

Part 1 General

1.1 SECTION INCLUDES

- .1 Methods and procedures for start-up, verification and commissioning, for building Energy Monitoring and Control System (EMCS) and includes:
 - .1 Start-up testing and verification of systems.
 - .2 Check out demonstration or proper operation of components.
 - .3 On-site operational tests.

1.2 RELATED SECTIONS

- .1 Division 01 – General Requirements.
- .2 Section 21 05 01 – Common Work Results for Mechanical.
- .3 Section 25 05 01 - EMCS: General Requirements.
- .4 Section 26 05 01 – Common Work Results for Electrical.

1.3 DEFINITIONS

- .1 Design Criteria: All pertinent information for the design, including key assumptions and limitations including such as temperature, occupancy, codes, references and indoor air quality.
- .2 Design Intent: a detailed explanation of the ideas, concepts and criteria that are defined by the Owner to be important.
- .3 PID – Proportional, Integral and Derivative.

1.4 CONTROLS VERIFICATION

- .1 EMCS contractor shall test each point system, and sequence, and submit verification reports to satisfaction of Owner's Representative.
- .2 Reports required:
 - .1 Point Verification Report. – See Appendix II.
 - .2 Above noted report shall be submitted prior to interim inspection, or substantial performance.

1.5 DESIGN REQUIREMENTS

- .1 Confirm with Owner's Representative that Design Criteria and Design Intent are still applicable.
- .2 Commissioning personnel to be fully aware of and qualified to interpret Design Criteria and Design Intent.

1.6 SUBMITTALS

- .1 Submittals in accordance with:
 - .1 Division 01 – General Requirements.
 - .2 Section 21 05 01 – Common Work Results for Mechanical, Part 1.5.
- .2 Final Report: submit report to Owner's Representative:
 - .1 Include measurements, final settings and certified test results.
 - .2 Bear signature of commissioning technician and supervisor
 - .3 Report format to be approved by Owner's Representative before commissioning is started.
 - .4 Revise "as-built" documentation, commissioning reports to reflect changes, adjustments and modifications to EMCS as set during commissioning and submit to Owner's Representative in accordance with Section 01 78 00 - Closeout Submittals.
 - .5 Recommend additional changes and/or modifications deemed advisable in order to improve performance, environmental conditions or energy consumption.

1.7 CLOSEOUT SUBMITTALS

- .1 Provide documentation, O&M Manuals, and training of O&M personnel for review by Owner's Representative before interim acceptance in accordance with Section 01 78 00 – Closeout Submittals.

1.8 CONTROL SYSTEM CHECKOUT AND TESTING

- .1 Start-up Testing: All testing listed in this article shall be performed by the Contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owner's Representative is notified of system demonstration and before the Commissioning Agent is to perform the functional performance testing.
 - .1 The Contractor shall furnish all labour and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
 - .2 Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
 - .3 Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures per manufacturers' recommendations.
 - .4 Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
 - .5 Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The Contractor shall check all control valves and automatic dampers to ensure proper action and closure. The Contractor shall make any necessary adjustments to valve stem and damper blade travel.
 - .6 Verify that the system operation adheres to the Sequences of Operation.

- .7 Alarms and Interlocks:
 - .1 Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - .2 Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
 - .3 Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.
- .8 Mechanical deficiencies which may inhibit operation/control of the mechanical systems shall be brought to the attention of Owner's Representative.

1.9 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

- .1 Demonstration:
 - .1 Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed its own tests.
 - .2 The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" in this specification. The Owner's Representative will be present to observe and review these tests. The Owner's Representative shall be notified at least 10 days in advance of the start of the testing procedures.
 - .3 The demonstration process shall follow that approved in "Submittals". The approved checklists and forms shall be completed for all systems throughout the demonstration.
 - .4 The contractor shall provide at least two persons equipped with two-way communication, and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point/object and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
 - .5 As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed. This will form part of the "**Point Verification Report**" **Appendix II**. Verification of all input/output points with regards to proper operation. Owner's Representative will inspect 100% of all points for physical installation, including conduit, wire, labels, connections, etc. Owner's Representative commissioning agent may choose to randomly inspect 50% of each point type for input/output response. Any failure will result in termination of inspection and future 100% inspections will be at the contractor's cost.

- .2 Final Acceptance:
 - .1 This phase shall consist of verifying to Owner's Representative that the deficiencies as identified during "Demonstration" have been rectified. If deficiencies are still found, the Contractor will have one week to correct them and costs for additional inspection shall be billed to the contractor.
 - .2 Demonstrate compliance with "System Performance".
 - .3 Demonstrate and simulate compliance with Sequences of Operation through all modes of operation.
 - .4 Demonstrate complete operation of Operator Interface.
 - .5 Additionally, the following items shall be demonstrated:
 - .1 DDC Loop Response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in setpoint, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the setpoint, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the contractor.
 - .2 Optimum Start/Stop. The contractor shall supply a trend data output showing the capability of the algorithm. The hour-by-hour trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
 - .3 Operational logs for each system that indicate all setpoints, operating points, valve positions, mode, and equipment status shall be submitted to the Owner's Representative. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.
 - .4 A power failure for the building will be simulated and proper system operation and recovery observed.
- .3 Any tests that fail to demonstrate the proper operation of the system shall be repeated at a later date. The Contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.
- .4 **Point Verification Reports Appendix II** – To be completed by the contractor and forwarded to the Owner's Representative prior to completing Demonstration. Owner's Representative will provide blank forms in Microsoft Excel format to the contractor as requested.
- .5 The Owner's Representative will require testing, verification, of all commissioning for all points, and full simulation of all sequences. This contractor is to commit the necessary resources, manpower, and devices (example - radios) to allow Owner's Representative to complete commissioning.
- .6 All software, database files, modem, phone number and instruction must be provided to Owner's Representative 10 days in advance of inspections.

- .7 All repeat testing and commissioning due to noncompliance to specification will be at the contractor's expense.
- .8 All tests described in this specification shall have been performed to the satisfaction of both the Owner's Representative prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the Owner's Representative. Such tests shall then be performed as part of the warranty.
- .9 The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved.

1.10 CLEANING

- .1 The contractor shall clean up all debris resulting from its activities daily. The contractor shall remove all cartons, containers, crates, etc., under its control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
- .2 At the completion of work in any area, the contractor shall clean all of its work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
- .3 At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

Part 2 Products

2.1 EQUIPMENT

- .1 Provide sufficient instrumentation to verify and commission the installed system. Provide two-way radios.
- .2 Instrumentation accuracy tolerances: higher order of magnitude than equipment or system being tested.
- .3 Independent testing laboratory to certify test equipment as accurate to within approved tolerances no more than 2 months prior to tests.
- .4 Locations to be approved, readily accessible and readable.
- .5 Application: to conform to ASHRAE Guideline 0-2013 – The Commissioning Process and Guideline 1.1 – 2007 – The HVAC Commissioning Process.

Part 3 Execution

3.1 PROCEDURES

- .1 General: test installation of each system part after completion of mechanical and electrical hook-ups, to verify correct installation and function.

- .1 Test each system independently and then in unison with other related systems.
 - .2 Commission each system using procedures prescribed by the Owner's Representative.
 - .3 Commission integrated systems using procedures prescribed by Owner's Representative.
 - .4 Debug Programming.
 - .5 Optimize operation and performance of systems by fine-tuning PID values and modifying programming as required.
 - .6 Test full scale emergency evacuation and life safety procedures including operation and integrity of smoke management systems under normal and emergency power conditions as applicable.
- .2 Include following activities:
 - .1 Test and calibrate field hardware including stand-alone capability of each controller.
 - .2 Verify each analog to digital convertor.
 - .3 Test and calibrate each analog input using calibrated digital instruments.
 - .4 Test each binary input to ensure proper settings and switching contacts.
 - .5 Test each binary output to ensure proper operation and lag time.
 - .6 Test each analog output to ensure proper operation of controlled devices. Verify tight closure and signals.
 - .7 Test operating software.
 - .8 Test application software and provide samples of logs and commands.
 - .9 Debug software.
 - .10 Provide point verification list in table format including point identifier, point commissioning technician and Owner's Representative comments. This document will be used in final start-up testing.
- .3 Demonstration: Upon satisfactory completion of tests, perform point-by-point test of entire system under direction of Owner's Representative and provide:
 - .1 Two technical personnel capable of re-calibrating field hardware and modifying software.
 - .2 Detailed daily schedule showing items to be tested and personnel available.
 - .3 Owner's Representative Acceptance signature to be on executive and applications programs.
- .4 Demonstration testing is to be in accordance with the following conditions:
 - .1 Commissioning to commence during final start-up testing.
 - .2 O&M personnel may assist in commissioning procedures as part of training.
 - .3 Commissioning to be supervised by qualified supervisory personnel, Owner's Representative and Commissioning Agent.
 - .4 Commission systems considered as life safety systems before affected parts of the facility are occupied.
 - .5 Operate systems as long as necessary to commission entire project.
 - .6 Monitor progress and keep detailed records of activities and results.

3.2 ADJUSTING

- .1 Final adjusting: upon completion of commissioning as reviewed by Owner's Representative, set and lock devices in final position and permanently mark settings.

3.3 DEMONSTRATION

- .1 Demonstrate to Owner's Representative, operation of systems including sequence of operations in regular and emergency modes, under normal and emergency conditions, start-up, shut-down interlocks and lock-outs.

END OF SECTION