

SECTION 25 0800 - COMMISSIONING OF INTEGRATED AUTOMATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This section defines responsibilities of the Integrated Automation Contractor to facilitate the Commissioning process for the Building Automation System (BAS).
- B. Commissioning is the process of ensuring that building systems are installed and perform interactively according to the design intent, the systems are efficient and cost effective and meet the Owner's operational needs, and the installation is adequately documented and that the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.
- C. Commissioning Authority shall work with the GC and the A/E to direct and oversee the Cx process and perform functional performance testing.
- D. The Commissioning Plan outlines the Commissioning Process. The Commissioning Plan is part of the Contract Documents and stipulates Contractor responsibilities that are part of this project. It also provides examples of functional performance testing that the contractor must participate in. The commissioning plan shall be referenced for details of the Cx process.
- E. This section, along with Section 01 9113, defines responsibilities of the Contractor to facilitate the Commissioning process particularly during the Construction Phase.
- F. This section includes:
 - 1. BAS (Building Automation System) and equipment testing and start-up.
 - 2. Validation of proper and thorough installation of BAS systems 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.
- G. Refer to Division 01, Section 01 9113, for a full list of commissioning related definitions. A few critical definitions are included below:
 - 1. *Commissioning*. A systematic process that provides documented confirmation that specific and interconnected building automation systems function according to the intended design criteria set forth in the project documents and satisfy the owner's operational needs, including compliance requirements of any applicable laws, regulations, codes, and standards requiring building automation systems.
 - 2. *Commissioning Authority (CxA)*. The qualified person, company, or agency that plans, coordinates, and oversees the entire Cx process.
 - 3. *Commissioning Plan*. The document prepared for each project, which identifies the processes and procedures necessary for a successful Cx process.

4. *Commissioning Record.* The complete set of commissioning documentation for the project, which is turned over to Northwestern facilities at the end of the construction phase.
5. *Functional Testing.* Tests performed to verify compliance with manufacturers' specifications, applicable codes and standards, and the project Basis of Design (BOD) and Owner's Project Requirement (OPR).

1.2 RELATED SECTIONS

- A. Division 01 Section 01 9113 - General Commissioning Requirements
- B. Division 21 Section 21 0800 - Commissioning of Fire Suppression
- C. Division 22 Section 22 0800 - Commissioning of Plumbing Systems
- D. Division 23 Section 23 0800 - Commissioning of HVAC Systems
- E. Division 26 Section 26 0800 - Commissioning of Electrical Systems
- F. Individual Division 01, 21, 22, 23, 25, and 26 sections contain requirements related to the commissioning process.

1.3 ROLES AND RESPONSIBILITIES

- A. Refer to Section 01 9113 for Commissioning Authority, Owner, Architect, and General Contractor roles and responsibilities.
- B. Refer to Section 21 0800 for fire protection contractor roles and responsibilities.
- C. Refer to Section 22 0800 for plumbing contractor roles and responsibilities.
- D. Refer to Section 23 0800 for mechanical contractor roles and responsibilities.
- E. Refer to Section 26 0800 for electrical contractor roles and responsibilities.
- F. Integrated Automation Contractors
 1. Include cost for commissioning requirements in the contract price, including assisting the Commissioning Authority with implementation of Functional Test Procedures and reviewing control system operation with the Commissioning Authority.
 2. Review design for controllability with respect to selected manufacturers equipment:
 - a. Verify proper hardware specification exists for functional performance required by specification and sequence of operation.
 - b. Verify proper safeties and interlocks are included in design.
 - c. Verify proper sizing of control valves and actuators based on design pressure drops. Verify control valve authority to control coil properly.
 - d. Verify proper sizing of control dampers. Verify damper authority to control air stream. Verify proper damper positioning for mixing to prevent stratification. Verify actuator and damper sections for smooth operation.
 - e. Verify proper selection of sensor ranges.
 - f. Clarify all questions of operation.

3. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
4. Provide the following submittals to the GC:
 - a. Hardware and software submittals.
 - b. Control panel construction shop drawings.
 - c. Narrative description of each control sequence for each piece of equipment controlled.
 - d. Diagrams showing all control points, sensor locations, point names, actuators, controllers and, where necessary, points of access, superimposed on diagrams of the physical equipment.
 - e. Logic diagrams showing the logic flow of the system.
 - f. A list of all control points, including analog inputs, analog outputs, digital inputs, and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
 - g. A complete control language program listing including all software routines employed in operating the control system. Also provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and the functions of each routine and sub-routine. It should also explain individual math or logic operations that are not clear from reading the software listing.
 - h. Hardware operation and maintenance manuals.
 - i. Application software and project applications code manuals.
5. Verify proper installation and performance of controls/BAS hardware and software provided by others.
6. Integrate installation and programming schedule with construction and commissioning schedules.
7. Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system.
8. Demonstrate system performance to Commissioning Authority including all modes of system operation (e.g. normal, abnormal, and emergency).
9. Provide control system technician for use during Pre-functional Checklists and Functional Performance Testing.
10. Provide system modifications as required.
11. Provide support and coordination with TAB contractor on all interfaces between their scopes of work. Provide all devices, such as portable operator terminals, for TAB use in completing TAB procedures.
12. Provide trend logs as required to facilitate the Commissioning Process.

1.4 SEQUENCING

- A. The following list outlines the general sequence of events for submittals and commissioning of the BAS.
 1. Submit Product data and Shop Drawings, and receive A/E and Owner acceptance.
 2. Submit Control Logic Documentation, and receive A/E and Owner acceptance.
 3. Submit startup checklists and manufacturers startup procedures for all equipment provided by the BAS contractor.
 4. Install BAS controls.
 5. Submit BAS startup test Agenda/schedule to CxA and GC for review and acceptance.
 6. Submit Training Plan.
 7. Place systems under BAS control.
 8. Prepare and initiate Trend Log data storage and format trend graphs.

9. Perform BAS system startup.
10. Submit completed BAS startup reports.
11. Receive BAS startup report acceptance and approval to schedule Commissioning Demonstrations.
12. Demonstrate system performance as requested by Owner and CxA.
13. Submit trend logs in format specified.
14. Receive Demonstration acceptance and approval to schedule Acceptance Period.
15. Train Owner on control system operation and maintenance.
16. Substantial Completion.
17. Begin Acceptance Phase.
18. Two-week Operational Test.
19. Perform Functional Performance Testing.
20. Receive Acceptance Period approval which is Functional Completion for the BAS.
21. Train Owner on final Sequences and modes of operation.
22. Install Framed Control Drawings.
23. Provide password access to Owner.
24. Revise and Re-Submit Record drawings and O&M manuals.
25. Begin Warranty Phase.
26. Schedule and begin Opposite Season Acceptance Period.
27. Receive Opposite Season Acceptance Period approval.
28. Submit As-Built drawings and O&M manuals.
29. Update Framed Control Drawings.
30. Complete Owner training.
31. Final Acceptance.

1.5 SCOPE OF WORK

- A. Refer to Section 21 0800 for listing of fire suppression systems to be commissioned and requirements.
- B. Refer to Section 22 0800 for listing of plumbing systems to be commissioned and requirements.
- C. Refer to Section 23 0800 for listing of HVAC systems to be commissioned and requirements.
- D. Refer to Section 26 0800 for listing of Electrical Systems to be commissioned and requirements.
- E. Integrated Automation scope of work includes the controls and automation related to systems described in the above referenced Divisions.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All industry standard test equipment required for performing the specified tests shall be provided by the applicable contractor (as specified) and shall be approved by the CxA. Any proprietary vendor specific test equipment shall be provided by the equipment vendor or manufacturer.
- B. Any portable or hand-held setup / calibration devices required to initialize the control system shall be made available by the control vendor (at no cost) to the contract or CxA.

C. The instrumentation used in the commissioning process shall meet the following standards:

1. Be of sufficient quality and accuracy to test and/or measure system performance within the tolerances required.
2. Be calibrated at the manufacturer's recommended intervals with calibration tags permanently affixed to the instrument
3. Be maintained in good repair and operating condition throughout the duration of use on this project.
4. Be immediately re-calibrated or repaired if dropped and/or damaged in any way during use on this project.

2.2 BAS HARDWARE AND SOFTWARE

A. Field Panel Software and Hardware

1. The BAS Contractor shall furnish the CxA with two (2) copies of all hardware and software needed to connect to, communicate with and command the BAS field panels and controllers at no additional charge to the CxA. This hardware and software will be used by the CxA for execution of the commissioning process. Software and hardware provided to the CxA for this purpose, does not include any provisions for use by the Test & Balance Contractor.
2. Hardware and software covered under this requirement includes, but is not limited to:
 - a. Latest versions of proprietary software such as Johnson Controls HVAC Pro, Siemens Building Technologies CIS, etc.
 - b. Communication modules, software keys, and similar hardware needed for communication from a laptop computer, PDA or similar device to field panels or controllers
 - c. Proprietary cables required for communication between laptop computers or PDAs to field panels or controllers
 - d. Passwords, access levels and similar software permissions necessary for execution of the Cx Process.
 - e. Software and hardware manuals for all control system hardware and software provided to the CxA.
3. This requirement is not meant to include provision of standard hardware such as laptop computers and PDAs nor provision of standard software such as Windows or MS Explorer.
4. At the conclusion of the Commissioning Process, this hardware and software will be turned over back to the contractor.

B. Front-End Software & Hardware

1. The BAS Contractor shall furnish the CxA with one (1) copy of their front-end software and associated hardware as needed to connect to, communicate with, and command the BAS at no additional charge to the CxA.
2. Hardware and software covered under this requirement includes, but is not limited to:
 - a. Proprietary software needed to communicate to field panels or controllers such as Johnson Controls Metasys, Siemens Building Technologies Apogee, ALC, Tridium etc. Revision levels for all software shall be identical with the revision level being provided to the project for the front-end operator workstation(s).
 - b. Communication modules, software keys, and similar hardware needed for operation of the software or to communicate with the BAS.

- c. Proprietary cables required for communication between laptop computers and the BAS.
 - d. Passwords, access levels and similar software permissions necessary for execution of the Cx Process.
 - e. Software and hardware manuals for all control system hardware and software provided to the CxA.
3. This requirement is not meant to include provision of standard hardware such as laptop computers nor provision of standard software such as Windows or MS Explorer.

C. Operator Workstation Access

1. The BAS Contractor shall provide the CxA with software and hardware needed for accessing the BAS' front-end operator workstation(s). At a minimum, this shall include appropriate level user identification names and passwords. Access level shall allow the CxA to fully execute all commissioning procedures and will include the ability to:
 - a. View system operation
 - b. Override setpoints
 - c. Command digital and analog output points
 - d. View BAS programming source code (read-only)
 - e. View and print graphics
 - f. Create, view, modify, print and download trend logs, histories and reports

D. Technical Support

1. The BAS Contractor shall also provide technical support to the CxA as reasonably requested by the CxA regarding setting up and operating BAS hardware and software to support successful execution of the Cx Process.

E. Duration of Support

1. The BAS Contractor shall provide the CxA with technical support for the duration of the project, through the post occupancy phase commissioning activities, warranty period, and seasonal testing of the project to support the Cx process. The duration of this support is typically one year after turn over to Northwestern facilities, to provide time to complete deferred and seasonal testing and the warranty phase activities.

PART 3 - EXECUTION

3.1 GENERAL

- A. A pre-construction meeting of all Commissioning Team members shall be held at a time and place designated by Northwestern University. The purpose shall be to familiarize all parties with the Commissioning Process, and to ensure that the responsibilities of each party are clearly understood.
- B. The Contractor shall complete all phases of work so the systems can be started, tested, balanced, and commissioning procedures undertaken. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, and change orders.

- C. A Commissioning Plan shall be developed by the Commissioning Authority. The Contractor shall assist the Commissioning Authority in preparing the Commissioning Plan by providing all necessary information pertaining to the actual equipment and installation. If contractor-initiated system changes have been made that alter the Commissioning Process, the Commissioning Authority shall notify the Owner.
- D. Acceptance procedures are normally intended to begin prior to completion of a system and/or sub-systems, and shall be coordinated with the Division 25 contractor. Start of acceptance procedures before system completion does not relieve the contractor from completing those systems as per the schedule.

3.2 PARTICIPATION IN COMMISSIONING

- A. The Contractor shall provide skilled technicians to start-up and debug all systems within Divisions 21, 22, 23, 25, and 26. These same technicians shall be made available to assist the Commissioning Authority in completing the commissioning program. Work schedules, time required for testing, etc., shall be requested by the Commissioning Authority and coordinated by the contractor. Contractor shall ensure that the qualified technician(s) are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.
- B. System performance problems and discrepancies may require additional technician time, Commissioning Authority time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent commissioning periods until the required system performance is obtained.
- C. The Commissioning Authority reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians shall include expert knowledge relative to the specific equipment involved and a willingness to work with the Commissioning Authority. Contractor shall provide adequate documentation and tools to start up and test the equipment, system, and/or sub-system.

3.3 DEFICIENCY RESOLUTION

- A. In some systems, maladjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work shall be completed under the direction of the Owner, with input from the contractor, equipment manufacturer, and Commissioning Authority. Whereas all members shall have input and the opportunity to discuss, debate, and work out problems, the Owner shall make final determination over any additional required work to achieve performance.
- B. Corrective work shall be completed in a timely fashion to permit the completion of the Commissioning Process. Experimentation to demonstrate system performance may be permitted. If the Commissioning Authority deems the experimentation work to be ineffective or untimely as it relates to the Commissioning Process, the Commissioning Authority shall notify the Owner, indicating the nature of the problem, expected steps to be taken, and suggested deadline(s) for completion of activities. If the deadline(s) pass without resolution of the problem, the Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner shall be the contractor's responsibility.
- C. The Owner's contract with the Commissioning Authority includes up to two Functional Performance Tests of each piece of equipment or system included in the commissioning scope.

Commissioning Authority time and expenses required for retests beyond two, if required, due to incomplete installation or otherwise, will be paid by the Owner and reimbursed by the contractor.

3.4 ADDITIONAL COMMISSIONING

- A. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The contractor(s), manufacturers, and Commissioning Authority shall include a 5% contingency allowance to complete this work as part of their contractual obligations.

3.5 SEASONAL COMMISSIONING

- A. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions during off-peak periods. Initial commissioning shall be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different peak and off-peak conditions. Each contractor and manufacturer shall be responsible to participate in the initial and the alternate peak and off-peak tests of the systems as required to demonstrate performance.

3.6 CONSTRUCTION PHASE OBSERVATION

- A. Scope of Construction Phase Observation
 - 1. The Commissioning Authority will conduct periodic observations during the Construction Phase to monitor progress and compliance with the design intent and contract documents. It is the responsibility of the contractor to address the issues noted on the Issues Log and notify Commissioning Authority of completion.
 - 2. Commissioning Authority observations will coincide with Design Team observations and are not intended to take the place of this work.
- B. Documentation and Reporting
 - 1. Issues identified by the Commissioning Authority during Construction Phase will be documented on the Web-based Commissioning Software (WCxS) and distributed to Commissioning Team members.
 - 2. Progress during the Construction Phase will also be documented by the Commissioning Authority using Commissioning Process Reports.

3.7 CONTRACTOR STARTUP TESTING

- A. The contractors shall conduct all startup testing as required by the specifications, equipment manufacturer, the manufacturer's installation, operations and maintenance manual or as necessary to verify all equipment is properly installed.
- B. Startup testing shall be documented. Appropriate documentation shall be by the contractor and/or the manufacturer's representative or entity specified in the construction documents.
- C. The startup testing may be documented using the contractors or manufacturer's standard forms.

3.8 CONTROLS & INSTRUMENTATION TESTING

- A. Prior to start of control system Functional Performance Testing, the Building Automation System (BAS) Contractor shall verify and document that all control systems are installed and operating properly including the following:
1. Control Panels & Hardware Installation shall be fully verified and the appropriate Pre-Functional checklists completed prior to proceeding to subsequent installation/checkout steps.
 2. Point-to-Point Checkout shall be completed and documented per the requirements of Integrated Automation and Controls section of Division 25 and item 3 below.
 3. Control Sequence Checkout. Contractor shall verify that operation of control system programming matches the specified sequences of operation. For these checkouts, the Contractor shall, as much as possible, simulate actual operating conditions for the various operating modes being tested (heating, cooling, etc) by false-loading systems, adjusting setpoints and similar techniques. The CxA will make the control sequence functional performance tests available to the BAS Contractor for use in these checkouts.
 4. Tune all Control Loops to obtain the fastest stable response without unreasonable hunting, offset or overshoot. Record tuning parameters and response test results for each control loop and provide trend reports to document results. Trend logs shall show both steady-state operation and response to setpoint changes.
 5. Test All Alarms and Safeties. Record all alarm parameters and alarm messages. Document all alarms and safeties have been tested and are functioning properly.
- B. The BAS Contractor shall work with the TAB Contractor(s) to make sure that changes to the BAS made during TAB, such as flow coefficients, flow setpoints and duct areas are permanently archived in the BAS and become the initial or default values for their respective controllers. If BAS adjustments made by the TAB Contractor(s) get lost or overwritten prior to archiving, it shall be the BAS Contractor's responsibility to re-enter this data at no additional cost to the Owner.
- C. Point-to-Point Checkout Requirements
1. Items described in this section apply to and augment the requirements of the Integrated Automation and Controls section of the Division 25 specifications.
 - a. These procedures will verify the following for each physical control point:
 - 1) Field device is installed per the manufacturer's recommendations and the project drawings and specifications
 - 2) Field verify calibration of all analog inputs and outputs
 - 3) Verify labeling of controllers, field devices, and wiring
 - 4) Physical points are correctly addressed and communicating properly between its controller and the field device.
 2. Detailed written procedures for execution of Point-to-Point Checkouts shall be submitted to the CxA and Engineer by the Contractor for review and acceptance prior to the start of testing. Include proposed test forms as part of this submittal.
 3. The Contractor shall provide all tools and instrumentation necessary for execution of this testing. All instrumentation must be in calibration and meet the requirements of Part 2 of this specification.
 4. The CxA reserves the right to field verify up to 5% of the Contractor's Point-to-Point Checkout testing. The Contractor shall provide the technicians and instrumentation used for the original testing to assist the CxA with this field verification.

3.9 ACCEPTANCE PROCEDURES

- A. The Commissioning Authority shall develop the pre-functional checklists (PFC) and distribute them to the GC.
- B. The contractor shall complete the checklists online using the WCxS.
- C. PFCs consist of a series of field observations and verification checks conducted by the contractors during the installation of commissioned equipment to verify the following:
 - a. Installed equipment matches the specifications and approved submittals
 - b. Equipment is installed per the specifications, drawings and manufacturer's recommendations
 - c. Utility connections to equipment, such as electrical, steam, chilled water, etc. have been successfully completed
 - d. Equipment is ready for functional performance testing
- D. Contractors should expect to complete one (1) PFC for each piece of equipment covered by the commissioning process such as pumps, fans, air handling units, terminal units, control panels, and lighting control panels.
- E. PFCs for mechanical equipment will include verification of the safety devices intended to stop and/or prevent equipment operation unless minimum safety standards or conditions are met. These may include adequate oil pressure, proof-of-flow, non-freezing conditions, maximum static pressure, maximum head pressure, etc. The CxA shall observe the actual performance of safety shutoffs in a real or closely simulated condition of failure.
- F. Systems may include safety devices and components that control a variety of equipment operating as a system. Interlocks may be hard-wired or operate from software. Operation of these interlocks shall be verified by the CxA during functional performance testing.
- G. Additional checklists will be required to verify installation of distribution systems such as piping, ductwork, electrical wire and conduit, etc. The number of required PFCs will vary from system to system, but will typically be limited to one form per system per floor or zone.
- H. The PFC used for this project will be finalized by the CxA after receipt of equipment Installation, Operation & Maintenance (IOM) Manuals from the Contractors.
- I. PFCs shall be completed by the contractor and maintained on-site per the requirements of this specification, Section 1.5 "Commissioning Documentation".

3.10 FUNCTIONAL PERFORMANCE TEST PROCEDURES

- A. Scope
 - 1. Functional Performance Test (FPT) procedures are executed after commissioned equipment and systems have been installed, started-up and balanced. The goal of these procedures is to conclusively verify that commissioned equipment, sub-systems and major systems operate and perform per the design intent, the project specifications and OPR.
 - 2. FPTs will be used to verify operation and capacity of selected equipment and systems such as boilers, chillers, cooling towers, pumps, exhaust fans, air handling units, etc.
 - a. System operation under both normal and alternate operating conditions and modes
 - b. Interactions between equipment and sub-systems

- c. Operation of safeties and interlocks
- d. Control system operation, response time, stability and tuning
- e. System response to abnormal and/or emergency conditions such as fire, equipment failure and power outages
- f. All control sequence of operation strategies, alarm generation and reporting shall also be reviewed and proper operation verified by the CxA.
- g. The central work station graphics, point assignments, alarm messages, and logging functions shall be verified.

B. Functional Performance Test Forms

1. The commissioning authority will upload the FPTs to the web-based commissioning software.
2. The FPTs used for this project will be finalized by the CxA after receipt of approved contractor submittals, including equipment Installation – Operations & Maintenance manuals.

C. Contractor Requirements

1. The Cx team will, in a joint effort, coordinate and schedule FPT activities.
2. Scheduling of FPTs shall be contingent on notification from the affected contractor(s) to the GC and CxA that equipment and systems are ready for checkout.
3. Other prerequisites for execution of FPTs shall include the following:
 - a. All Pre-Functional Checklists, Contractor Startup Procedures have been completed and documented.
 - b. TAB has been completed.
 - c. All Cx issues identified affecting equipment or system performance or operations have been resolved.
4. Prior to claiming readiness for FPT, the controls contractor shall ensure that the following items are completed and documented:
 - a. Point-to-point checkouts
 - b. Verify that network communication between all devices and systems is established
 - c. Sequence of Operation checkouts
 - d. Printed and annotated trend logs and alarm histories establishing acceptable operation including
 - 1) Stable control
 - 2) Recovery from upset/changes (e.g., from setback)
 - 3) Special and/or seasonal modes
 - 4) Emergency and alarm modes including loss/restoration of power
5. Execution of the FPTs will be conducted by the contractors providing and installing the equipment and systems being commissioned and the BAS contractors and witnessed by the CxA.
6. Typical activities during FPT execution will include the following
 - a. Starting/stopping equipment
 - b. Energizing/de-energizing electrical distribution gear
 - c. Opening/closing valves and dampers
 - d. Manipulating BAS inputs, outputs and setpoints
 - e. Setup, collection and downloading of BAS trend data

- f. Test all modes of operation (normal, failure, backup, emergency, etc.)
7. The Contractor(s) shall maintain full responsibility for the facility, equipment and systems operated during the FPTs, maintain all guarantees and warranties, and shall repair any damage to the facility caused during the FPTs.
8. Contractors shall conduct seasonal FPTs as necessary. This includes performing FPTs on equipment during the season it is intended to operate (i.e. test cooling equipment during the peak cooling season and test heating equipment during the peak heating season, etc.). All seasonal FPT's shall be witnessed by the CxA.
9. Tools, test equipment and instrumentation required for completion of the FPTs shall be provided by the contractor.
10. Special-purpose or proprietary tools, test equipment and instrumentation shall be provided by the contractors.
11. All instruments shall meet the requirements of Part 2 of this specification.
12. FPT acceptance shall confirm the performance of systems to the extent of the design intent. When a system is accepted, the Owner shall be assured that the system is complete, works as intended, is correctly documented, and operator training has been performed.

3.11 COST OF RE-EVALUATION

- A. The cost for Contractors to re-evaluate any Commissioning Procedure due to open issues shall be borne by the contractors.
- B. The CxA will be available for two attempts of the Functional Performance Tests (one initial and one re-try) with minimal follow-up where necessary (due to deficiencies, systems not ready, incomplete work, etc.) to try to accomplish each test as part of the contract. When additional work is required because systems are not ready or because they do not successfully pass the FPT after they have been indicated as ready, the contractor will be charged for the CxA's additional retesting costs. Additional fees will be paid to the CxA by the Owner and shall be reimbursed by the Contractor.
- C. Any required re-testing by any contractor shall not be allowed as a justified reason for a claim of delay or for a time extension by the contractor.

3.12 SOFTWARE DOCUMENTATION REVIEW

- A. Review detailed software documentation for all DDC control systems. This includes review of vendor documentation, their programming approach, and the specific software routines applied to this project. Discrepancies in programming approaches and/or sequences shall be reported and coordinated in order to provide the Owner with the most appropriate, simple, and straightforward approach to software routines.

3.13 SYSTEMS MANUAL:

- A. The Systems Manual shall be submitted in paper AND/OR electronic format and shall contain the following major sections:
 - B. System Descriptions:
 1. The Commissioning Authority shall review the draft form of the Systems Manuals provided by the Division 21, 22, 23, 25, and 26 contractors. The review process shall verify that

- O&M s meet specifications and are included for all equipment furnished by the contractor, and that the instructions and wiring diagrams are project specific (edited where necessary) to the actual equipment provided for this project.
2. Published literature shall be specifically oriented to the provided equipment indicating required operation and maintenance procedures, parts lists, assembly/disassembly diagrams, and related information.
 3. The contractor shall incorporate the standard technical literature into system specific formats for this facility as designed and as actually installed. The resulting O&M information shall be project and system specific, concise, to the point, and tailored specifically to this facility. The CxA shall review and edit these documents as necessary for final corrections by the contractor.
- C. The O&M manual review, and coordination efforts MUST be completed prior to Owner training sessions, as these documents are to be utilized in the training sessions.
- D. In addition to the O&M manual requirements within specification Divisions 21, 22, 23, 25, and 26, O&M manuals shall include at a minimum the following:
1. An equipment data sheet with the equipment name tag, model#, serial # and any other relevant information for the equipment for entry into the owner's central maintenance management system (CMMS).
 - a. The format of the data entry sheets will be provided by the owner and/or CxA.
 - b. Data entry of the equipment information into the CMMS will be the responsibility of the owner.
 2. A copy of the approved submittal, indicating the exact make and model of the equipment installed.
 3. A copy of the manufacturer's IOM manual
 4. A copy of all warranties
 - a. If not included on warranty certificate, provide the start/end dates of warranty period, descriptions of what is and isn't covered and contact information for warranty claims.

3.14 TRAINING

A. General

1. The Contractor shall train the Owner's personnel in the operation and maintenance of systems and equipment listed in this Section and as mentioned in other sections.
2. The required training and demonstration required in the technical sections of the specifications is supplemental or in addition to the training required in this Section (where not a duplication).

B. Scope of Training

1. Training must be conducted in two parts and include both classroom and on-the-job (hands-on) instruction by qualified manufacturer's representatives, vendors, installation/service technicians and operation personnel having the necessary knowledge, experience, and teaching skills.
2. The training shall provide comprehensive instruction on the operation and maintenance of building components, equipment, controls, and systems including procedures for startup,

- shutdown, normal operation, abnormal operation, preventive maintenance, troubleshooting, and corrective maintenance.
3. The classroom portion of each training session, shall be based on the information contained in the approved O&M Manuals and will use copies of these manuals for reference. This shall include the following items as applicable:
 - a. Content and organization of appropriate O&M Manual materials
 - b. Overall equipment / system layout and configuration
 - c. Locations and tag numbers of major components
 - d. Theory of Operation / Design Intent
 - 1) Startup and Shutdown Procedures
 - 2) Normal Operating Procedures
 - 3) Non-normal Operating Procedures (unoccupied, seasonal operation, etc.)
 - 4) Emergency procedures
 - e. Health and Safety issues (both to O&M personnel and building occupants)
 - f. Energy Efficiency Issues
 - g. Occupant Comfort and Indoor Air Quantity IAQ Issues
 - h. Control System Sequence of Operation
 - i. Preventive Maintenance Procedures
 - j. Diagnostic & Troubleshooting Procedures
 - k. Corrective Maintenance & Repair Procedures
 - l. Review of the BAS front end operators work station. A temporary work station and/or laptop shall be set up to review and train O&M staff on the actual BAS controls for this project.
 4. The field portion of each training session shall at a minimum cover the following items as applicable:
 - a. Walk-down of covered equipment and systems
 - b. Demonstration of startup, shutdown and operating procedures
 - c. Demonstration of diagnostic, service, maintenance and repair procedures
 - d. Emergency shutdown procedures
 - e. Locations of critical isolation valves
 5. Follow-up or post-occupancy training, where specified, shall be planned, scheduled and conducted per the requirements of this specification. This training will focus on seasonal issues that could not be addressed during the initial training and on addressing operational and maintenance issues identified by the Owner since turnover.

C. Coordination & Scheduling

1. Training shall not begin until the following items have been completed:
 - a. Building systems and equipment are complete and operational.
 - b. Functional Performance Testing for the equipment and systems being trained on have been successfully completed.
 - c. The Owner has received and approved the final submittal copies of the Operation and Maintenance Manuals
 - d. The contractor's proposed training plan and schedule have been approved by the owner.
 - e. The Building Automation System (BAS) has been completed and tested.

2. The contractor shall work closely with the Owner's personnel and the CxA in the development and implementation of the training program. This may include preliminary meetings to map out the direction the training will take and development, with Owner acceptance, of the written training materials.
3. The minimum specific hours of training time provided for equipment and systems shall be in accordance with the requirements in the individual equipment spec sections.
4. All training shall include two identical training sessions. The first training session shall occur in the morning and shall cover the early morning and day shift staff and the second session shall occur in the late afternoon and cover the evening and night shift staff. Exact training plan and schedule shall be submitted to owner for acceptance prior to any training session.
5. OWNER retains the option of redistributing training time, subject to the total time specified. This may include repetition of selected training sessions or provision for follow-up training sessions after occupancy.
6. Specific schedules for all training sessions must be coordinated in advance with Owner.

D. Training Program and Materials

1. The contractor will submit a written training program outlining the proposed scope of training, training materials and instruction schedule for review and acceptance by the Owner approximately 30 days before the scheduled completion of the work for which training is to occur.
2. Copies of training materials furnished by the Contractor as part of their training program shall become the property of the Owner. This includes but is not limited to:
 - a. All lesson plans, teachers' guides or training aids used to instruct the students. One complete set shall be given to the Owner.
 - b. All written materials. e.g. workbooks, manufacturers' instructions, brochures, student tests, charts or other printed or photographed visual aids. Three (3) sets with one complete reproducible master shall be given to the Owner.
 - c. All audio-visual materials e.g. DVD's, CD's, video tapes, film and audio cassettes, overhead projector transparencies, software files of presentations, or other audio visual medium. Three sets shall be given to the Owner.
3. The Contractor shall provide all equipment related to the conveyance of the training program e.g. DVD's, CD,s projectors, TV monitors, overhead projector, or other related equipment. Non-permanent mounted white boards, cork board and projector screens. Equipment of this nature provided by the contractors for use during training sessions does NOT become the property of the Owner. Contractors shall promptly remove said equipment at the end of the training session(s).

E. Instructor Qualifications

1. Credentials of training instructors are subject to review and acceptance by the Owner.
2. Instructors must have knowledge and experience with the equipment on which they are providing training
3. Instructors must be familiar with the organization and content of Operation and Maintenance Manuals for the equipment on which they are providing training.
4. Instructors for controls must be knowledgeable and familiar with the specific controls equipment, project applications, and specific sequences of operation for this project.

F. Classroom Training Facilities

1. Locations for classroom training sessions shall be coordinated with the Owner. All training shall be conducted on-site except by prior arrangement and acceptance by the Owner.

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JOB # _____

FOR: _____
ISSUED: 03/29/2017

3.15 RECORD DRAWINGS

- A. The Commissioning Authority shall review the as-built contract documents to verify incorporation of both design changes and as-built construction details. Discrepancies noted shall be corrected by the appropriate party.

3.16 EXCLUSIONS

- A. Responsibility for construction means and methods: The CxA is not responsible for construction means, methods, job safety, or any construction management functions on the job site.
- B. Hands-on work by the CxA: The contractors shall provide all services requiring tools or the use of tools to start-up, test, adjust, or otherwise bring equipment and systems into a fully operational state. The CxA shall coordinate and observe these procedures (and may make minor adjustments), but shall not perform construction or technician services other than verification of testing, adjusting, balancing, and control functions.

END OF SECTION