SECTION 01 91 00 – GENERAL COMMISSIONING REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

1.1.1 Commissioning (Cx) is a quality-oriented process of assuring that a facility is constructed and performs as intended in accordance with the contract documents. The process confirms that all building systems (including building envelope) have been installed and exercised throughout their full range of intended operation, and that anticipated failures have been initiated or simulated to verify response and recovery.

1.1.2 Commissioning requires cooperation and direct involvement by all parties throughout the construction process. Successful Cx requires not only that all building systems and assemblies comply with contract requirements, but also that installation is achieved early enough in the construction phase to allow full operational check-out, testing, and adjusting of equipment and systems prior to Substantial Completion. Planning adequate time for all Cx activities will require the development and maintenance of a detailed Cx schedule with input from, and the active participation of, all members of the Cx team.

1.1.3 In addition to fulfilling scheduling and planning requirements, the Contractor is responsible for verifying and documenting equipment and system installation as well as demonstrating and documenting operational performance of all systems and assemblies. This includes successful demonstration of full systems integration in the facility to the Owner's Designated Representative (ODR). The cost of Cx administration as outlined in this specification shall be shown as a separate line item on the Contractor's schedule of values.

1.1.4 The Contractor is solely responsible for all Cx responsibilities contained in the project plans and specifications. The Contractor shall submit to the Owner within 30 days after Notice to Proceed the resume of a qualified individual to act as the Contractor's Commissioning Coordinator (CxC). The CxC shall be a full-time project resource and will be the primary point of contact for all Cx related activities. The proposed individual shall have formal Cx credentials from UW, BCA, AEE, ACG, or ASHRAE, or other Cx credentials can be submitted for evaluation and potential acceptability. The individual proposed to fill the Contractor's CxC role must be approved by the Owner. Fulfilling the Contractor's responsibilities for the CxC, as outlined herein, shall be the individual's primary role for the project. The CxC cannot be the project manager or a project superintendent. The Contractor may elect to outsource the CxC position to a third party firm with the approval of the Owner, and the outsourced individual filling the role of the CxC must be a full-time project resource. Outsourcing the CxC role will be contingent upon Owner review and approval of the proposed individual's qualifications to fill the position.

1.2 DEFINITIONS

1.2.1 Commissioning Coordinator (CxC) -- the individual appointed by the Contractor (and approved by the Owner) to act as the Contractor's single point-of-contact for all Cx related activities.

1.2.2 Cx Authority (CxA) -- the party having a contract Agreement with the Owner to provide third party Cx services as a consultant to the Owner. In some cases, the CxA will be contracted by the A/E firm.

1.2.3 Cx Team Members -- all parties who represent the Owner, A/E, Contractor, Subcontractors, Manufacturers, Vendors, and Suppliers and Consultants associated with the project.

1.2.4 Contractor's Cx Record (CCR) -- the compilation of Cx related documentation including but not limited to the Commissioning Plan, the Equipment Matrix, Close-out Documentation Matrix, Cx Schedule, observation reports, inspections, meeting minutes, Cx checklists/testing scripts/procedures, etc.

1.2.5 Building Automation System (BAS) – A control system designed to automatically control and monitor building systems.

1.2.6 Owner's Project Requirements (OPR) – A formal document developed early in the design process that communicates what the Owner wants accomplished in the project.

1.2.7 Basis of Design (BOD – A formal document developed by the design team early in the design process that communicates how the systems designed will meet the project objectives.

1.2.8 UW – University of Wisconsin

1.2.9 AEE – The Association of Energy Engineers

1.2.10 ACG – AABC Commissioning Group

1.2.11 BCA – The Building Commissioning Association

1.2.12 ASHRAE – The American Society of Heating, Refrigerating, and Air-conditioning Engineers

1.3 RELATED DOCUMENTS

1.3.1 The Uniform General Conditions, applicable requirements of all Divisions of the Contract specifications and all Contract Drawings apply to work of this section. In the event of conflict between specific requirements of the various documents, the more restrictive, the more extensive (i.e., more expensive) requirement shall apply.

1.3.2 Technical specifications throughout all Divisions of the Project Manual, which pertain to operable and non-operable equipment and/or building systems, are directly applicable to this section, and this section is directly applicable to them. Particular attention is directed to:

1.3.2.1 Division 1 General Requirements, specifically
Section 01 32 16 – Project Planning and Scheduling
Section 01 45 00 – Project Quality Control
Section 01 77 00 – Project Closeout Procedures

1.3.2.2 Divisions 7-14

1.3.2.3 Divisions 21-33 sections as appropriate, and Cx-specific sections:
Section 21 08 00 – Commissioning of Fire Protection Systems
Section 22 08 00 – Commissioning of Plumbing Systems
Section 23 08 00 – Commissioning of Mechanical Systems
Section 26 08 00 – Commissioning of Electrical Systems

1.4 WORK INCLUDED

1.4.1 SCOPE OF THIS SECTION

1.4.1.1 It is of primary concern that all systems installed in the project perform in accordance with the design intent and the OPR. This is particularly critical for systems affecting life safety, building controls, plumbing, HVAC, building envelope, lighting, power delivery systems, security system, article protection system, and access control system.

1.4.1.2 This section establishes minimum general and administrative requirements pertaining to Cx progress-tracking tools, documentation of installation, startup and performance testing of equipment, devices, assemblies and building systems. Additional technical and operational requirements for particular systems and components are established in the various technical sections of the specifications. The Contractor is solely responsible for the Cx process. This responsibility shall not be delegated to subcontractors, but by necessity will require the participation of subcontractors.

1.4.2 OFPC will provide the Contractor with an electronic copy of standard Cx coordination and tracking tools, and document templates for various inspections, outage requests, reports, etc. Cx-related documents, including tracking tools will be delivered to the Owner at Substantial Completion as part of the CCR. The Contractor shall customize the provided tools and templates to meet the specific details of the project. It is the responsibility of the Contractor to develop project-specific documentation forms and tracking tools where they are not provided by OFPC.

1.4.3 The Owner's Quality Assurance (QA) testing and inspection program is independent of the Cx program. The Contractor is required to perform all testing (or provide or make available portions of the building for consultant and/or third party testing) as specified in the contract documents in addition to the Cx requirements outlined herein. Coordination of these processes by the Contractor will help minimize any duplication of effort. Unless stipulated elsewhere in the contract documents, QA testing and inspection documentation shall be included in the CCR.

1.5 COMMISSIONING PLAN

1.5.1 The Cx Plan is a detailed description of the entire Cx process. The Cx Plan identifies processes, procedures, roles and responsibilities, and protocols to be administered and managed by the Contractor to satisfy the Cx responsibilities included in the contract documents. The Cx Plan provides a step-by-step outline to assure the Owner's project requirements are met during the construction process. The Contractor is responsible for development, implementation and maintenance of the Cx plan, and associated tools for scheduling and tracking Cx activities. The Owner may choose to engage a CxA to develop a draft construction phase Cx plan. When a draft Cx plan is provided by the Owner's CxA, the Contractor is required to review, submit recommended changes, and update the draft (template) Cx plan with approved changes. The Contractor shall adopt the final approved draft Cx plan as the project's Cx plan. The Cx plan will include, as a minimum, the following Project Cx Team Members:

1.5.1.1 Contractor's Cx Coordinator (CxC)
1.5.1.2 UT System Office of Facilities Planning and Construction (OFPC)
1.5.1.3 A/E and relevant consultants
1.5.1.4 Institution departments, groups, and representatives
1.5.1.5 Subcontractors
1.5.1.6 Manufacturers, vendors and suppliers as appropriate
1.5.1.7 Owner's TAB contractor
1.5.1.8 Independent testing labs
1.5.1.9 Campus Liaison(s)
1.5.1.10 Cx Authority (if appropriate)

1.5.2 Commissioning activities shall be identified, scheduled, executed, documented, and tracked by the Contractor and coordinated with the Owner and Owner-designated consultants, and shall include, but not be limited to:

1.5.2.1 Inspections/Tests as required by plans and specifications
1.5.2.2 Equipment Startup
1.5.2.3 Functional Tests
1.5.2.4 Integrated System Testing
1.5.2.5 Entire Facility Integration Testing
1.5.2.6 Training

1.5.3 Equipment List

1.5.3.1 The Contractor shall prepare an equipment list using the approved Commercial Software Solution or the Owner-furnished template form. This list shall contain a complete record of operable equipment, devices, and systems, organized by function and logically grouped with supported/related systems.

1.5.3.2 The list shall be populated with all available information for the Cx kickoff meeting. The list shall, as a minimum, include the following data for each item:

1.5.3.2.1 Brief equipment identification text
1.5.3.2.2 Equipment or device ID number (device tag)
1.5.3.2.3 Startup inspection required? (Yes/No)
1.5.3.2.4 Associated building system, (Lighting, Access Control, Life Safety, Building Envelope, Domestic Hot Water, Chilled Water Distribution, etc.)
1.5.3.2.5 Governing specification section
1.5.3.2.6 Installation location
1.5.3.2.7 Area(s) served
1.5.3.2.8 Manufacturer and model number
1.5.3.2.9 Serial number
1.5.3.2.10 Date of the Equipment Startup by the Contractor
1.5.3.2.11 Completion date of Functional Test demonstration by the Contractor
1.5.3.2.12 Completion date of Integrated System Test demonstration by the Contractor (multiple equipment items may be included in a single IST)
1.5.3.2.13 Trending Data required? (Yes/No) Trending data includes loop tuning documentation (log values and graphed) of stable control through a setpoint change.
1.5.3.2.14 Date of Verification of Trended Data (graphical data and tabular logs to be included in the CCR)
1.5.3.2.15 Date of completion of Training
1.5.3.2.16 Systems shall be included at the end of the list for systems that require an IST (not all columns, such as specific equipment-related data will be applicable).

1.5.3.3 During construction, the equipment list data shall be continuously updated at regular intervals and provided at each Cx Meeting. The equipment list will be a part of the CCR. Updates should occur at least weekly, and more often as deemed necessary by the Owner.

1.5.3.4 The requirement to provide continuous updates to the equipment list for distribution at Cx meetings may be waived with the employment of a commercial Cx software solution that is capable of generating equipment reports that satisfy the intent of the equipment list used as a progress-tracking tool. The aforementioned report shall be provided at each Cx meeting. The

Owner must approve any waiver of the use and maintenance of the equipment list, and reserves the right to reinstate the equipment list requirement.

1.6 COMMISSIONING ACTIVITY DOCUMENTATION REQUIREMENTS

1.6.1 To verify the Cx work, a logical sequence of Cx activity documentation shall be completed by the Contractor and witnessed and reviewed by The Owner (or an Owner-designated consultant). All Contractor installed systems (static and dynamic), subsystems, assemblies, equipment, components and devices shall be tested, operationally verified and documented. The Contractor is responsible to provide Cx forms and testing procedures with appropriate rigor to meet the specific needs of the project. Sequence of operation testing procedures (in an itemized action-response format) shall be contained in applicable FPTs and/or ISTs and the EFIT. The sequence of operation testing procedures shall include testing and demonstration of failure conditions. At a minimum, Cx documentation shall include:

1.6.1.1 Pipe/Duct Pressure Test - Contractor shall provide map (plan view) detailing each tested section.

1.6.1.2 Construction Checklist (CC) - CCs shall be used to document the condition of equipment upon delivery to the site and appropriate installation for submitted and approved components of a system, i.e., motor installation, waterproofing membrane application, roof application, etc. The manufacturer installation checklist should be completed and attached to the completed CC. (Contractor may implement with Owner approval either their own construction checklists or manufacturer checklists.

1.6.1.3 Equipment Startup Checklist (ESC) - Checklist shall be used to document the startup (energizing the equipment) of operable equipment. The purpose of the ESC is to verify and document that equipment is energized and started in accordance with manufacturer recommended procedures, and to coordinate witnessing of the event with the Owner and interested campus entities.

1.6.1.4 Functional Performance Test (FPT) - Document containing verification and operational procedures for demonstrating the full functionality and performance of an installed component, equipment or system. FPT procedures shall employ an itemized action-response format.

1.6.1.5 Integrated System Test (IST) - The IST documentation shall be used to document demonstration of operational performance of multi-component sequences of operation to include integration with other components, interlocks and alarm conditions for homogeneous systems. Testing procedures are to include all modes of operation and shall employ an itemized action-response format.

1.6.1.6 Entire Facility Integration Test (EFIT) - The EFIT shall document demonstration of operational performance and integrated operation of the entire facility as a multi-functioning operational system.

1.6.1.7 All FPT, IST, and EFIT documents shall be submitted to the Owner for approval for use no less than 60 calendar days before applicable scheduled activity.

1.6.1.8 Other specialized test reports (identified in technical specifications) - Contractor shall submit industry standard or custom forms and report formats as appropriate for approval by the Owner.

1.6.1.9 Closeout Documentation Matrix shall include all project deliverables to be transmitted to the Owner prior to substantial completion. Deliverables listed shall include:

1.6.1.9.1 The prescribing specification section
1.6.1.9.2 Description of item(s)
1.6.1.9.3 Type of item to be transmitted (spare parts, attic stock, training, warranties beyond one year, O&M manuals, as-builts, keys checklist, and service contracts)
1.6.1.9.4 Quantities transmitted
1.6.1.9.5 Transmittal date
1.6.1.9.6 Recipient of transmitted deliverable
1.6.1.9.7 Initials of the recipient of transmitted deliverable

1.7 CONTRACTOR'S COMMISSIONING RECORD

1.7.1 The CCR is a consolidation of all Cx and testing documentation for the project. The Contractor shall transmit the CCR to the Owner at the conclusion of the project construction phase (Substantial Completion), as agreed upon in writing by the Owner.

1.7.2 The Contractor shall employ a commercial software solution to generate and maintain the CCR. A proposed commercial software solution shall be submitted to the Owner for approval.

1.7.3 The Contractor is responsible to provide the necessary input/access devices (iOS or Android device) for the Owner to utilize the software solution for the duration of the project. Each assigned construction inspector and the ODR shall receive an input/access device.

1.7.4 The Contractor may request that the Owner waive the requirement for the use of a commercial software solution. The requested waiver must include a detailed, project-specific plan for documenting and providing a comprehensive CCR.

1.7.5 The CCR shall include, but not be limited to, the following:

1.7.5.1 The Contractor's Cx Plan
1.7.5.2 Equipment List Cx Schedule (Duration to include every Cx activity through Substantial Completion
1.7.5.3 Closeout Documentation Matrix
1.7.5.4 Commissioning Schedule (final with updates)
1.7.5.5 Paint/Finish Schedule

1.7.5.5.1 Schedule shall include all paints, wall coverings, flooring, finishes, etc. used on the project.
1.7.5.5.2 Provide manufacturer, model #, color formula, location on project, purchase source and any other information helpful to the institution's maintenance personnel.

1.7.5.6 Field Observation Reports
1.7.5.7 Cx Meeting Minutes
1.7.5.8 Building Envelope Inspections and Tests
1.7.5.9 Pipe Pressure Tests
1.7.5.10 Duct Pressure Tests
1.7.5.11 Fire Alarm and Suppression System Tests and Reports
1.7.5.12 Completed NFPA Forms
1.7.5.13 Commissioned Component/Equipment/System Documentation
1.7.5.14 Construction Checklists (w/attachments)
1.7.5.15 Equipment Startup Checklists (ESC)
1.7.5.16 Functional Performance Tests (w/attachments)
1.7.5.17 Integrated System Tests (w/attachments)
1.7.5.18 Entire Facility Integration Test
1.7.5.19 Owner Training Plans (with sign-in sheets)

1.7.6 Equipment and system submittals, shop drawings, and as-built documentation shall be submitted separately as required elsewhere in the contract documents.

1.7.7 Operating and Maintenance (O&M) Manuals for each system, equipment, and device shall be submitted separately as required elsewhere in the contract documents. An exception to the CCR including the O&M Manuals is made when a commercial software solution incorporates the O&M Manuals as attachments to the Equipment Record and the CCR is being delivered electronically as a packaged output (or export) from the commercial software solution.

1.7.8 Prior to delivering the CCR, Contractor shall schedule and facilitate a meeting to align BAS/HVAC Controls as-built documentation with TAB documentation and (as applicable) 3rd party Cx provider documentation. This meeting should focus on the sequences of operation for all operable equipment and associated control parameters, variables, algorithms and setpoints.

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

2.1.1 Subcontractors shall provide all specialized tools, test equipment and instrumentation required to execute startup, checkout, functional performance, integrated systems and entire facility testing that includes equipment under their contract.

2.1.2 Test equipment shall be of sufficient quality and degree of accuracy to test and/or measure system performance within tolerances specified. Subcontractors and vendors shall provide calibration certificates for all test equipment and instrumentation. A testing laboratory shall use test equipment that has been calibrated within the previous 12 months. Calibration shall be NIST traceable. Test equipment shall be calibrated according to manufacturer's recommended intervals and recalibrated when dropped, damaged, or when Owner deems necessary. Calibration tags shall be affixed or certificates readily available.

PART 3 EXECUTION

3.1 COMMERCIAL COMMISSIONING SOFTWARE SOLUTION

3.1.1 The Contractor shall submit for approval by the Owner, a commercial Cx software solution used to generate and collect the CCR and associated Cx activity checklists and procedures, equipment information, associated manuals, photos, etc. in a database format that is COBie compliant, and that employs an issue/deficiency tracking system. The commercial Cx software solution shall provide for customizable systems and equipment types and designations such as, but not limited to, access control systems, security systems, building envelope systems and healthcare systems (nurse call, medical gas, pneumatic tube conveyance, etc.). The Cx Software shall:

3.1.1.1 Provide for online storage of "library" files that can be organized in a customizable folder structure.

3.1.1.2 Include sufficient licensing to accommodate the maximum users necessary to meet the needs of the project, including licenses necessary for Owner's project team. Coordinate with the Owner to determine license quantity requirements. Licenses and access to the Cx software will be required to be maintained for 12 months after Final Completion.

3.1.1.3 Employ security capabilities using industry standard encryption (128-bit minimum) for web-based access and offline device synchronization. The software solution shall employ the use of a unique user ID and password for each individual user. Access and permissions shall be assignable to each unique user ID, or to categories or groupings of users engaged in similar roles. The Cx software shall allow for simultaneous multiple user access to database records

for checklist updates, entry of issues, attachment of photos, access to library files, etc.

3.1.1.4 Allow for custom data elements (attributes) associated with each type of equipment (VAV Box, Air Handling Units, Electrical Panels, etc.) that can be configured by the user. Each project must be able to support a unique (user defined) set of data elements specific to the requirements of the project. The system shall provide support for industry standard barcode or QR code for each equipment/system item.

3.1.1.5 Provide for checklist generation (creation) with customizable checklist responses. Software shall employ the use of checklist templates to create individual equipment-specific checklists. Software shall provide for auto "Issue Generation" based on user-selected trigger responses. Responses shall include a default "Pass/Fail", numeric (only) response and user-defined "single item select list" as a minimum.

3.1.1.6 Provide for tracking of systems/equipment status as each item progresses through the Cx process. The process (progressive list of statuses) shall be user defined and selectable from a drop-down or "single item select list."

3.1.1.7 Provide for interactive field data entry in either an online or offline environment. The data entry or Cx software remote (field) access device shall be Android and/or iOS compatible. Contractor shall provide (and maintain) Owner with Android or iOS compatible remote access devices for the duration of the project. (Examples are an iPad or tablet PC.) Offline access capability shall support storage of all database items enabling full software functionality. The remote access device shall be capable of storing for offline access contract documents (drawings, specifications, etc.) and software library documents.

3.1.1.8 Provide browser-based access to the online database via the internet using current industry standard browsers (e.g., Chrome, Fire Fox, Internet Explorer, Edge or Safari). Browser-based access must be fully compatible with a minimum of two of the listed industry standard browsers.

3.1.1.9 The use of any software that does not comply with each of the requirements listed above or use of an alternative methodology of generating/collecting/documenting the CCR shall require a written substitution proposal that includes samples of each tracking tool and document type (checklist, report, equipment tracking, etc.) that will be included in the CCR. Substitution proposals must list each criterion in Section 3.1 and designate compliance or detail specific non-compliance. Substitution proposal shall be submitted prior to Contractor's Notice to Proceed (NTP) for project construction phase.

3.2 COMMISSIONING SCHEDULE

3.2.1 The objective of scheduling Cx process activities is to integrate and coordinate Cx activities with other construction phase activities. Detailed scheduling will allow Cx Team members to coordinate work with other team members in order to complete all Cx activities prior to Substantial Completion. The Cx Schedule shall include major Cx activities, essential prerequisites for major equipment and system activities and operable equipment/system/assembly functional and integrated systems performance demonstrations. The Cx Schedule shall account for Test and Balance (TAB) consultant activities properly scheduled and coordinated into the project work flow to allow for the completion of all TAB work prior to Substantial Completion. The Cx Schedule shall account for building envelope consultant inspections, tests and other activities properly scheduled and coordinated into the project work flow to allow for inspections and testing prior to covering or concealment. As applicable, the following milestones and activities shall be incorporated into the project master construction schedule:

3.2.1.1 Cx Kickoff Meeting
3.2.1.2 Building Automation System Submittal Approval
3.2.1.3 Control Sequence of Operation Coordination Meeting (reference Specification Section 23 05 93A)
3.2.1.4 Ethernet Connectivity
3.2.1.5 Building Envelope Testing and Verification Activities
3.2.1.6 Major HVAC Equipment/Systems Startup
3.2.1.7 System Specific Test and Balance Activities
3.2.1.8 Major HVAC Equipment Functional Performance Tests
3.2.1.9 Integrated System Tests
3.2.1.10 Entire Facility Integration Test
3.2.1.11 Training

3.2.2 The Contractor shall provide a minimum of 72 hours' notice prior to each Cx activity to the Owner and the CxA and Testing Consultants when applicable, unless stipulated otherwise in this specification or other technical specifications.

3.3 COMMISSIONING KICKOFF MEETING

3.3.1 Within 120 days after the effective date of the NTP for the construction scope or package that includes building operational systems, the CxC will schedule a date to conduct a Cx kickoff meeting with all parties involved in the Cx process. As a minimum the meeting should include the major subcontractors, specialty manufacturers/suppliers, the A/E, mechanical and electrical consultants, the Owner's testing, adjusting and balancing (TAB) firm, the CxA, the Owner and representatives from the UT institution.

3.3.1.1 The Contractor shall prepare for the meeting by creating drafts of the following documents for review at the meeting:

3.3.1.1.1 The Cx Plan
3.3.1.1.2 Equipment List
3.3.1.1.3 Closeout Documentation Matrix
3.3.1.1.4 The Cx Record - Table of Contents
3.3.1.1.5 An overview or demonstration of the approved Cx software
3.3.1.1.6 Sample ESCs and FPTs
3.3.1.1.7 Preliminary Cx Schedule incorporating Cx activities to coincide with the work flow contained in the master construction schedule

3.3.1.2 The Contractor shall conduct the meeting and review the Cx process and specifications, including discussion of documentation requirements, available test procedures and Cx forms.

3.3.1.3 The Cx Plan review shall outline roles and responsibilities of each Cx team entity and the potential schedule impact as related to Cx requirements.

3.3.1.4 The CCR Table of Contents review shall include discussion of the scope of work. The Contractor shall be prepared to distribute copies of the pertinent document samples to the subcontractors involved in the Cx process.

3.3.1.5 The Cx Schedule review shall include the dates and durations for major systems startup, and shall identify functional performance testing that is included in the master construction schedule. Team members should identify potential schedule impact pertaining to their scope of work and test sequencing.

3.3.1.6 Commissioning shall be an agenda item for project progress meetings until separate Cx meetings are deemed necessary.

3.4 PRE-INSTALLATION MEETINGS

3.4.1 At a minimum, the Contractor shall schedule a separate meeting for the work involving each major building system or systems and assemblies. The pre-installation meeting shall be scheduled, in writing, a minimum of five (5) days in advance, and shall be scheduled so that the Owner, Owner-designated consultants and Architect/Engineer can attend. The meeting shall be convened following approval of system submittals and prior to commencement of system installation work.

3.4.1.1 The Contractor shall arrange for all subcontractors, suppliers and manufacturers involved in the system to be present or adequately represented.

3.4.1.2 The Contractor shall bring the following to this conference, at a minimum, for review and discussion:

3.4.1.2.1 The portion of the equipment list applicable to the system/trade under discussion

3.4.1.2.2 Current work schedule data pertaining to the equipment delivery, installation, required testing, construction checklists, equipment startup and functional performance testing anticipated

3.4.1.2.3 Copy of all approved submittals for the system

3.4.1.2.4 Draft of documentation/checklists to be used for inspection, startup and functional performance testing of the system(s)/assembly under review.

3.4.1.3 The purpose of this meeting is for the Contractor and all applicable subcontractors and/or suppliers and/or factory representatives to discuss all aspects of the installation of the particular system, testing and documentation required and procedures to be followed. Special attention is to be directed to the scheduled order of work and any impact on or by any other building systems.

3.4.1.4 The Contractor shall demonstrate the commercial Cx software and use of remote access device. An explanation of the use and protocols that will be employed should accompany the demonstration. This is not intended to be a training session; it is a demonstration for familiarization purposes.

3.5 CONTRACTOR'S VERIFICATION OF INSTALLATION – CONSTRUCTION CHECKLIST

3.5.1 The Contractor shall document using a construction checklist a review of testing/inspection forms to ensure each is accurate and complete. This documentation shall include, but not be limited to, first-hand knowledge of the following items:

3.5.1.1 Equipment/system is delivered in new condition and in accordance with approved submittals. Delivered equipment and materials are protected, staged and stored in accordance with the specifications and the manufacturer recommendations.

3.5.1.2 Each component device has been installed and terminated in accordance with the project specifications and governing codes as well as the manufacturer's written recommendations.

3.5.1.3 All shop drawings and product data submittals have been approved for each component device.

3.5.1.4 All valve schedules, wiring diagrams, control schematics, electrical panel directories, etc. have been submitted, approved, and equipment/systems installed in accordance with specifications.

3.5.1.5 All test reports and/or certifications required have been submitted and accepted. If required, certificate of acceptance from manufacturer representative and/or engineering technician have been received. Provide copies of all checklist/inspection documentation completed by the manufacturer or certified technician.

3.5.2 The Contractor shall be responsible for correction of all noted deficiencies. Any request for inspection/re-inspection or test/retest of a device or system shall first be confirmed as being compliant by the Contractor before submitting a request to the Owner for inspection/re-inspection and testing/retesting.

3.6 EQUIPMENT STARTUP

3.6.1 Startup of Independent Systems, Assemblies, Components and Devices

3.6.1.1 Equipment startup is a documented formal Cx activity for the Owner (and others) to verify and witness proper startup in accordance manufacturer recommendations and contract documents. The Contractor shall utilize the Equipment Startup Checklist (ESC) to document the activity, participants, and witnesses.

3.6.1.2 The Contractor shall not energize or activate, or allow activation of any operable device prior to equipment startup by a manufacturer representative. It is NOT permissible to “bump” motors prior to equipment startup. Contractor shall verify proper electrical service wiring (phasing) with the use of a phase rotation meter.

3.6.1.3 The Contractor and manufacturer’s representative shall inspect and accept the installation and preparedness for startup. The Contractor shall execute startup under supervision of a responsible manufacturer's representative in accordance with manufacturer's instructions and as specified in the contract documents. The installation shall not vary from provisions of the applicable specifications and the manufacturer's written recommendations for startup. The Contractor shall develop and use the ESC to document (for the CCR) preparedness for startup, startup procedures and record operational measurements and data appropriate for the equipment and in accordance with the technical specifications. The Contractor is encouraged to incorporate any manufacturer provided installation and startup checklists as part of the ESC.

3.6.1.4 The Contractor shall provide five (5) business days’ notification of scheduled equipment startup to the Owner, the Owner’s designated consultants and the A/E team.

3.7 FUNCTIONAL PERFORMANCE TESTING

3.7.1 After all relevant Construction Checklists are completed and startup has been accomplished, the Contractor shall coordinate pre-functional testing by the subcontractors and applicable Owner consultants in preparation for the Functional Performance Test (FPT). Contractor shall provide five (5) business days' notice of the scheduled FPT (demonstration) to the Owner, Owner designated consultants and A/E team.

3.7.2 The Demonstration of an FPT is a documented formal Cx activity for the Owner (and others) to verify the operation of equipment/assembly/system in accordance with contract documents to include all modes of operation, sequences of operation and anticipated failure conditions. The Contractor shall operate, or cause to be operated, each system, device, assembly or equipment item, both intermittently and continuously, for the duration indicated in the specification section(s) for such item and/or in accordance with the manufacturer's written recommendations, and in accordance with the approved FPT procedures. The details of these activities shall be documented for the CCR. The Owner and/or an Owner-designated consultant shall witness and verify the results of the functional performance test demonstration.

3.7.3 For operable equipment/systems, each component device and each building system shall be exercised to the full extent of its capability, from minimum to maximum, under automatic and manual control, and in bypass when applicable. The equipment/assembly/system shall be exercised using the Campus BAS graphics on a campus operator's workstation. All inputs, outputs and calculated values, as displayed on the operator's workstation graphics, shall be verified and documented.

3.7.4 The Contractor and, when applicable, manufacturer's representative, shall supervise and coordinate adjustments, alignments, calibrations and balancing of all devices, equipment and systems for proper operation as part of the pre-functional testing activities.

3.7.5 The Contractor shall coordinate with the Owner's consultants to support the progression and completion of their scope of work. The Contractor shall provide the TAB firm and envelope consultant with installation and performance data as requested by the consultant (and approved by the Owner).

3.7.6 For Static systems, periodic observations shall be documented in accordance with manufacturer installation guidelines and recommendations. Performance testing as recommended by the manufacturer and in accordance with applicable technical specifications requirements shall be documented.

3.7.7 Where final TAB of a system or particular components thereof are not specifically indicated to be performed by Owner or Owner's consultants, the Contractor is to

provide final balancing and adjustments for operation within specified tolerances and provide documentation of it prior to scheduled FPT of each system.

3.8 INTEGRATED SYSTEM TESTING

3.8.1 After successful completion and documentation of all system/assembly/equipment FPTs, the Contractor shall schedule a meeting with the Project Cx Team to review the approved Integrated System Tests (ISTs) and demonstration procedures for each designated system. An integrated system contains two or more system components that have been functionally tested and have physical, hardwired or software interfaces that require one component to respond as the result of the operation of one or more other components. Examples of a few systems that would require an IST are: chilled water distribution, domestic hot water system, primary electrical distribution, fire alarm, access control and security systems.

3.8.2 Development of IST and demonstration procedures may vary with each project. The Contractor is responsible for providing ISTs that include all modes of operation for the system that could act upon or react to operation of separate system components. An IST shall be submitted to the Owner for review and comment and final approval by the A/E team. Collaboration with the A/E design team during IST development will ensure that a thorough performance demonstration is achieved. ISTs shall include a comprehensive, action-response checklist for all modes of operation and failure conditions included in the sequence of operation and shall itemize for each action, the anticipated response from each integrated system and/or associated component.

3.8.3 Following compliance with the provisions noted above and following submission of Operating & Maintenance (O&M) Manuals for the all systems to be demonstrated, the Contractor shall provide the Owner a five (5) business day notice of their intent to perform an IST demonstration. The Contractor is responsible for documenting the results of the ISTs.

3.9 ENTIRE FACILITY INTEGRATION TESTING

3.9.1 After successful completion and documentation of all ISTs, the Contractor shall schedule a meeting with the Project Cx Team to review the Entire Facility Integration Test (EFIT). The EFIT is a facility-wide test to verify that all building systems interact and predictably perform in accordance with the design documents.

3.9.2 Development of the EFIT and demonstration procedures shall be a collaborative effort of the Cx Team facilitated by the Contractor. The Contractor is responsible for ensuring that all building systems are included in the EFIT, that each system responds to designed modes of operation, and that anticipated failure conditions are itemized for monitoring and verification. The format of the EFIT testing procedures shall be an action-response matrix that identifies for each action (mode of operation), the itemized list of responses that are to be verified and documented. The Contractor shall submit the EFIT to the Owner and A/E team for review and comment.

3.9.3 Following compliance with the provisions noted above, the Contractor shall provide the Owner a five (5) business day notice of their intent to perform an EFIT. The Contractor is responsible for documenting the results of the EFIT.

3.10 OWNER TRAINING

3.10.1 Training shall consist of classroom type sessions and on-site demonstrations of system operation. See specification technical sections for specific system/equipment requirements. If a system/equipment requires both field demonstration and training, they may be combined if the Owner approves.

3.10.2 The Contractor shall provide a professional-grade video recording of training, with audio, in accordance with the technical specifications. The Owner will select those portions of the training to be recorded.

3.10.3 The Contractor shall be responsible for submitting individual training plans and for coordination, scheduling and completion of the training for all equipment as specified in the contract documents. The training will be conducted by the installing subcontractor and/or manufacturer's representative for each specific piece of equipment in accordance with the applicable technical specification sections. Each training plan shall be submitted to the Owner no later than 14 calendar days in advance of proposed training. Training plans shall include the specifications section reference, proposed trainer and relevant qualifications (resume), training agenda with learning objectives, copies of training materials/handouts/visual aids, training date, time, location and duration.

3.10.4 Training shall use the O&M Manuals as a basis for instructing the Owner's personnel regarding system operation. Training shall include a review of the contents of O&M Manuals and a review of equipment data and performance verification from the FPT checklists.

3.10.5 Demonstrate in the field: startup, operation, control, adjustment, trouble-shooting, servicing, maintenance, each component device and shutdown of the system(s).

3.10.6 Demonstrate both in the field and with the use of operator (workstation) graphics a detailed check-out at each stage of the sequences of operation. All equipment graphics, alarms and sequences of operation are to be reviewed, and demonstrated to the extent the Owner agrees is feasible.

3.10.7 The Contractor shall participate in demonstration of Owner Furnished/Contractor Installed equipment in accordance with applicable technical specifications.

3.10.8 As a minimum, the Contractor shall perform training on all Life Safety systems including, but not limited to, the following (if system is part of the project):

3.10.8.1 HVAC and Controls
3.10.8.2 Fire Alarm
3.10.8.3 Fire Sprinkler Systems (including pumps)
3.10.8.4 Elevator/Escalator
3.10.8.5 Smoke Purge
3.10.8.6 Stairwell Pressurization
3.10.8.7 Communications Systems
3.10.8.8 Emergency Power/Generator/UPS
3.10.8.9 Alternative Energy/Energy Recovery Systems
3.10.8.10 Facility Security System
3.10.8.11 Medical Gas Systems
3.10.8.12 Security/CCTV/Access Control/Article Protection Systems

End of Section 01 91 00

REVISION LOG

The following is provided for convenience to the Owner, Architect/Engineer and Contractor to track changes between annual document issuances and is not to be considered by any party to be contractual or 100% complete.

Date	Items Revised
9/1/2007	Original Document
3/11/11	Provided additional language for CxC qualification and duties. Provided Owner approval for proposed candidate for this position
	Further defined role of 3rd party Cx authority (CxA)
	Further defined Cx activities within project schedule and increase notice for testing/demonstration
	Renamed Pre-functional Test – Pre-functional Test *Checklist* and revised C&C documents accordingly
	Further defined Functional Testing and Integrated Testing
	Added Entire Facility Integration Test (EFIT) form to clarify test procedure to demonstrate operational performance of entire facility
12/12/16	Updated Contractor's Cx Coordinator (CxC) required qualifications
	Construction Checklist now replaced Pre-Functional Checklist
	Added requirement for Contractor to employ a Commercial Cx Software solution for managing the Cx Process
	General formatting update