

## SECTION 01 9113 - GENERAL COMMISSIONING REQUIREMENTS

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. The Owner has retained an independent Commissioning Authority (CxA) to coordinate commissioning activities for this project. The objective of the commissioning process is to verify and document that the performance of facilities, systems, and assemblies installed as part of this project meet defined objectives and criteria.
- B. This section outlines the general roles and responsibilities of the CxA, Owner, and General Contractor. Division 21, 22, 23, 25 and 26 sections define roles and responsibilities which are applicable to Division 21, 22, 23, 25 and 26 work.
- C. The CxA is an independent contractor retained directly by the Owner.
- D. Commissioning requires support from the contractors. The Commissioning Process does not relieve any contractors from their obligations to complete all portions of work in a satisfactory manner.
- E. The General Contractor is responsible for coordinating all commissioning activities. In the absence of a General Contractor, the Prime Contractor shall take on this role.

#### 1.2 Related sections

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

#### 1.3 DEFINITIONS

- A. *Acceptance*: A formal action, taken by a person with appropriate authority (which may or may not be contractually defined) to declare that some aspect of the project meets defined requirements, thus permitting subsequent activities to proceed.
- B. *Basis of Design (BOD)*: A document that records the concepts, calculations, decisions, and product selections used to meet the Owner's Project Requirements and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative

descriptions and lists of individual items that support the design process. The BOD typically incorporates the schematic design documents produced early in the design process.

- C. *Checklists*: Project and element-specific checklists that are developed and used during all phases of the Commissioning Process to verify that the Owner's Project Requirements are being achieved. Checklists are used for general Evaluation, testing, training, and other design and construction requirements.
- D. *Commissioning Process or Commissioning (Cx)*: A quality focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements.
- E. *Commissioning Process Activity*: A component of the Commissioning Process.
- F. *Commissioning Authority (CxA)*: An entity identified by the Owner who plans, schedules, and coordinates the commissioning team to implement the Commissioning Process.
- G. *Commissioning Field Report*: A written document that identifies the commissioning activities completed during a visit to the project site. The report identifies significant findings, results, comments and questions that resulted from the visit. This is typically produced by the CxA per site visit.
- H. *Commissioning Photo Log*: A log of photographs that support the items identified in the Contractor Commissioning Issues Log. The photo log numbering corresponds to the issue numbers listed in the contractor Cx issues log.
- I. *Commissioning Plan*: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process.
- J. Commissioning Process Activities (Cx Process Activities): Components of the Commissioning Process
- K. *Commissioning Progress Report (Cx Progress Report)*: A written document that details activities completed as part of the Commissioning Process and significant findings from those activities, and is continuously updated during the course of a project.
- L. *Commissioning Request for Information (RFI)*: Form used by the Commissioning Authority to request information from the design or construction team.
- M. *Commissioning Team (Cx Team)*: The individuals and agencies who, through coordinated actions, are responsible for implementing the Commissioning Process.
- N. *Commissioning Testing (Cx Testing)*: The Evaluation and documentation of the equipment and assemblies delivery and condition, installation, proper function according to the manufacturer's specifications, and project documentation to meet the criteria in the Owner's Project Requirements.
- O. *Construction Team*: The General Contractor, related sub-contractors, and other contractors working for the Owner during the Construction Phase.
- P. *Construction Documents*: This includes a wide range of documents, which will vary from project to project, and with the owner's needs and regulations, laws, and jurisdictional requirements.

Construction documents usually include the project manual (specifications), plans (drawings), and general terms and conditions of the contract.

- Q. *Contract Documents*: This includes a wide range of documents, which will vary from project to project and with the owner's needs, regulations, laws, and jurisdictional requirements. Contract documents frequently include price agreements; construction management process; subcontractor agreements or requirements; requirements and procedures for submittals, changes, and other construction requirements; timeline for completion; and the construction documents.
- R. *Contractor Commissioning Issues Log*: A formal document and ongoing record of problems or concerns identified through the construction phase which deviate from the project's construction documents, applicable codes and/or normal construction industry practices and their resolution. Items on this issues log should be reviewed by the GC and corrected in a timely manner by the applicable trades and contractors.
- S. *Coordination Drawings*: Drawings showing the work of all trades to illustrate that equipment can be installed in the space allocated without compromising equipment function or access for maintenance and replacement. These drawings graphically illustrate and dimension manufacturers' recommended maintenance clearances.
- T. *Current Facility Requirements (CFR)*: A written document that details the current functional requirements of an existing facility and the expectations of how it should be used and operated. This includes goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information to meet the requirements of occupants, users, and owners of the facility.
- U. *Design Checklist*: A form developed by the Commissioning Team to verify that elements of the design are in compliance with the Owner's Project Requirements. Also see checklists.
- V. *Design Review (Peer)*: An independent and objective technical review of the design of the project or a part thereof, conducted at specified stages of design completion by one or more qualified professionals, for the purpose of enhancing the quality of the design.
- W. *Design Review (Constructability)*: The review of effective and timely integration of construction knowledge into the conceptual planning, design, construction, and field operation of a project to achieve project objectives efficiently and accurately at the most cost-effective levels to reduce or prevent errors, delays, and cost overruns
- X. *Design Review (Code or Regulatory)*: A review of a document conducted by staff or designated entity of an authority having jurisdiction to determine whether the content of the document complies with regulations, codes, or other standards administered by the jurisdiction.
- Y. *Design Review (Commissioning)*: A review of the design documents to determine compliance with the Owner's Project Requirements, including coordination between systems and assemblies being commissioned, features and access for testing, commissioning and maintenance, and other reviews required by the OPR and Commissioning Plan.
- Z. *Design Team Commissioning Issues Log*: A formal and ongoing record of issues pertaining to the project construction documents, from the design phase and through the construction phase of the project, which identifies areas of concern with the design regarding to coordination between divisions, constructability, maintenance clearances, operability or other commissioning concerns, and the issue resolution.

- AA. *Evaluation*: The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems and their performance are confirmed with respect to the criteria required in the Owner's Project Requirements.
- BB. *Existing Building Commissioning Process*: A quality focused process for attaining the Current Facility Requirements of an existing facility and its systems and assemblies being commissioned. The process focuses on planning, investigating, implementing, verifying, and documenting that the facility and/or its systems and assemblies are operated and maintained to meet the Current Facility Requirements, with a program to maintain the enhancements for the remaining life of the facility.
- CC. *Facility Guide*: A basic building systems description and operating plan with general procedures and confirmed facility operating conditions, setpoints, schedules, and operating procedures for use by facility operations to properly operate the facility.
- DD. *Final Commissioning Report (Final Cx Report)*: A document that records the activities and results of the Commissioning Process and is developed from the final Commissioning Plan with all of its attached appendices.
- EE. *Functional Performance Test (FPT)*: A written protocol that defines methods, personnel, and expectations, for tests conducted on components, equipment, assemblies, systems, and interfaces among systems.
- FF. *Issues and Resolution Log*: a formal and ongoing record of problems or concerns and their resolutions that have been compiled by members of the Commissioning Team during the course of the Commissioning Process.
- GG. *Ongoing Commissioning Process (Ocx)*: A continuation of the Commissioning Process well into occupancy/operations to continually improve the operation and performance of a facility to meet current and evolving CFR or Owner's Project Requirements. Ongoing Commissioning Process Activities occur throughout the life of the facility; some of these will be close to continuous in implementation, and others will be either scheduled or unscheduled as needed.
- HH. *Owner's Project Requirements (OPR)*: A written document that details the functional requirements of a project and the expectations of how it will be used and operated. This includes project and design goals, measurable performance criteria, budgets, schedules, success criteria, and supporting information. This document also identifies end user requirements and expectations for the operation of critical areas, spaces and systems.
- II. *Performance Test (PT)*: Performance testing is the process of verifying that a material, product, assembly, or system meets defined performance criteria. The methods and conditions under which performance is verified are described in one or more test protocols.
- JJ. *Pre-Functional Checklist (PFC)*: A form used by the contractor to verify that appropriate components are on-site, ready for installation, correctly installed, started up, tested and balanced, in compliance with the owner's project requirements, and is ready for functional performance testing. This documentation is available on the WCxS.
- KK. *Re-commissioning*: An application of the Commissioning Process requirements to a project that has been delivered using the Commissioning Process. (See existing building Commissioning Process.)
- LL. *Retrocommissioning*: The Commissioning Process applied to an existing facility that was not previously commissioned. (See existing building Commissioning Process.)

- MM. *Submittal Review*: A commissioning review of the equipment submittal for relevant mechanical, electrical, plumbing and energy consuming equipment and systems.
- NN. *Systems Manual*: A system-focused composite document that includes the OPR, BOD, design and construction documentation, facility guide and operation manual, maintenance information, approved submittals, training information and materials, Commissioning Process records, and additional information of use to the Owner during the Occupancy and Operation Phase. This is produced for selected projects as additional scope beyond the standard commissioning report.
- OO. *Test Procedure*: A written protocol that defines methods, personnel, and expectations for tests conducted on components, equipment, assemblies, systems, and interfaces among systems to verify compliance with the Owner's Project Requirements.
- PP. *Training Plan*: A written document that details the expectations, schedule, duration and deliverables of Commissioning Process Activities related to training of project operating and maintenance personnel, users, and occupants.
- QQ. *Verification*: The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the Owner's Project Requirements.
- RR. *Web-based Commissioning Software (WCxS)*: The web-based software used to manage the commissioning process including design review, construction review, field observations, checklists and tests.

#### 1.4 ROLES AND RESPONSIBILITIES

##### A. Commissioning Authority (CxA)

1. Develop a Commissioning Plan outlining the organization, schedule, and documentation requirements of the Commissioning Process.
2. Coordinate and direct the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications with the Cx team, and frequently update timelines and schedules for Cx activities.
3. The CxA is not responsible for the design concept, design criteria, compliance with codes, site safety, construction means and methods, review or approval of change orders, design or general construction scheduling, cost estimating, or construction management.
4. Review contract documents for completeness and quality. Document issues in the Design Team Commissioning Issues Log.
5. The CxA may assist with problem solving, non-conformance or deficiencies, but ultimately that responsibility resides with the General Contractor (GC) and the Architect/Engineer (A/E). The primary role of the CxA is to oversee the commissioning process. This includes site observations of installation of commissioned systems and equipment, development and coordination of the execution of a PFC and FPT testing plan and observation and documentation of performance that systems are functioning in accordance with the documented OPR, design intent and in accordance with the Contract Documents. The Contractors will provide all tools and personnel to start and check-out and test equipment and systems, except as noted in this section.
6. Coordinate the commissioning work and work with the GC to incorporate commissioning activities into the master project schedule maintained by the GC.
7. Update and revise the Commissioning Plan as required.

8. Plan and conduct a commissioning scoping meeting and other commissioning meetings with the Cx team. The CxA will record meeting minutes for Cx meetings facilitated by the CxA.
9. Request and review additional information required to perform commissioning tasks, including installation, operations and maintenance (IOM) manuals and materials, contractor start-up and checkout procedures. Document results and incorporate into the commissioning plan.
10. Review Contractor submittals applicable to systems being commissioned, for compliance with the Owner's Project Requirements and for coordination with the Commissioning Process. The CxA review provides information to the Design Team but is not a review for acceptance or rejection of the submitted equipment or system; acceptance or rejection of any submittal remains the responsibility of the Design Team.
11. Conduct periodic construction observations to verify that systems and equipment are installed consistently with Owner's Project Requirements. Document deficiencies on the Web Based Commissioning Software and share it with the Commissioning Team (Note: the Commissioning Authority is responsible for identifying deficiencies but is not responsible for ensuring that deficiencies are corrected).
12. Attend selected planning and job-site meetings to obtain information on construction progress.
13. With necessary assistance and review from installing contractors, write and distribute the pre-functional checklists and functional performance test procedures for systems and equipment.
14. Approve Pre-Functional Checklists completed by GC by reviewing Web Based Commissioning checklist reports and by selected site observation and spot checking to confirm that systems and equipment are ready for Functional Performance Tests.
15. Review start-up and TAB reports to confirm included systems are ready for functional performance testing.
16. Coordinate, witness and document functional performance testing by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved per design specifications. See 3.10 for extent of retesting included in the commissioning scope.
17. Coordinate, witness and document required seasonal or deferred functional performance testing and any deficiency corrections required.
18. Review equipment warranties and confirm that they are project specific and clearly define the Owner's responsibilities if any.
19. Oversee and review the training of the Owner's operating personnel.
20. Review O&M manuals submitted by the GC.
21. Provide a final commissioning report for review and acceptance by Owner.
22. The CxA is not responsible for construction means and methods or for site safety and security.
23. The CxA will not authorize or approve construction cost amendments, changes to the construction schedule, or changes to the contract documents.

B. General Contractor (GC) and Sub-Contractors

1. Include the cost of commissioning in the total contract price.
2. The GC is responsible for coordinating all commissioning activities of the sub-contractors. Commissioning activities may be completed by the Mechanical Contractor (MC), Electrical Contractor (EC), Controls Contractor (CC), or Test and Balance (TAB) contractor, but the GC is ultimately responsible for completion of all of these tasks.
3. Facilitate the coordination of the commissioning work by the CxA and incorporate commissioning activities into the master schedule.
4. Furnish a copy of all construction documents, addenda, change orders, Requests for Information (RFIs), approved submittals, shop drawings, and IOMs, related to commissioned systems and equipment to the CxA.

5. In each purchase order or subcontract written, include requirements for commissioning.
6. Ensure that all sub-contractor's execute their commissioning responsibilities according to the Contract Documents and schedule.
7. The GC shall designate a staff member who will be knowledgeable and responsible for the construction of the commissioned systems (typically the MEP superintendent) to be their active representative on the commissioning team. This person shall attend the commissioning scoping meeting and other necessary meetings scheduled by the CxA to facilitate the commissioning process.
8. The sub-contractors shall designate a staff member who will be knowledgeable and responsible for the construction of the commissioned systems (typically the trade superintendent) to be their active representative on the commissioning team. This person shall attend the commissioning scoping meeting and other necessary meetings scheduled by the CxA to facilitate the commissioning process.
9. Coordinate and share the issues identified on the WCxS Cx Issues Log with the appropriate trade sub-contractors. Respond on the Web Based Commissioning Software in writing to the CxA with the contractor's response, appropriate trade responsible for the corrective action and anticipated completion date for the corrective action.
10. Follow up with the subcontractors as to the status of the corrective actions to the items on the Web Based Commissioning Software Issues Log, and update the CxA.
11. The GC's designated Cx team staff member shall personally examine, witness and verify that all issues are corrected and complete when the sub-contractor states they have "corrected" an item on the Web Based Commissioning Software Issues Log.
12. After the GC has verified issues are resolved, they shall indicate so on the Web Based Commissioning Software the CxA accordingly.
13. Notify the CxA one week in advance of all equipment start-ups and tests required by the Contract Documents.
14. Submit test results for tests required by the Contract Documents, including (but not limited to) duct leakage tests, hydronic system pressure tests, plumbing system disinfection certification, generator tests, smoke evacuation system tests, fire pump tests, fire alarm tests, etc. as applicable to the commissioning scope.
15. Receive the Pre-Functional Checklists from the CxA. Create a "master" pre-functional document binder containing all checklists for the project.
16. Coordinate and distribute "copies" of the Pre-Functional Checklists to all relevant subcontractors.
17. Oversee the sub-contractors performance of pre-functional checks, followed by initialing and signing the "master" checklists maintained by the GC.
18. Notify the CxA when Pre-Functional Checklists are completed.
19. Remedy any deficiencies identified in the Pre-Functional Checklists and notify the Commissioning Authority (in writing) that deficiencies have been addressed.
20. Notify the CxA when TAB activities will be taking place and have been completed. Provide CxA with TAB report(s).
21. Participate in TAB verification, which may include repeating selected measurements contained in the TAB report(s).
22. Coordinate with subcontractors to ensure qualified technicians are available for performing the functional performance test procedures under direction of the CxA.
23. Coordinate the training of Owner personnel.
24. Verify that subcontractors prepare and submit O&M manuals, according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
25. Ensure that subcontractors execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.

26. Ensure that subcontractors correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
27. Gather and submit all project closeout documentation, including submittals, O&M manuals, as-built drawings, warranties, etc. to CxA for approval.

C. Owner

1. Manage the contract of the A/E and of the GC.
2. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions according to the Commissioning (Cx) Plan.
3. Provide final approval for the completion of the commissioning work.
4. Coordinate site visits and meetings with the Commissioning Authority (CxA).
5. Review and comment on commissioning documentation such as the Cx plan, field reports, and issue logs.
6. Provide interpretations and clarifications of the Owner's Project Requirements.
7. Provide input and direction on commissioning-related recommendations that arise from the commissioning process which may enhance the operation of the building but are not included in the project documents and may be an additional project cost. If the Owner is in agreement with commissioning recommendations, they are to direct the Design Team to review and issue the appropriate directive to add that scope and maintain the Design Team's responsibility for all construction documents.

D. Design Team (Architect/Engineer)

1. Perform normal submittal review, construction observation, as-built drawing preparation, O&M manual preparation, etc., as contracted with Owner.
2. Fulfill all obligations specified in the contract documents, including reviewing and approving submittals, conducting construction observation, issuing addenda and clarifications, responding to RFIs, issuing punchlists, and conducting substantial and final completion walkthroughs. Review and provide comments on all recommendations.
3. Provide any design narrative documentation requested by the CxA.
4. Prepare and submit final as-built design intent documentation for inclusion in the Systems Manual.
5. Review and approve the O&M manuals.
6. Coordinate resolution of design non-conformance and design deficiencies identified during the project.
7. Assist (along with the contractors) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
8. Participate in the resolution of system deficiencies identified during commissioning.
9. Notify the CxA of substantive changes to the Contract Documents.
10. Provide clarifications to Contract Documents as required.
11. Review the Design Team Commissioning Issues Log and respond to all items in a timely manner. Update contract documents as required to address commissioning items identified.
12. Review commissioning suggestions identified on the Design Team Commissioning Issues Log for impact to the design intent. If the design team is in agreement with the suggestion, they are to assist in reviewing the suggestion with the owner for their review and decision if it should be added to the project.
13. The design team shall review all shop drawing and submittal comments from the CxA



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 25 0800 for Integrated Automation commissioning requirements.
- E. Refer to Section 26 0800 for listing of Electrical Systems to be commissioned and requirements.

1.6 Commissioning Documentation

A. General

- 1. Timely and accurate documentation of commissioning activities is essential for the commissioning process to be effective. To this end, all commissioning activities conducted by the contractors shall be documented as outlined below and in Part 3 Execution of this specification.
- 2. Contractor commissioning responsibilities on WCxS include the following items:
  - a. Construction Issues
  - b. Pre-Functional Checklists
  - c. Functional Performance Tests
- 3. The Architect, Engineers, GC, subcontractors, and owner will be responsible for responding on the WCxS within five business days of an inquiry being assigned to them.
  - a. The owner(s) or their designated responsible party will be one of the final designated personnel in the approval process that will sign off before an item can be closed out.
  - b. All of the aforementioned entities will be responsible for the same response time in the identified field punch software.
  - c. The punch list and open commissioning items will be tied to identified retention dollars that will not be paid until all open issues are resolved.
  - d. CxAlloy will be the designated software that will be used by all Cx agents and used for MEP items identified by the Cx agent and NU staff.
- 4. The pre-functional checklists shall be completed by each respective trade contractor involved with the installation of any commissioned systems and equipment.
- 5. The functional performance tests will be completed by the CxA as they witness the test conducted by the contractors.
- 6. All Contractor Commissioning Documents prepared by the contractors will be fully completed in a neat and workmanlike manner so as to be fully legible. Documentation which, at the CxA's discretion, is incomplete or less than fully legible shall be deemed unacceptable.
- 7. Commissioning procedures and tests, which are rejected by the CxA due to incomplete, or illegible contractor documentation shall be repeated by the contractor and new Contractor Commissioning Documents shall be prepared to the Commissioning Team's satisfaction at no additional cost to the Owner.

8. Procedures deemed unacceptable by the Commissioning Team after being repeated due to inadequate documentation may be subject to completion by the CxA, at a cost to the contactor as outlined in item Section 3.10 "Cost of Re-Evaluation" below.
9. All Contractor Commissioning Documents shall be completed on the job-site concurrent with the activities being documented. Remedial documentation of commissioning activities either off-site or after the procedures have been completed is unacceptable.
10. All Contractor Commissioning Documents will be submitted to the CxA for review and acceptance upon completion.

B. Contractor Commissioning Process Status Tracking

1. Contractors shall be responsible for monitoring the progress of their commissioning activities. The contractor will update the status of issues, checklists and tests on WCxS.
2. The CxA will assist the contractor in using WCxS.
3. The contractors shall regularly update WCxS and upload drawings or pictures as commissioning activities are completed so as to provide a readily available report to CxA regarding current status of the contractors commissioning activities.
4. Example screenshots from the WCxS are included as Appendix A to this specification. These samples are provided for reference only to assist contractors in preparing their bids for this project. The actual forms used on this project will be similar in scope and format to the sample forms, but the specific content will differ somewhat from the sample forms to specifically reference the requirements of this project.

C. Record Drawings

1. Contractors shall regularly update a 'redlined' set of record drawings showing commissioned systems as work is being installed so that the drawings remain current with the field work, and as required in Division 01, 21, 22, 23, 25 and 26 of the project specifications.
2. Redlining record drawings at the end of construction shall not be acceptable
3. The Contractors up-to-date, in-progress redlines shall be kept on-site in the Contractor's field office and available for review by the Cx Team.

D. Access to Contractor Documentation

1. Contractors shall provide the CxA with access to shop drawings, coordination drawings, equipment cut-sheets, schematics, in-progress record drawings, manufacturers installation-operation-maintenance manuals, startup reports, etc. to assist the CxA in execution of the Cx process.

1.7 COORDINATION

- A. The CxA shall receive a copy of all construction documents, addenda, change orders, and appropriate approved submittals and shop drawings directly from the GC.
- B. The CxA shall disseminate written information and documents to all responsible parties relative to the nature and extent of the Cx communication.
- C. The CxA is primarily responsible to the Owner and, as such, shall regularly apprise the GC and the Owner of progress, pending problems and/or disputes, and shall provide regular status reports on progress with each system. Any potential change in the contractual and/or financial obligations of the owner (credits, change orders, schedule changes, etc.) shall be identified and quantified as soon as possible.

- D. The CxA shall coordinate the schedule of commissioning activities with the construction schedule. It is possible that some procedures will be completed before the entire system is completed.

## 1.8 SCHEDULE

- A. Commissioning of systems shall proceed per the criteria established in the specific sections that follow, with activities to be performed on a timely basis. The CxA shall be available to respond promptly to avoid construction delays.
- B. Start-up and testing of systems may proceed prior to final completion of systems to expedite progress. However, testing and checkout services that are the primary responsibility of the contractor / vendor will not proceed in advance of their testing and checkout.
- C. Problems observed shall be addressed immediately, responsible parties notified, and actions to correct deficiencies coordinated in a timely manner.
- D. Contractor schedules and scheduling is the responsibility of the GC. The CxA shall provide commissioning scheduling information to the GC for review and planning activities.
- E. The Contractor is to complete the Work in a sequence that allows for systemic and holistic functional testing rather than piecemeal testing. This includes HVAC, BAS and SCADA integration.

## 1.9 Reference Standards

- A. Industry standards and guidelines are a guide to the commissioning process and are hereby incorporated and will be applied as appropriate. Reference standards and guidelines include, but are not limited, to the following:
- B. References:
  - 1. ASHRAE Standard 202-2013: Commissioning Process for Buildings and Systems
  - 2. ASHRAE Guideline 0-2005: The Commissioning Process
  - 3. ASHRAE Guideline 1.1-2007: HVAC&R Technical Requirements for The Commissioning Process

## 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 that 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 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 three (3) 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, 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 and through the post occupancy phase commissioning activities and warranty period of the project to support the Cx process. The duration of this support is typically one year after turn over to the owner, to provide time to complete deferred and seasonal testing and the warranty phase activities.

### PART 3 - EXECUTION

#### 3.1 COMMISSIONING PLAN AND SCHEDULE

- A. The CxA shall generate a commissioning plan which identifies Cx tasks, roles and responsibilities for the Cx process. The CxA will submit a Cx schedule for the commissioning process which shall be integrated into the construction schedule by the GC.

#### 3.2 CONSTRUCTION OBSERVATION

- A. This is an additional and separate activity from that provided by the design team. Construction observation is required as part of the commissioning and coordination process to be provided by the CxA. Field Observation reports will be distributed through the WCxS.

### 3.3 Commissioning Issues Logs

A. As part of the commissioning process, all issues will be recorded on the WCxS. The WCxS will divide the issues as follows.

#### 1. Design Commissioning Issues

a. This log is part of the Web-Based Commissioning Software. This log is a formal and ongoing record of issues pertaining to the project construction documents which identifies areas of concern with the design regarding to coordination between divisions, constructability, maintenance clearances, operability or other commissioning concerns. This log specifically separates design issues from contractor issues. The contractor has no responsibility to track or comment on the design team Cx log.

#### 2. Construction Commissioning Issues

a. This log is also a part of the Web-Based Commissioning Software. It is a formal and ongoing record of problems or concerns pertaining to the installation of the commissioned systems and equipment which identifies where the contractors have deviated from the OPR, contract documents, applicable codes or normal industry construction practices. It is the GC's responsibility to regularly login and retrieve this log from the Web-Based Commissioning Software, follow up and review each item on the list with the appropriate trades, and respond to the CxA with feedback within 5 business days from the issuance of the log from the CxA.

b. Team members will be given access through the WCxS to comment on issues. This is where the GC should provide feedback which includes the following sections:

- 1) Response/Action: This is the contractor's response to the issue identified by the CxA.
- 2) Trade: This identifies the specific contractor responsible for the correction of the issue. The issue will be assigned to that contractor or subcontractor.
- 3) Expected Completion Date: This is the date which the GC and subcontractor agree the issue will be resolved by. This provides information back to the CxA as to when items should be corrected by for spot checking the correction of issues.

c. The GC shall provide feedback and updates to the construction Cx issues log to the CxA within 5 business days from its issuance from the CxA.

d. The CxA will maintain the master cx long on the WCxS.

e. A sample of the construction Cx issues log is included in Appendix B.

### 3.4 Pre-functional checklists

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 start-up per manufacturer's guidelines.
- 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.
- 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. A sample PFC is included in Appendix C. This sample form is provided for reference only to assist contractors in preparing their bids for this project. The actual forms used on this project will be similar in scope and format to the sample form, but the specific content will differ from the sample form to specifically reference the equipment and requirements of this project.
- I. The PFC used for this project will be finalized by the CxA after receipt of equipment Installation, Operation & Maintenance (IOM) Manuals from the Contractors.
- J. PFCs shall be completed by the contractor and maintained on-site per the requirements of this specification, Section 1.6 "Commissioning Documentation".
- 3.5 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 shall be documented using the contractors or manufacturer's standard forms and an electronic copy of the form shall be posted to the WCxS under the appropriate PFC.
- 3.6 Testing and balancing
- A. Testing, Adjusting, and Balance Contractor (TAB) Requirements
    - 1. Air and water balance shall be accomplished by an independent test and balance firm. The test and balance firm shall come back after the final balancing report is approved to work

- with the CxA and spot check this work to verify accuracy of results. Refer to Division 23 for acceptance criteria.
2. Test and balance contractor to provide final balancing report to CxA.
  3. The TAB contractor shall be responsible for successful completion and documentation of all TAB activities specified in the Division 23.
  4. Prior to the start of TAB activities, the TAB contractor shall submit a proposed TAB plan, procedures and documentation to the CxA and A/E for review. TAB procedures shall be submitted to allow sufficient time for CxA review and approval prior to the start of TAB activities.
  5. After this review, and prior to start of field work, the TAB contractor will attend one or more planning meetings as required with the Commissioning Team to review and discuss outstanding issues relating to TAB procedures and forms, discuss resolution of issues identified during the TAB contractor's plan review and field inspections, and to coordinate field work.
  6. Prior to the start of fieldwork, the TAB contractor shall issue a final set of TAB procedures and TAB forms which incorporate any comments received during the Commissioning Team review.
  7. The TAB contractor shall have at least one certified field technician on site whenever TAB work is being performed.
  8. The TAB contractor is responsible to notify the GC who in turn shall notify the Commissioning Team a minimum of two (2) weeks in advance of the time for start of TAB work to allow the CxA and A/E time to assess system readiness.
  9. The TAB contractor will work cooperatively with the CxA.
  10. The TAB contractor shall coordinate with the controls contractor to ensure that changes made to the control system during TAB (flow coefficients, duct areas, etc.) are archived and become the default or initial values for these parameters.
  11. The TAB contractor shall provide daily lists of issues and/or problems identified during TAB work to the GC, CxA and A/E for follow-up & resolution with the appropriate contractors.
  12. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the CxA for verification or diagnostic purposes.
  13. A TAB Final Acceptance Inspection shall be conducted by the A/E and CxA and will include a field verification of up to 5% of the TAB contractor's field readings.
  14. The TAB contractor will provide technicians and instrumentation to support the field verification.
  15. Instruments used for the field verification shall be the same instruments (by model and serial number) that were used for the original TAB work.
  16. Failure of an item during the TAB field verification is defined as:
    - a. For all readings other than sound, a deviation of more than 10 percent.
    - b. For sound pressure readings, a deviation of 3 decibels. (Note: variations in background noise will be considered).
  17. A failure of more than 10 percent or 10 (whichever is greater) of the readings tested during the field verification shall result in the rejection of the final TAB report and require re-balancing of the system(s) in question.

### 3.7 Controls & Instrumentation Testing

- A. Prior to start of control system Functional Performance Procedures, 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 checklists 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 section of the Division 25 specifications.
  - a. These procedures will verify the following for each physical control point:
    - b. Field device is installed per the manufacturer's recommendations and the project drawings and specifications
    - c. Field verify calibration of all analog inputs and outputs
    - d. Verify labeling of controllers, field devices, and wiring
    - e. 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 approval 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.

### 3.8 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. Equipment-level FPTs will be used to verify operation and capacity of selected equipment such as boilers, chillers cooling towers, pumps, exhaust fans, air handling units, etc.
  3. System-level FPTs will verify the following aspects of system operation
    - 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. A sample FPT is included at the end of this specification as Appendix D. These sample forms are provided for reference only to assist contractors in preparing their bids for this project. The actual procedures and forms used for this project will be similar in scope and format to the samples, but the specific content will differ somewhat to specifically address the requirements of this project.
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.)
  - g. Confirmation of required alarms sent to BAS
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 except for special-purpose or proprietary tools, test equipment and instrumentation which will be provided by the contractors. All instruments shall meet the requirements of Part 2 of this specification.
10. 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.

### 3.9 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.

### 3.10 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.

3.11 OPERATING AND MAINTENANCE (O&M) MANUALS

- A. The CxA shall review the draft form of the O&M manuals provided by the Division 21, 22, 23, 25, and 26 contractors. The review process shall verify that O&M instructions 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.

Published literature shall be specifically oriented to the provided equipment indicating required operation and maintenance procedures, parts lists, assembly/disassembly diagrams, and related information.

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 Commissioning Authority shall review and edit these documents as necessary for final corrections by the contractor.

- B. 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.
- C. In addition to the O&M manual requirements within specification Division 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 warranty's
    - 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.

3.12 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 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 approval, 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 approval 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 approval 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 approval 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 approval by the Owner.

3.13 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.

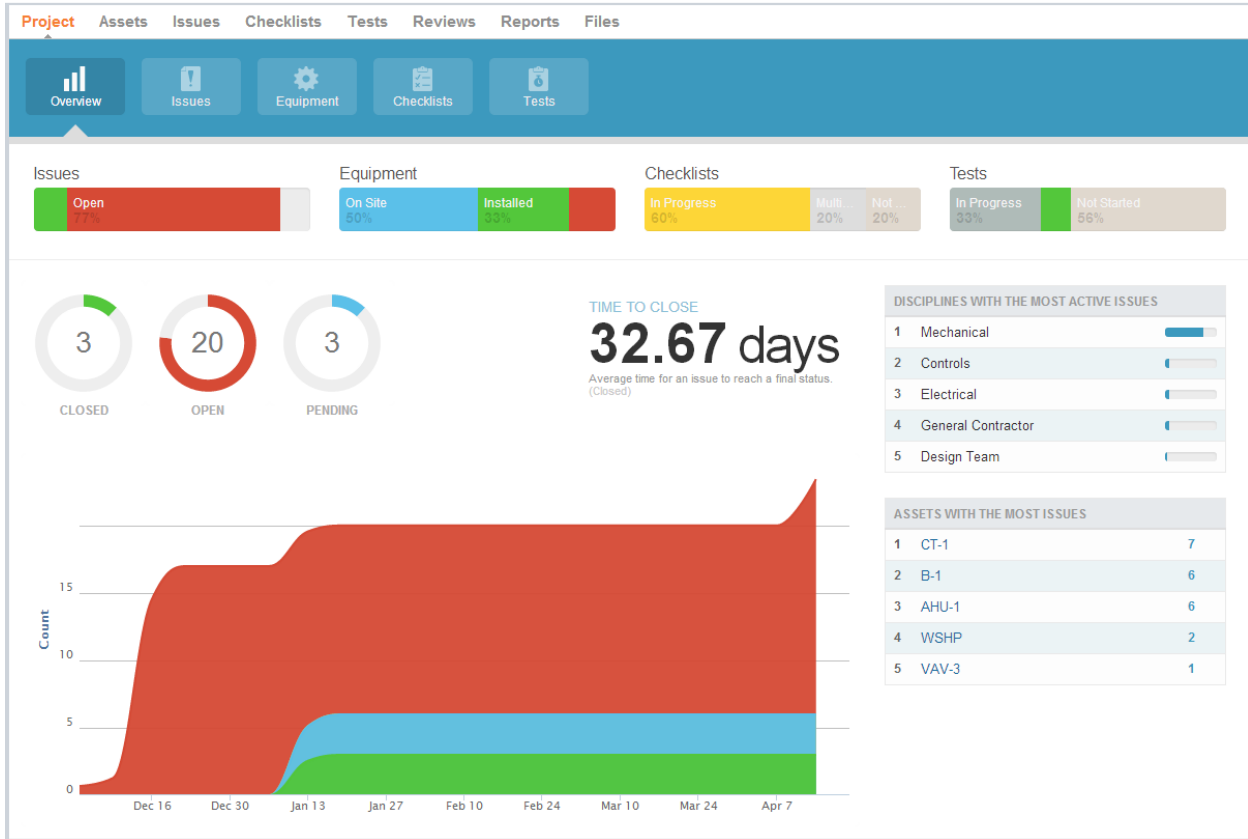
3.14 EXCLUSIONS

- 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**

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APPENDIX A – EXAMPLE WCxS (CxAlloy) COMMISSIONING STATUS DASHBOARD









APPENDIX B – EXAMPLE CONTRACTOR COMMISSIONING ISSUES LOG

Construction Issues | Grumman/Butkus Associates |

| 12231

**TST-59-4** OPEN MODERATE

temperature offset knob position (+/- 3) not shown on graphics (typ for all)  
nor does it show the effective room temp setpoint

Assigned To Johnson Controls  
Asset  VAV-88 (D)  
 VAV Box (D)  
 ICU PATIENT ROOM-  
 ISOLATION 473  
Due Date 4/11/2014  
Identified On 3/28/2014 1:34 PM



**TST-63-2** OPEN MODERATE

S-40 supply duct access panel for FD 5-5 located above Pent 11 doorway  
is quite leaky under pressure

Assigned To Mechanical, Inc.  
Asset  S-40  
 Air Handling Unit  
 Mech. Penthouse 11  
Due Date 4/11/2014  
Identified On 3/28/2014 1:26 PM

recommend adding cam locks to all sides rather than having them just on two sides  
Kevin Vander Klay on 03/28/2014 at 01:26 PM





**TST-60-4** OPEN MODERATE

HHW system graphics should be changed as follows:  
-show hx isolation valves as manual, not automated  
-show individual hx entering and leaving temps  
-show hws temp setpoint value  
-show outdoor temp and humidity

Assigned To Johnson Controls  
Asset Heating Hot Water  
Due Date 4/11/2014  
Identified On 3/28/2014 1:02 PM

**TST-93-1** OPEN MODERATE

SUH-5 control valve is open when temp is above setpoint

Assigned To Johnson Controls  
Asset SUH-5  
Unit Heater  
Mech. Penthouse 12  
Due Date 4/11/2014  
Identified On 3/28/2014 10:52 AM

**TST-92-1** OPEN MODERATE

SUH-4 control valve is open when space temp is above setpoint

Assigned To Johnson Controls  
Asset SUH-4  
Unit Heater  
Mech. Penthouse 12  
Due Date 4/11/2014  
Identified On 3/28/2014 10:35 AM



NORTHWESTERN UNIVERSITY  
PROJECT NAME \_\_\_\_\_  
JOB # \_\_\_\_\_

FOR: \_\_\_\_\_  
ISSUED: 11/05/2018

NORTHWESTERN UNIVERSITY  
PROJECT NAME \_\_\_\_\_  
JOB # \_\_\_\_\_

FOR: \_\_\_\_\_  
ISSUED: 11/05/2018

APPENDIX C - PRE-FUNCTIONAL CHECKLIST

The following is a sample Pre-Functional Checklist. PFC's for other equipment will be similar and follow the same rigor for checkout by all relevant contractors.

## Checklist AHU-1 System

Grumman/Butkus Associates |



NOT STARTED

Type Pre-Functional  
Asset AHU-1

### Sections 3

General NOT STARTED Mechanical Contractor

Status set by Kevin Vander Klay on 3/10/2014.

- 1 All supply and return terminal boxes as well as reheat coils installed and operational
- 2 Adequate maintenance access space allowed for terminal box and controller replacement
- 3 Construction filters have been replaced by clean filters at fan powered boxes
- 4 Piping pressure tests completed and successful
- 5 Duct leakage tests completed and successful

Controls NOT STARTED Controls Contractor

Status set by Kevin Vander Klay on 3/10/2014.

- 1 All DDC I/O points wired, programmed, generated in graphics and integrated at the front end computer
- 2 DDC network communications completed and operational
- 3 All schedules coordinated with the Owner and programmed
- 4 All trends installed and running per design requirements
- 5 Controls sequence of operation implemented and tested
- 6 Point-to-point checks (including graphics) have been completed and documentation record submitted for this system

Installation and Startup NOT STARTED Mechanical Contractor

Status set by Kevin Vander Klay on 3/10/2014.

### TEST AND BALANCE

- 2 Test and balance (air and heating hot water) completed including report

### INSTALLATION CHECKLISTS

- 4 Permanent labels affixed to all equipment, piping, ductwork, sensors, control dampers, control valves, control panels, switches and safety devices

### START-UP PROCEDURES AND CHECKLISTS

- 6 Start-up of room pressurization monitors completed by controller manufacturer's representative
- 7 All dampers stroke fully open, fully closed, and are calibrated
- 8 All zone combination fire / smoke dampers tested and verified point to point with FACP



NORTHWESTERN UNIVERSITY  
PROJECT NAME \_\_\_\_\_  
JOB # \_\_\_\_\_

FOR: \_\_\_\_\_  
ISSUED: 11/05/2018

#### APPENDIX D - FUNCTIONAL PERFORMANCE TEST

The following is a sample Functional Performance Test. FPT's for other systems and equipment will be similar and follow the same rigor. These tests will be conducted by the contractors and witnessed by the CxA.

# Test S-40

Grumman/Butkus Associates |

| 12231



IN PROGRESS

Asset S-40

- Air Handling Unit
- Mech. Penthouse 11

## Attempts Most Recent

Attempt No. 1 IN PROGRESS Status set by Fiona Martin on 3/20/2014.

### PREREQUISITE ITEMS

- Yes 2 Temperature control is complete. All associated devices are installed and calibrated. Control set points, alarms and schedules have been adjusted.
- Yes 3 TAB is complete. Test and balance report approved indicating that system meets design intent.
- Yes 4 All trades have completed Pre-functional Checklists.

### RECORD THE FOLLOWING BAS POINTS DISPLAYED ON THE FRONT END COMPUTER.

- Yes 6 Global OA temp (AI)  
*added during testing*
- Yes 7 Global OA humidity (AI)
- Yes 8 Return air temp (AI)
- Yes 9 Return air humidity (AI)
- Yes 10 Return fan 1 status (DI)
- Yes 11 Return fan 2 status (DI)
- Yes 12 Return fan 3 status (DI)
- Yes 13 Return fan 4 status (DI)
- Yes 14 Return fan 5 status (DI)
- Yes 15 Return fan 6 status (DI)
- Yes 16 Return fan 1-6 VFD Alarm (DI)
- Yes 17 Return fan VFD command (AO)
- Yes 18 Return fan VFD start/stop (DO)
- Yes 19 Return airflow (AI)
- N/A 20 Relief damper position (AI)
- Yes 21 Relief damper command (AO)
- N/A 22 Return air damper position (AI)
- Yes 23 Return air damper command (AO)
- Yes 24 Min OA damper command (DO)
- Yes 25 Max OA damper command (AO)
- N/A 26 Outside air position (AI)



NORTHWESTERN UNIVERSITY  
PROJECT NAME \_\_\_\_\_  
JOB # \_\_\_\_\_

FOR: \_\_\_\_\_  
ISSUED: 11/05/2018



Test S-40 | Grumman/Butkus Associates |

| 12231

N/A	27	Min OA airflow (AI)
Yes	28	Mixed air temp (AI)
Yes	29	Pre-filter status (DI)
Yes	30	Preheat coil valve command (AO)
N/A	31	Preheat coil valve position (AI)
Yes	32	Preheat coil pump status (DI)
Yes	33	Preheat coil pump start/stop (DO)
Yes	34	Preheat coil water alarm (DI)
Yes	35	Steam isolation valve open/close (DO)
Yes	36	Humidifier valve command (AO)
Yes	37	Preheat coil air temp (AI)
Yes	38	Cooling coil valve command (AO) <i>Cooling enable point on graphic was not working properly, fixed during testing</i>
N/A	39	Cooling coil valve position (AI)
N/A	40	Cooling coil water alarm (DI)
Yes	41	Supply fan 1 status (DI)
Yes	42	Supply fan 2 status (DI)
Yes	43	Supply fan 3 status (DI)
Yes	44	Supply fan 4 status (DI)
Yes	45	Supply fan 5 status (DI)
Yes	46	Supply fan 6 status (DI)
Yes	47	Supply fan 7 status (DI)
Yes	48	Supply fan 8 status (DI)
Yes	49	Supply fan 9 status (DI)
Yes	50	Supply fan 1-9 VFD Alarm (DI)
Yes	51	Supply fan VFD command (AO)
Yes	52	Supply fan VFD start/stop (DO)
Yes	53	Supply airflow (AI)
Yes	54	Final filter status (DI)
Yes	55	Discharge static pressure 1 (AI)
Yes	56	Discharge humidity (AI)
Yes	57	Discharge temp (AI)
Yes	58	Discharge duct humidity switch (DI)
<b>CALIBRATION OF SENSORS</b>		
Yes	60	MAT (AI) <i>BAS says 60.6F - JCI lowered by 2.5F to match preheat temp</i>
Yes	61	Preheat temp (AI) <i>Act 58F, BAS 60.1, JCI lowered by 2F</i>



NORTHWESTERN UNIVERSITY  
PROJECT NAME \_\_\_\_\_  
JOB # \_\_\_\_\_

FOR: \_\_\_\_\_  
ISSUED: 11/05/2018

Test S-40 | Grumman/Butkus Associates | | 12231

Yes	62	Discharge air temp (AI) <i>Act 59.8 BAS 59.4</i>
Yes	63	Discharge air humidity (AI) <i>Act 31.5%, BAS 28.9%</i>
Yes	64	Supply fan CFM (AI) <i>28150</i>
Yes	65	Supply fan CFM measured <i>28020</i>
Yes	66	Return fan CFM (AI) <i>20977</i>
Yes	67	Return fan CFM measured <i>21050</i>
Yes	68	Supply to Return CFM offset for final balance <i>5875</i>
Yes	69	OA minimum cfm <i>25% of 25800 = 6500</i>
Yes	70	OA CFM measured, record mixed air damper position <i>8416 cfm</i>
Yes	71	Return air temp (AI) <i>Act 74.3F, BAS 75.2F, - JCI dropped temp 0.5F</i>
Yes	72	Return air humidity (AI) <i>BAS 17.6%, Act 20%</i>

**AHU SHUTDOWN**

Yes	74	Turn AHU OFF at the BMS or local switch and verify by visual inspection that:
Yes	75	Supply fans are off
Yes	76	Return fans are off
N/A	77	Interlocked exhaust fan is de-energized
Yes	78	Outdoor damper is fully closed
Yes	79	Min outdoor air damper is fully closed
Yes	80	Exhaust air damper is fully closed
Yes	81	Return air damper is open
Yes	82	Pre-heating coil remains under control of its input sensor
Yes	83	Isolation steam valve is closed
N/A	84	All smoke and combination fire/smoke dampers are closed
N/A	85	Cooling coil valves are closed

**OCCUPIED MODE**

Yes	87	Place AHU in occupied mode at BMS or local switch and verify by visual inspection that:
N/A	88	Smoke and fire/smoke dampers open
Yes	89	The minimum outdoor air damper opens
Yes	90	Supply fans ramp up after 30 second delay
Yes	91	Return fan ramps up after supply fan has started

Test | Printed on 04/07/2014 | Page 3 of 8



Test S-40 | Grumman/Butkus Associates | | 12231

N/A	92	Interlocked exhaust fan energizes
N/A	93	If in cooling mode, the chilled water coils maintain the design discharge air setpoint [55]°F
Yes	94	The minimum OA damper maintains minimum outdoor airflow (9,000 cfm)
Yes	95	Humidifiers maintain [40]% return air relative humidity

**HOT WATER PUMP SEQUENCING**

Yes	97	Recirculation pump is to run continuously when unit is in heating mode. Record what defines heating mode.
Yes	98	If unit is in heating mode, override command point to not be in heating mode, otherwise verify by visual inspection that the hot water pump is not indexed to run.
Yes	99	Place unit in heating mode, verify recirculation pump is indexed to run.
Yes	100	Command the HW valve to close and verify that the recirculation pump continues running. Make sure there isn't a delay that is keeping the pump running.
Yes	101	Turn pump OFF at local disconnect, verify alarm at BAS after 2 min. delay.
Yes	102	Release all overrides

**DISCHARGE AIR TEMPERATURE CONTROL**

N/A	104	With the system in operation, in COOLING mode, override the discharge air setpoint to [57]°F and verify: <i>Too cold, still in economizer</i>
N/A	105	Chilled water valve modulates to maintain the cooling coil air temp at 53 F. <i>Controlled to DAT sensor, not cooling coil leaving temp. Response should be quick enough.</i>
N/A	106	Override the discharge air setpoint to [53]°F and verify:
N/A	107	Chilled water valve modulates towards open and maintains cooling coil air temp at 49 F.
N/A	108	Reset the discharge air setpoint back to the design [55]°F (adj.)
N/A	109	Release all overrides
N/A	110	Review trends to see that the discharge air temperature tracks closely with the discharge air temperature setpoint.

**SUPPLY AIR TEMPERATURE RESET**

Yes	112	Record current discharge air temp (DAT) setpoint <i>57.4 with OAT at 30.7</i>
Yes	113	Set up trending of the DAT setpoint to [10] min. increments
Yes	114	Override the OA temp to less than 0F and verify the supply setpoint is 60 F
Yes	115	Override the OA temp to above 60 F and verify the supply setpoint is 55 F
Yes	116	Override the OA temp to 30F and verify the supply setpoint is 57.5 F
Yes	117	Release all overrides

**SUPPLY FAN AIRFLOW CONTROL**

Yes	119	Record the supply static setpoint (___"w.g.) <i>1.85"</i>
Yes	120	Override the supply static setpoint to .2" w.g. above design and verify AHU supply fan ramps up to satisfy setpoint without overshooting
Yes	121	Override the supply static setpoint to .2" w.g. below design and verify AHU supply fan ramps down to satisfy setpoint without overshooting
Yes	122	Release all overrides

