors and air drying and filtering systems in accordance with the appropriate section and with manufacturer’s instructions.
				1. Validate adequate deliver and pressures
				2. Validate max run time and cycle time vs manufacturer’s recommendations
				3. Validate that routing of the compressed air does not result in condensation at any point in the system when used with the specified drier
			15. Verify proper interface with fire alarm system.
		1. Submit Start-Up Documentation. This shall be completed, submitted, and approved prior to Acceptance Phase.
	1. Sensor CHeckout and Calibration
		1. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. 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.
		2. Calibration: Calibrate all sensors using one of the following procedures:
			1. Sensors without Transmitters--Standard Application: 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, gage or BAS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20% of the expected range.
			2. Sensors with Transmitters--Standard Application: 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 desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. 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 BAS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.
		3. Sensor Tolerance: Sensors shall be within the tolerances specified for the device.
	2. Loop Tuning
		1. For all control loops, tune the loops to ensure the fastest stable response without hunting, offset or overshoot. Introduce upsets to the load when possible to affect response. Otherwise, setpoints can be changed to affect the response.
		2. Generally, tune loops during periods of high gain.
		3. Document all parameters either by capturing text, short interval trends, or screen shots of trend graph documenting the final response.
	3. Coil Valve Leak Check
		1. 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 OI, 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.
	4. Valve Stroke Setup and Check
		1. For all valve and actuator positions checked, verify the actual position against the OI readout.
		2. 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 valve to a few intermediate positions. If actual valve position doesn’t reasonably correspond, replace actuator or add pilot positioner (for pneumatics)
	5. Alarm Setpoint Coordination
		1. Prepare a list of all conceptual point types and recommend the types and recommended alarming strategies and setpoint for review of CxA and USPS. USPS shall use this alarm list to provide direction to Contractor for alarm strategies and setpoints. Alarm list shall be provided at least two months prior to the first functional test. Have alarm setpoints entered prior to functional testing. Omitting an alarm setting, using the wrong strategy, or entering the wrong setpoints will be considered a failure from the perspective of the functional test.
	6. Graphic Coordination
		1. Prepare all graphics (only one example graphic is required for typical systems like terminal units) with points embedded for review of CxA and USPS. USPS shall use these graphics to provide direction to Contractor for the required final graphic. All final graphics must be complete and active before functional testing. Any deviation from the approved graphics will be considered a failure from the perspective of the functional test.
	7. BAS DEMONSTRATION
		1. Demonstrate the operation of the BAS hardware, software, and all related components and systems to the satisfaction of the Commissioning Authority and USPS. Schedule the demonstration with the USPS 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 for re-demonstration, Contractor shall reimburse USPS for costs of subsequent Commissioning Authority site visits.
		2. Provide 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 BAS systems. All training documentation and submittals shall be at the job site.
		3. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by USPS and CxA.
		4. 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 BAS workstations. 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 dial-up 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 Commissioning Authority and/or USPS 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 Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
			9. Identify access to equipment selected by Commissioning Authority. Demonstrate that access is sufficient to perform required maintenance.
			10. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.
		5. BAS Demonstration shall be completed and approved prior to Functional testing.
		6. Any tests successfully completed during the demonstration will be recorded as passed for the functional performance testing and will not have to be re-accomplished.
	8. Functional Performance Testing
		1. Requirements for assistance with functional performance testing are specified in Section 019113 – General commissioning Requirements, Section 220800 – Commissioning of Plumbing, Section 230800 – Commissioning of HVAC, and Section 260800 –Commissioning of Electrical Systems. Provide assistance during Functional Performance Testing per the enumerated Specifications.
	9. BAS ACCEPTANCE PERIOD
		1. After approval of the BAS Demonstration, and prior to Substantial Completion, Acceptance Phase shall commence. [Acceptance Period shall not be scheduled until all HVAC systems are in operation and have been accepted, all required cleaning and lubrication has been completed (i.e. filters changed, piping flushed, strainers cleaned, etc.), and TAB report has been submitted and approved. Acceptance Period and its approval will be performed on a system-by-system basis if mutually agreed upon by contractor and USPS.]
		2. Operational Test: At the beginning of the Acceptance Phase, the system shall operate properly for two weeks without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. At the end of the two weeks, forward the trend logs to the CxA for review. CxA shall determine if the system is ready for functional performance testing and document any problems requiring Contractor attention.
			1. If the systems are not ready for functional performance testing, correct problems and provide notification to USPS representative that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time for an additional one week period. This process shall be repeated until Commissioning Authority issues notice that the BAS is ready for functional performance testing.
		3. During the Acceptance Period, maintain a hard copy log of all alarms generated by the BAS. For each alarm received, diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the contractor’s opinion, the cause of the alarm is not the responsibility of the contractor, immediately notify the USPS representative.
		4. During the Acceptance Phase, maintain all controller network and workstation hardware and software in a state that will allow remote access by Commissioning Agent to Trend Logs as specified below.
	10. Trend Logs
		1. Configure and analyze all trends required under Division 23, as described below.
		2. Trends are historical archives on computer disks that document the operation of the systems and equipment. Trends can be interval recordings of system I/O parameters or Change of Value based trends that record when a system value changes by more than a specified threshold.
		3. CxA will analyze trend logs of the system operating parameters to evaluate normal system functionality. The requirements of the trending are specified below. Establish these trends, ensure they are being stored properly, and forward the data in electronic format to the CxA.
		4. 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. 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 two dimensional formats with time being the vertical axis and field name being the horizontal axis. Data shall be forwarded in one of the following formats.
			1. Microsoft ACCESS Database (.mdb)
			2. Microsoft EXCEL Spreadsheet (.xls)
			3. Comma Separated Value (.csv or .txt) preferably with quotes delimiting text fields and # delimiting date/time fields
		5. Sample times indicated as COV (±) or change of value mean that the changed parameter only needs to be recorded after the value changes by the amount listed. When output to the trending file, the latest recorded value shall be listed with any given time increment record. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the interval common to the unit.
		6. Provide the CxA with required passwords, phone numbers, etc. to allow the CxA access to the trend log data and allow downloading to a remote location. Also provide step-by-step written instructions for accessing the data.
		7. Trending Requirements: At a minimum, trend the following on 15 min. intervals for analog values and change of value for binary values.
			1. Outside Air Temperature
			2. Outside Air Enthalpy
			3. Cooling Tons
			4. All sensed Hydronic Temperatures
			5. All sensed air temperatures on primary equipment
			6. All damper outputs on primary equipment
			7. All valve outputs on primary equipment
			8. All sensed Fan Volumes on primary equipment
			9. All inputs and outputs to VFDs
			10. Return (or exhaust) Air Temperature on each air handler
			11. All safety indications
			12. Status on all primary equipment
			13. All air and water pressures on primary equipment or systems
			14. Space Temperatures
			15. Steam Flow
			16. Electricity consumption where monitored.
			17. Natural Gas flows
			18. Converter steam valves and hot water temperatures
			19. Steam supply pressures and temperatures.
			20. Basically all points on primary equipment and selected sampling of terminal points unless approved otherwise
		8. Trending to document functional tests will typically be at a more frequent interval. Consult with the CxA to determine the required intervals for functional testing and modify intervals as required.
	11. TREND Graphs
		1. Trend graphs shall generally be used during the Acceptance Phase to facilitate and document testing. Prepare controller and workstation software to display graphical format trends during the Acceptance Period. Trend graphs shall demonstrate compliance with contract documents. Trended values and intervals shall be the same as those specified for the functional performance tests.
		2. Set-up the trend graphs to provide a grouped display of all pertinent information for each control loop. For example, for a steam converter, one graph would include the HWS setpoint, HWS & R temperatures, and steam valve output. Consult CxA for questions regarding trend groupings.
		3. Lines shall be labeled and shall be distinguishable from each other by using either different line types, or different line colors.
		4. Indicate engineering units of the y-axis values; e.g. degrees F., inches w.g., Btu/lb, percent wide open, etc.
		5. The y-axis scale shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.
		6. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended.
		7. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended during the same trend period.
		8. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.
	12. Warranty Phase BAS OPPOSITE SEASON Trending and Testing
		1. Trending: throughout the Warranty Phase, trend logs shall be maintained as required for the Acceptance Period. Forward archived trend logs to the CxA for review upon CxA’s request. CxA will review these and notify Contractor of any warranty work required.
		2. Opposite Season Testing: Within 6 months of completion of the Acceptance Phase, CxA shall schedule and conduct Opposite Season functional performance testing. Support this testing and remedy any deficiencies identified.
	13. SOFTWARE OPTIMIZATION ASSISTANCE
		1. Provide the services of a controls technician as specified above at the project site to be at the disposal of the CxA. 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 CxA 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 8 hour days, unless otherwise mutually agreed upon by contractor, Commissioning Authority, and USPS. The USPS representative shall notify contractor 2 days in advance of each day of requested assistance.
		2. The controls technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the controls technician provided cannot perform every software task requested by the Commissioning Authority in a timely fashion, provide additional qualified personnel at the project site as requested by the Commissioning Authority, to meet the total specified requirement [on-site.]
	14. BAS OPERATOR TRAINING:
		1. Provide up to 6 complete sets of User Manuals hard copy and one electronic copy to be used for training.
		2. Submit a Training Plan to USPS and CxA for review.

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**NOTE TO SPECIFIER**

The following training hours needs to be customized and/or selected for each project. For example, larger projects may take up to 40 hours whereas smaller projects may take 16 hours. Select the applicable system and submit to USPS Project Manager.

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* + 1. On Site Training: Provide services of qualified controls technical personnel for total of [40] [\_\_\_] hours to instruct USPS personnel in operation and maintenance of BAS. Instruction shall be in classroom setting at the project site for appropriate portions of the training. Training may be in non-contiguous days at the request of the USPS. The USPS representative shall notify Contractor 1 week in advance of each day of requested training. The Contractor’s designated training personnel shall meet with the AE, CxA and USPS 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 Training – [8] [\_\_\_] hours for all potential users of the OWS in 4 hour non-contiguous segments:
				1. Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of controller portable and built-in operator interface device display capabilities.
				2. Brief overview of the various parts of the O&M manual, including hardware and software programming and operating publications, catalog data, controls installation drawings, and DDC programming documentation.
				3. Demonstration of workstation login/logout procedures, password setup, and exception reporting.
				4. Demonstration of workstation menu penetration and broad overview of the various workstation features.
				5. Overview of systems installed
				6. Present all site specific naming conventions and points lists, open protocol information, configuration databases, back up sequences, upload/download procedures, etc.
				7. Overview of scheduling procedures.
				8. Overview of alarm features, including how to acknowledge and respond to alarms, archive alarms and mine them
				9. Overview of trend features, including how to set up and view trends.
				10. Overview of workstation reporting features and introductory level report generation and scheduling.
			2. Control Technician Training: [16] [\_\_\_\_] hours that can be in 4 hour non-contiguous segments for individuals who will troubleshoot the system hardware, I/O devices, and the systems in general.
				1. General review of sequence of operation and control logic for the project site, including standalone and fail safe modes of operation
				2. Uploading/Downloading and backing up controller configuration and application programs
				3. Review of installed components including all communication devices, controllers, I/O, etc., and how to install/replace, maintain, commission, and diagnose them
				4. Introduction to Controller programming and overview of the programming application interface.
				5. Defining trends: generating graphs in real time; archiving trends, accessing historical archive and generating reports from them.
				6. Introductory network administration
				7. Introduction to Creating and editing graphics
				8. Review of setpoint optimization and fine-tuning concepts.
				9. OI use and maintenance
				10. Web page creation as applicable
			3. System Administrator Training: [2] [\_\_\_] hour sessions that may be done in 2- hour segments on non-contiguous days. Target audience is the person who will be maintaining the system from an IT perspective as well as USP IT personnel. Agenda shall be as follows:
				1. Overview of system architecture including all routers, bridges, repeaters, gateways, communications protocols, servers, controllers, etc.
				2. Overview of and recommendations for backing up and restoring the system configuration database
				3. Server Maintenance
				4. Security Management: assigning passwords and rights for various users on the server, workstations and GUI software.
			4. BAS Sequence Training
				1. The BAC shall conduct a [12] [\_\_\_\_] hour session that can be in 4 hour non-contiguous segments to present the final sequences programmed into the control system. The session will basically present:

Control System Architecture

Addressing and location of panels

Schematic configuration of the systems

Final programmed sequences. It shall present the written sequences and illustrate the programming that accomplishes those sequences. This session is typically presented on site by the primary BAS technician that managed the installation of the controls at that facility.

* + - * 1. The BAC shall be use the Record Control Shop Drawings as the handout for the training. The audience for the session will be the Building Operators and managers. The setting should be primarily classroom. Since the presentation will typically need to use a live Operator Interface, BAC shall work out the logistics of projecting the video for an effective presentation.

END OF SECTION

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