

SECTION 230800
HVAC SYSTEMS COMMISSIONING

PART 1 – GENERAL

1.1 STIPULATIONS

- A. The Specifications Sections "General Conditions of Contract", "Special Conditions" and "Division 1 – General Requirements" form a part of this Section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.2 DESCRIPTION

- A. The systems that shall be commissioned in this project include but are not limited to the following:
1. Boilers and ancillary equipment (i.e. deaerator, pumps, feed water tanks, combustion air and other such similar boiler system equipment).
 2. Fuel systems (Gas and Oil).
 3. Boiler Controls System.
 4. Air Conditioning Unit.
 5. HVAC Control System.

1.3 SCHEDULING

- A. The CxA will provide the initial schedule of primary commissioning events using the information gathered from the commissioning scoping meeting. The Commissioning Plan provides a format for this schedule. The timeline is fine-tuned as construction progresses. In particular, 30 days prior to startup of the primary HVAC equipment, the CxA meets with the DGS, UA and Contractors and develops a detailed commissioning schedule. The CxA will approve the commissioning schedule.
1. General Contractor shall coordinate requirements of Construction Scheduling with this work.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. The .2 Contractor shall provide all standard testing equipment required to perform startup, initial checkout, and testing requirements of Division 23.
- B. The 0.2 Contractor or the Controls Subcontractor shall provide all standard testing equipment required to test the control system and the HVAC packaged controls, including calibration of valve and damper actuators and all sensors. Trend logs for

functional testing shall be generated through the control system, as requested by the CxA.

- C. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the following tolerances. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. 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. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

3.1 RESPONSIBILITIES

- A. 0.2 Contractor, Controls Subcontractor and TAB Contractor. The commissioning responsibilities applicable to each of the 0.2 Contractor, Controls Subcontractor and TAB Contractor of Division 23 are as follows:

Construction and Acceptance Phases

1. Attend the initial commissioning meeting conducted at the start of construction, the commissioning meeting held 30 days prior to startup of the primary equipment, and all commissioning team meetings.
2. Copies of approved shop drawings and startup reports for all commissioned equipment shall be submitted to the CxA through E-Builder. Supplement the shop drawing data with the manufacturer's installation and start-up procedures. This material should be identical to the literature which will be included in the Operation and Maintenance Manuals.
3. The Operation and Maintenance Manuals shall be submitted to the CxA, through E-Builder prior to the start of training (3 weeks before start-up and training and at least 60 days before substantial completion). Manuals shall include recommended operating procedures.
4. During the startup and initial checkout process, execute all portions of the manufacturer's start-up checklists, for all commissioned HVAC equipment.
5. Perform and clearly document all completed startup and system operational checkout procedures, including the Prefunctional Checklists provided by the CxA, providing copies to the CxA.
6. Address current Professional punch list items and Commissioning corrective action items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
7. Provide skilled technicians to execute starting of equipment and to perform tests in accordance with all Division 23 sections. Where specified, startup shall be performed by a factory authorized service representative. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

8. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA and Professional and retest the equipment.
9. Provide training of Using Agency's operating staff as specified in Division 23 Sections. Use expert qualified personnel.
10. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

11. Correct deficiencies and make necessary adjustments to O&M manuals for applicable issues identified in any seasonal testing.

B. 0.2 Contractor. The responsibilities of the 0.2 Contractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Provide startup for all HVAC equipment.
2. Calibrations: The 0.2 CONTRACTOR is responsible to calibrate all factory installed sensors and actuators. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated by the 0.2 CONTRACTOR.
3. Supervise all commissioning activities executed by subcontractors, including the Controls Subcontractor.
4. List and clearly identify on the as-built duct and piping drawings the locations of all flow meters, fire and smoke dampers, duct detectors, temperature sensors, relative humidity sensors, static and differential pressure sensors (air, water, and building pressure).

C. Controls Subcontractor. The commissioning responsibilities of the Controls Subcontractor, during construction and acceptance phases in addition to those listed in (A) are:

1. Attend controls coordination meeting prior to beginning the submittal process. Meeting will include the 0.2 Contractor, the Controls Subcontractor, the Professional, the Using Agency, DGS and the CxA. Controls functions for all systems will be reviewed so the submittal process proceeds as required.
2. Attend controls coordination meeting at the completion of the submittal process. Meeting will include the 0.2 Contractor, the Controls Subcontractor, the Professional, the Using Agency, DGS and the CxA. All sequences will be reviewed to ensure that they are per the contract documents and that all parties are in agreement.
3. Sequences of Operation Submittals. The Controls Subcontractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
 - a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
 - b. Logic diagrams detailing the flow of information for each control algorithm. These diagrams should include all inputs, outputs, and computations.
 - c. All interactions and interlocks with other systems.

- d. Detailed delineation of control between any packaged controls, listing what points the SCADA monitors only and what SCADA points are control points and are adjustable.
 - e. Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included but will generally require additional narrative).
 - f. Start-up sequences.
 - g. Warm-up mode sequences.
 - h. Normal operating mode sequences.
 - i. Unoccupied mode sequences.
 - j. Shutdown sequences.
 - k. Capacity control sequences and equipment staging.
 - l. Temperature and pressure control: setbacks, setups, resets, etc.
 - m. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
 - n. Effects of power or equipment failure with all standby component functions.
 - o. Sequences for all alarms and emergency shutdowns.
 - p. Seasonal operational differences and recommendations.
 - q. Initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
 - r. Schedules, if known.
 - s. To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. Where possible, the numbering sequence shall correspond with Section 230993 "Sequence of Operation for HVAC Controls".
4. Control Drawings Submittal:
- a. The control drawings shall have a key to all abbreviations.
 - b. The control drawings shall contain graphic schematic depictions of the systems and each component.
 - c. The schematics shall include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
 - d. Provide a full points list with at least the following included for each point:
 - 1) Controlled system
 - 2) Point abbreviation
 - 3) Point description
 - 4) Display unit
 - 5) Control point or setpoint (Yes / No)
 - 6) Input point (Yes / No)
 - 7) Output point (Yes / No)
 - e. The Controls Subcontractor shall keep the Professional, CxA, 0.2 and TAB Contractor informed of all changes to this list during programming and setup.
5. Submit a written checkout plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional testing. At minimum, the checkout plan shall include for each type of equipment controlled by the building automation system:
- a. System name.

- b. List of devices.
 - c. Step-by-step procedures for testing each controller after installation, including:
 - 1) Process of verifying proper hardware and wiring installation.
 - 2) Process of downloading programs to local controllers and verifying that they are addressed correctly.
 - 3) Process for performing and documenting point-to-point checkout for each digital and analog input and output.
 - 4) Process of performing operational checks of each controlled component.
 - 5) Plan and process for calibrating valve and damper actuators and all sensors.
 - 6) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
 - d. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor, controller or command has "passed" and is operating within the contract parameters.
 - e. A description of the instrumentation required for testing.
 - f. Indicate the portion of the controls checkout plan that should be completed prior to TAB using the controls system for TAB work. Coordinate with the CxA and TAB Contractor for this determination.
6. Point-to-Point Checkout: Include in the checkout plan a point-to-point checkout. Each control point tied to a central control system shall be verified to be commanding, reporting and controlling according to its intended purpose. For each output, commands shall be initiated and verified to be functioning by visually observing and documenting the status of the controlled device in the field (e.g. valve or damper actuator response, pump or fan status). For each input, the system or conditions shall be altered to initiate the input response being tested and the response in the control system observed and recorded (e.g. high duct static pressure alarm).
7. Calibrations: The CONTROLS SUBCONTRACTOR is responsible to calibrate all field installed sensors and actuators using test and documentation methods approved by the CxA. The 0.2 CONTRACTOR is responsible to calibrate all factory installed sensors and actuators.
- a. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated by the 0.2 CONTRACTOR.
 - b. All procedures used shall be fully documented by the Controls Subcontractor on suitable forms, clearly referencing the procedures followed and written documentation of initial, intermediate and final results.
8. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as indicated in the Specifications.
9. Provide a signed and dated certification to the CxA upon completion of the Supervisory Control and Data Acquisition (SCADA) system installation, including checkout and calibration of each controlled device, that all system programming is complete as to all respects of the Contract Documents. This shall be submitted by the Controls Subcontractor prior to the start of functional testing by the CxA.

3.2 SUBMITTALS

- A. Copies of MEP shop drawings will be provided to CxA, when they are submitted to the Professional, electronically through E-Builder. CxA will review shop drawings concurrently with the Professional and provide any comments to the Professional so they may be included in their comments. Copies of approved shop drawings and startup reports for all commissioned equipment will be forwarded to the CxA through E-Builder. Supplement the shop drawing data with the manufacturer's installation and start-up procedures. This material should be identical to the literature which will be included in the Operation and Maintenance Manuals.
- B. The CxA may request additional design narrative from the Professional and Controls Subcontractor, depending on the completeness of the basis of design documentation and sequences provided with the Specifications.
- C. These submittals to the CxA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the Contractor, though the Professional will approve them.

3.3 STARTUP

- A. The 0.2, Controls and TAB Contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section. Equipment start-up is required to complete systems and sub-systems so they are fully functional, in compliance with the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the Commissioning Agent or Department.
- B. Testing is intended to begin upon completion of a system. Refer to Section 019100 for additional information related to scheduling.

3.4 TESTS

- A. The 0.2 Contractor and Controls Subcontractor shall provide the necessary support to the CxA to complete functional testing. The Controls Subcontractor shall fully test and verify all aspects of the SCADA Contract Work on a point / system / integrated operational basis for all points, features and functions specified. The following requirements apply to all mechanical and control systems and features that are to be commissioned when referenced below. Tests shall:
 - 1. Verify functionality and compliance with the basis of design for each individual sequence module in the sequence of operations. Verify proper operation of all control strategies, energy efficiency and self-diagnostics features by stepping through each sequence and documenting equipment and system performance. Tests shall include startup, normal operation, shutdown, scheduled 'on' and 'off', unoccupied and manual modes, safeties, alarms, over-rides, lockouts and power failure.
 - 2. Verify operation of systems and components that may be impacted during low, normal and high load conditions and during combinations of environmental and

interacting equipment conditions that could reasonably exist and potentially result in adverse system reaction.

3. Verify all alarm and high and low limit functions and messages generated on all points with alarm settings.
 4. Verify integrated performance of all components and control system components, including all interlocks and interactions with other equipment and systems.
 5. Verify shutdown and restart capabilities both for scheduled and unscheduled events (e.g. power failure recovery and normal scheduled start / stop).
 6. Verify proper sequencing of heat transfer elements as required to prevent simultaneous heating and cooling, unless specifically required for dehumidification operation.
 7. Verify system response and stability of control loops under different load conditions and determine if additional loop tuning is required by the Controls Contractor.
 8. When applicable, demonstrate a full cycle from 'off' to 'on' and 'no load' to 'full load' and then to 'no load' and 'off'.
 9. Verify time of day schedules and setpoints.
 10. Verify all energy saving control strategies.
 11. Verify that all control system graphics are representative of the systems and that all points and control elements are in the same location on the graphic as they are in the field.
 12. Verify operator control of all adjustable control system points including proper access level as agreed to during the controls system demonstration.
- B. In addition to specific details, and/or standards referenced for acceptance testing indicated in other Division 23 sections, the following common acceptance criteria apply to all mechanical equipment, assemblies and features:
1. For the conditions, sequences and modes tested, the equipment, integral components and related equipment shall respond to varying loads and changing conditions and parameters appropriately as expected, according to the sequence of operation, as specified, according to acceptable operating practice and the manufacturer's performance specifications.
 2. Systems shall accomplish their intended function and performance (e.g. provide supply air and water at designated temperature and flow rate, etc., and maintain space conditions in terms of air temperature and relative humidity) at specified levels at varying conditions.
 3. Control loops shall be stable under all operating conditions. Control loops shall exhibit a quarter decay ratio type response to a step change or other upset and return to stable operation in a time frame that is reasonable and realistic for the system that they are associated with.
 4. All safety trips shall require a manual reset to allow a system restart, unless otherwise explicitly stated in the specified sequence of operation.
 5. Resetting a manual safety shall result in a stable, safe, and predictable return to normal operation by the system.
 6. Safety circuits and permissive control circuits shall function in all possible combinations of selector switch positions (hand, auto, inverter, bypass, etc.).
 7. Additional acceptance criteria will be defined by the CxA when detailed tested procedures are developed.

- C. At the CxA's discretion, if large numbers or repeated deficiencies are encountered, the CxA shall suspend functional testing until the Contractor corrects the deficiencies and troubleshoots all remaining systems at issue on their own. The Contractor shall be responsible for any resulting schedule delays that increase the overall time period to complete functional testing.

3.5 WRITTEN WORK PRODUCTS

- A. Written work products of Contractors shall consist of the filled out start-up, initial checkout, prefunctional checklists and test documentation in accordance with all Division 23 sections.

END OF SECTION