SECTION 23 08 00

PART 1 - MECHANICAL, ELECTRICAL AND PLUMBING SYSTEMS COMMISSIONING

PART 2 - GENERAL

2.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

2.2 DEFINITIONS

A. Architect/Engineer: The prime consultant (Architect) and sub-consultants who comprise the design team, including the mechanical, electrical and plumbing engineering and the lighting designer.

B. CxA: Commissioning Authority: An independent party, not otherwise associated with the CMGC or the Trade Subcontractors. The Commissioning Authority directs and coordinates the day-to-day commissioning activities in concert with the CMGC.

C. Commissioning Plan: An overall plan, developed before or after bidding, that provides the structure, schedule and coordination planning for the commissioning process. The commissioning plan includes details of the commissioning scope; systems to be commissioned; rigor of commissioning; team contact information; roles and responsibilities of all players; communication and reporting protocols; commissioning process overview as well as details of submittal activities; construction observation, construction checklisting and start-up activities; the process for dealing with deficiencies; test procedure development and execution; O&M manual review and training issues; warranty period activities; description of summary report, description of progress and reporting logs and initial schedule including phasing, if applicable. The Commissioning Authority updates the plan as construction progresses.

D. Contract Documents: The documents binding on parties involved in the construction of this Project (Drawings, Specifications, Change Orders, Addenda, Contracts, Requests for Information).

E. CMGC: The Construction Manager/General Contractor or authorized representative.

F. Facilities Monitoring and Control System (FMCS): The central building energy management control system. Also referred to as the BAS (Building Automation System) or DDC (Direct Digital Controls).
G. Construction Checklist: A list of items to include in the installation, start-up and initial checkout of a piece of equipment or assembly. Construction checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels, labels affixed, gauges in place, sensors calibrated, etc.). Some construction checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). Construction checklists augment and are combined with the manufacturer’s start-up checklist. An example is provided as supplement to this Section.

H. Datalogging: Monitoring flows, currents, status, pressures, etc., of equipment using stand-alone dataloggers separate from the control system.

I. Deferred Tests: tests that are performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow the test from being performed.

J. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents (that is, does not perform properly or is not complying with the design intent).

K. Design Basis: The basis and assumptions for calculations, decisions, schemes and product selections to meet the Owner’s Project requirements and objectives and to satisfy applicable regulatory requirements, standards and guidelines.

L. Design Narrative: A narrative submitted with each design submittal describing the concepts and features in the Drawings. The Design Narrative is written by the designer and is updated and increases in detail with each phase of the design. Initially, it may describe general building and space use and later should include detailed space usage and system and assembly descriptions.

M. Documenting Tests: The recording of what actions were taken to perform each individual test procedure, along with the results or system response of the procedure, with any deficiencies noted.

N. Functional Test Procedures (FTP): The written procedures and documentation forms of tests used to guide and record testing. For mechanical systems, FTPs are composed of repeatable, step-by-step procedures and include the test prerequisites, the test process, the expected outcomes and acceptance criteria. Forms or space for recording the results of tests may be included integrally in the written procedures or attached on separate sheets. For electrical component testing, the procedures may be less step-by-step-like than for dynamic mechanical equipment. For each piece of equipment, checks and test procedures and their documentation record forms may be different documents or combined in the same document, but checks and tests should be grouped. Responsibility for test procedure development is shared between the Commissioning Authority and the Trade Subcontractor according to the Check and Check and Testing Responsibility Table, attached as a supplement to this Section.
O. Issues Log: Ongoing record of the issues identified during the commissioning process that require or did require correction. For each entry the log includes a unique identification number, identification date, identification party, a short description of the issue, the equipment or assembly it is associated with, a long description of the issue, including cause, implications of the issue, recommendations for correction, assignment of responsibility for correction, an issue closed date and the name of the party verifying the correction. The Commissioning Authority is responsible to maintain the log.

P. Installation Verification: This initial portion of the Commissioning Process includes observations and punch-lists recorded and performed by the Engineer to ensure that all equipment is installed in accordance with the Specifications and Drawings. The Commissioning Authority shall overview this process.

Q. Manufacture’s Service Representative (MSR): A company that is certified and trained by a manufacturer to provide startup, testing, and troubleshooting service for equipment.

R. Monitoring: The recording of parameters (flow, current, status, pressure, etc.) of equipment operation using dataloggers or the trending capabilities of control systems.


T. Over-written Value: Writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 50 degrees F to 75 degrees F to verify economizer operation). See also “Simulated Signal.”

U. Phased Commissioning: Commissioning that is completed in phases (by floors, for example) due to the size of the structure or other scheduling issues, in order minimize the total construction time.

V. Pre-Functional Check Lists (PFC): This portion of the Commissioning Process primarily involves the test and balance and start-up personnel to ensure that individual pieces of equipment are capable of performing in accordance with the Specifications, Drawings and manufacturers' requirements. This is documented with a pre-functional checklist provided and completed by the contractor. The Commissioning Authority shall overview this testing.

W. Sampling: Functionally testing only a fraction of the total number of identical or near identical pieces of equipment.

X. Seasonal Tests: Tests that are deferred until the system(s) will experience conditions closer to their design conditions.

Y. Simulated Condition: Condition that is created for the purpose of testing the response of a system (e.g., applying a hair blower to a space sensor to see the response in a VAV box).

Z. Simulated Signal: Disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and DDC system to simulate a sensor value.
AA. Start-up: The initial starting or activating of dynamic equipment, including executing construction checklists.

BB. Trade Subcontractor: A sub-tier Contractor to the CMGC.

CC. Systems Manual: A manual providing to the immediate and future operating staff the information needed to understand and optimally operate each system. The manual is in addition to the O&M Manuals submitted by the CMGC. The systems manual focuses on operating, rather than maintaining the equipment, particularly the interactions between equipment. Some components of the manual may reside in the CMGC-submitted O&M Manuals.

DD. Trending: Monitoring using the building control system.

2.3 SUMMARY

A. The CxA shall be contracted directly to the General Contractor.

B. Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent, basis of design, construction documents and Owner’s system operational needs. This is achieved by beginning in the design phase, documenting design intent/basis of design and continuing through construction, building acceptance and the warranty period with actual verification of performance. The commissioning process shall coordinate what traditionally have been separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and Owner training.

C. Provide the services of a qualified CxA with commissioning expertise as described in this section.

D. This Section includes a description of the commissioning process to be used for this Project and applies to all commissioned systems and assemblies.

E. Commissioning Process Overview: The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.

1. Commissioning during construction begins with a planning meeting followed by a kick-off meeting conducted by the Commissioning Authority where the commissioning process is planned and reviewed with the commissioning team members.

2. Additional meetings will be required throughout construction, scheduled by the Commissioning Authority with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.

3. Equipment and assembly documentation is submitted to the Commissioning Authority during normal submittals, including detailed start-up procedures.

4. The Trade Subcontractor develops start-up plans for selected equipment with review by the Commissioning Authority. The Commissioning Authority and/or
Trade Subcontractor develop construction checklists to be completed by the Trade Subcontractor during the start-up process.

5. In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with construction checklists being completed before testing.

6. The Trade Subcontractor, under their own direction, execute and document the construction checklists and perform start-up and initial checkout. The Commissioning Authority documents that the checklists and start-up were completed through spot witnessing and reviewing Trade Subcontractor's completed checklists and startup reports.

7. The Commissioning Authority performs periodic construction observation.

8. The Commissioning Authority shall develop specific written equipment, system and assembly test procedures for all commissioned equipment.

9. Items of non-compliance in material, installation or setup are corrected by the Trade Subcontractor and the system is re-tested.

10. The Commissioning Authority reviews the O&M manuals for clarity, accessibility and completeness.

11. The Commissioning Authority reviews, pre-approves and coordinates the training provided by the Trade Subcontractor and verifies that is was completed.

12. Commissioning is complete before Substantial Completion, except for trend log monitoring, seasonal testing, near-warranty end activities, verification of later controls system training sessions and review of final red-line drawings.

13. Opposite season or deferred testing and near-warranty-end activities are conducted, as specified.

2.4 COMMISSIONING AUTHORITY FIRM (CxA) QUALIFICATIONS

A. The CxA shall meet the following minimum qualifications:

1. A minimum of five (5) years documented experience specifically in building commissioning.

2. Documentable experience in startup and troubleshooting HVAC, hot water heating, chilled water, plumbing, fire suppression, electrical, emergency power, fire alarm, life safety and specialty systems of similar complexity to those contained in these documents.

3. Competency in system design and intent.

4. Knowledge of the test and balance of air and hydronic systems.

5. Provide day to day project management by a registered professional engineer with a commissioning certification with extensive practical field experience and knowledge of the commissioning process. The technical training and experience with extensive practical field experience of all field personnel will also be reviewed.

B. The CxA shall not be associated in anyway with the construction team.

C. Prequalified commissioning authority firms:

1. G2 Consulting Engineers, Inc.
2. Contact: Nick Casady, PE, CPMP
3. Phone: (970) 657-1023
4. E-mail: ncasady@g2ce.com

2.5 CONSTRUCTION PHASE COMMISSIONING RESPONSIBILITIES

A. The primary role of the Commissioning Authority is to develop and coordinate the execution of a process of improved equipment installation and checkout and to verify and document that systems are functioning in accordance with the design intent and in accordance with the Contract Documents. The Commissioning Authority is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The Commissioning Authority may assist with problem-solving non-conformance or deficiencies, but ultimately that responsibility resides with the engineer of record, the CMGC and/or the Trade Subcontractors.

B. The CxA Responsibilities include, but are not limited to:
   1. General Tasks:
      a. Coordinate, schedule and manage the commissioning activities.
      b. Assist the Contractor to coordinate all Trade Sub Contractor commissioning activities.
      c. Obtain, assemble and submit commissioning documentation.
      d. Attend periodic on-site commissioning activities.
      e. Be proactive in resolving any and all deficiencies.
   2. Commissioning Documentation Development Tasks:
      a. Develop the commissioning plan and schedule.
      b. Develop detailed pre-functional check lists.
      c. Develop detailed functional performance test procedures.
      d. Coordinate locations of test ports required for Commissioning on P&ID’s, shop drawings and during installation.
      e. Conduct and coordinate the installation verification inspections with the Engineer, A/E, CMGC and Owner Construction Staff.
      f. Prepare and submit the Commissioning Reports.
   3. Pre-Functional Testing Tasks:
      a. Assist and witness portions of the start-up activities and pre-functional testing.
      b. Monitor the performance of a statistically representative portion of the Test, Adjust and Balance contractor activities.
   4. Functional Performance Testing Tasks:
      a. Direct the functional performance testing. Provide testing of all required systems to provide complete confidence in the systems. The tests will include the interaction between individual components, sub-systems and complete building systems under both normal and emergency power conditions.
b. Ensure that necessary test instrumentation is available during functional performance testing and instruments meet quality and calibration requirements and are in good working order.

c. Enforce system compliance and recommend modifications to the system design that will correct or enhance the system performance.

d. Coordinate witnessing of the tests.

e. Track commissioning deficiencies until correction and retesting are successfully completed. Assist the Commissioning Team in determining the cause of failure. Offer multiple solutions to correct the deficiencies.

C. Owner:

1. Furnish a copy of all Construction Documents, addenda, requests for information, change orders and approved submittals and Shop Drawings related to commissioned equipment to the Commissioning Authority for their permanent retention.

2. Facilitate the coordination of the commissioning work by the Commissioning Authority.

3. With the CMGC and Commissioning Authority, ensure that commissioning activities are being scheduled into the master schedule.

4. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions according to the Commissioning Plan.

5. Participate in issue resolution as necessary.

6. Provide final approval for the completion of the commissioning work.

7. Assist in the Commissioning Authority.


1. Attend the commissioning scope meeting and selected commissioning team meetings.

2. Coordinate resolution of system deficiencies (which are related to possible design deficiencies) identified during commissioning, according to the contract documents.

3. Provide any design narrative and sequences documentation requested by the CxA. The designers shall 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.

4. The Design Engineer shall be responsible for the observations and checklists for the Installation Verification.

5. Additional calculation and investigation of design adjustments needs by the Engineers as defined by the Commissioning Authority.

6. Participate in the resolution of potential design concerns as discovered during the commissioning process.

E. Construction Manager/General Contractor:
1. Facilitate the coordination of the commissioning work by the CxA, and ensure that commissioning activities are being scheduled into the project's master schedule.

2. In each purchase order or subcontract written, include requirements for submittal data, O&M data, commissioning tasks and training.

3. Ensure that all Subcontractors execute their commissioning responsibilities according to the Contract Documents and commissioning plan and schedule.

4. Notify the Commissioning Authority when the installation will begin for static assemblies that are being commissioned, dates for pipe and duct system testing, flushing, cleaning, start-up of each piece of equipment and starting of testing adjusting and balancing. Notify the Commissioning Authority ahead of time, when commissioning activities not yet performed or not yet scheduled may delay construction.

5. Provide time in selected construction meetings to cover commissioning-related issues.

6. A representative shall attend a commissioning scope meeting scheduled by the CxA and other necessary meetings scheduled by the CxA to facilitate the Cx process.

7. Coordinate the activities of all contractor, subcontractor and vendor personnel, required to complete training of Owner personnel in accordance with the requirements of the Specifications and the Training Agenda.

8. Prepare and submit the O&M manuals, according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

9. Include Trade Subcontractor’s cost associated with commissioning in the total contract price.

F. CMGC and Trade Subcontractors:

1. The details of this article apply to both the CMGC and sub-tier Contractors providing commissioned equipment. Other responsibilities for each party are listed in individual articles specific to each party.

2. Construction Phase.
   a. Coordinate with the Commissioning Authority to facilitate the commissioning work.

   b. Be proactive in seeing that commissioning processes are executed and that the requirements of the Commissioning Authority for the commissioning work are coordinated into the over-all construction schedule.

   c. Attend the commissioning planning and kick-off meetings and other necessary meetings scheduled by the Commissioning Authority to facilitate the commissioning process.

   d. With the A/E and Commissioning Authority, actively assist in the development of the emergency power and fire alarm response matrix during the initial submittal period.

   e. The CMGC and Trade Subcontractors shall respond to notices of issues identified during the commissioning process, making required
corrections or clarifications and returning prompt notification to the Commissioning Authority.

f. When completion of a task or other issue has been identified as holding up any commissioning process, particularly functional testing, the Trade Subcontractor shall notify the CMGC within one day of identification. The CMGC shall within two days of notification of the issue, notify the Commissioning Authority and provide an expected date of completion or resolution of the issue. The CMGC shall notify the Commissioning Authority within one day of completion. It is not the responsibility of the Commissioning Authority to obtain this status information through meeting attendance, asking questions or field observation.

G. Trade Subcontractors:
1. Under the direction of the CMGC, Trade Subcontractors shall provide the services outlined in this paragraph.
   a. Cooperate with the CxA to complete commissioning activities.
   b. Include all costs associated with commissioning within their price.
   c. The Contractor shall be responsible for the Pre-functional Testing.
   d. The Contractor shall be responsible for providing any technical personnel required for physical operation, testing, and simulation of control sequences for each piece of controlled equipment as required by the Commissioning Authority during the Functional Performance Testing. This shall include chiller service personnel, boiler service personnel, the temperature control engineering and technical startup crew, mechanical contracting service personnel for miscellaneous mechanical equipment, and balancing contractor personnel. To the extent possible, these personnel will be scheduled.
   e. The temperature controls contractor shall provide additional, overridable points to assist the CxA with commissioning on a separate, commissioning graphic, including, but not limited to:
      1) Outdoor air temperature and humidity (dew point).
      2) Space temperature and humidity (dew point).
      3) Additional points as directed by the CxA.
      4) Additional points per specification section 23 09 23 “Direct Digital Control (DDC) System for HVAC.”
   f. Additional calibration and adjustment of the mechanical equipment included in each mechanical system for proper operation under actual operation as defined by the CxA.
   g. Additional testing, calibration, adjustment, tuning, and minor adjustments to the temperature controls system sequences for proper operation under actual operation as defined by the CxA.
   h. Additional testing, calibration and adjustment of the mechanical water and air flows of each mechanical system for proper operation under actual operation as defined by the CxA.
   i. Review final construction phase commissioning plan procedures for equipment installed, training and functional testing required under the particular subcontract.
j. Provide training services as required.
k. Submit a written plan to the Owner and Commissioning Authority for temporary startup of equipment used for space conditioning. Obtain plan approval of Owner and Commissioning Authority prior to such startup.
l. Ensure that the local authorities having jurisdiction are available to witness any acceptance test (e.g., fire alarm testing, smoke cycle testing, fire damper acceptance testing, sprinkler system hydro-testing, etc.) that is a condition of occupancy for the building.

H. Equipment Suppliers:
1. Construction Phase:
   a. Provide requested submittal data, including detailed start-up and checkout procedures to keep warranties in force for all commissioned equipment or assemblies.
   b. Assist in equipment or assembly testing per agreements with Trade Subcontractors.
   c. Include all special tools and instruments, when only available from vendor, specific to a piece of equipment, required for testing equipment according to these Contract Documents in the base bid price to the CMGC or Trade Subcontractors.
   d. Review test procedures for equipment installed by factory representatives.
   e. For larger primary equipment, provide the services for the first part of testing, of the technician that conducted start-up. For electrical commissioning, see Table of Testing Responsibility provided as a supplement to this Section.
   f. Provide expert qualified staff for equipment training.

2.6 QUALITY ASSURANCE

A. Test Equipment:
1. All standard testing equipment required for the Trade Subcontractors to perform installation, start-up and initial checkout and required testing shall be provided by the Trade Subcontractors.
2. Special tools and instruments, only available from vendor, specific to a piece of equipment, required for testing equipment according to these Contract Documents shall be included in the base bid price.
3. The Trade Subcontractors shall provide datalogging equipment for setting up and testing of cold rooms, clean room certification, fume hoods and lab room pressurization and equipment required to perform specified electrical equipment testing.
4. Datalogging equipment required for testing equipment in support areas shall be provided and used by the Commissioning Authority.

B. Test Equipment Calibration Verification:
1. Trade Subcontractors shall submit, within 90 days of notice to proceed and 30 days before any testing is performed, documentation of meeting the following calibration requirements.

2. Electrical equipment testing instruments must be calibrated in accordance with the following frequency:
   a. Field Instruments: Analog, 6 months maximum, digital, 12 months maximum.
   b. Leased specialty equipment: 12 months where accuracy is guaranteed by lessor.

3. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications.
   a. If not otherwise given, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5 degrees F and a resolution of + or - 0.1 degrees F. Pressure sensors shall have an accuracy of + or - 2.0 percent of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer’s recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

2.7 COORDINATION

A. Commissioning Team: The members of the commissioning team consist of the Commissioning Authority, the Owner, the CMGC, the Architect and design engineers, the mechanical contractor, the electrical contractor, the testing adjusting and balancing contractor, the controls contractor, any other installing subcontractors or suppliers of commissioned equipment or assemblies and the Owner’s facility staff.

B. Management: The Commissioning Authority is hired by the Owner directly. The Commissioning Authority directs and coordinates the commissioning activities and the reports to the Owner. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.

C. Scheduling: The CMGC shall provide sufficient notice to the Commissioning Authority regarding the installation of static assemblies being commissioned and the schedule for the construction checklists, start-up and initial checkout of all commissioned dynamic equipment and systems.

D. General: The CMGC and the Trade Subcontractors will coordinate with the Commissioning Authority in a number of areas as described in this Section in order to facilitate the successful completion of the commissioning plan.
2.8 CONSTRUCTION PHASE COMMISSIONING SUBMITTALS

A. Preliminary Commissioning Plan – Construction Phase: Within 60 calendar days of notice to proceed, the CxA shall submit a preliminary construction phase commissioning submittal including the following:
1. Commissioning Team: Provide a listing of all commissioning team members including the names, addresses, and office/fax/cell phone numbers of the owner, commissioning authority, architect, mechanical engineer, electrical engineer, general contractor, mechanical contractor, electrical contractor, controls contractor, fire alarm system contractor and test and balance contractor.
2. Overview of Testing Program Procedures: Provide a detailed description of the testing plan and procedures that will be implemented during the commissioning process.
3. Pre-Functional Testing Checklists: Provide prefunctional testing checklist forms to the contracting team for each individual piece of mechanical equipment. The forms shall describe all events required to fully start-up a piece of equipment.

B. Final Commissioning Plan – Construction Phase: CxA shall include all items described in the Preliminary Commissioning Plan, update as required with project changes and submittal review comments, and finalize the outstanding Preliminary Commissioning Plan items within 30 days of acceptance of the Preliminary Commissioning Plan:
1. Executive Summary: Same as preliminary
2. Commissioning Team: Update changes and add personnel as required.
3. Overview of Testing Program Procedures: Update as required.
4. Record Document - Sequences of Operation: Update as required with RFI’s and questions to the design team.
5. Pre-Functional Testing Checklists: Update as required to reflect additional or changed equipment.
6. Functional Testing Procedures and Data Forms:

2.9 SCHEDULE

A. Commissioning schedule: Integrate functional performance testing and commissioning requirements into the Critical Path Method (CPM) master construction schedule. Commissioning scheduling is the responsibility of the Contractor.
1. Prior to the beginning of start-up or functional performance testing activities, update the schedule of commissioning activities.

B. Commissioning of systems shall proceed per the criteria established in the specific sections that follow, with activities to be performed on a timely basis. Commissioning of systems may proceed prior to final completion of systems. The CxA must be available to respond promptly to avoid delay to the CPM schedule.
C. Problems observed shall be addressed immediately, in terms of notification to responsible parties and actions to correct deficiencies.

2.10 COMMISSIONING MEETINGS

A. Scope Meeting: Early in the construction process, a commissioning scoping meeting involving all members of the commissioning team shall be held at a time and place designated by the Owner. The purpose of the meeting will be to familiarize all parties with the requirements of the commissioning process, and to ensure that the responsibilities of each party are clearly understood.

B. Progress Meetings:
   1. Prior to the beginning of start-up or functional performance testing activities, the CxA will hold commissioning meetings at least monthly. These meetings may be held concurrently with the general construction meetings.
   2. Beginning two weeks prior to the commencement of start-up or functional performance testing activities, whichever is earlier, the CxA will hold commissioning meetings as required. Thereafter, and for the duration of commissioning for that construction phase, commissioning meetings will continue to be held bi-monthly. These meetings may be held concurrently with the general construction meetings.

C. The CxA may require additional meetings if the commissioning process appears to be behind schedule or if there are coordination problems.

D. Controls Integration Meetings: The Commissioning Authority coordinates a series of meetings to go over the control drawings, sequences of operation, points list and database and controls submittal requirements. These meetings are held prior to a formal control drawing submittal and any programming. The intent is to clarify control related issues for the controls contractor, mechanical, fire alarm and electrical contractor, Owner facility staff and Commissioning Authority prior to final point database development, programming and the formal control drawing submittal.
   1. The controls contractor shall attend all meetings. The mechanical, electrical and general contractor shall attend when issues regarding equipment they are responsible for are discussed. The mechanical and electrical designers attend as needed according to their contracts. The control technicians attending the meetings must be the same technicians that are/will install and program the DDC system.
   2. Preliminary control drawing submittals and sequences by system are provided by the Controls Contractor, reviewed beforehand and discussed at these meetings.
   3. Primary issues discussed and clarified are:
      a. Control drawing content and format
      b. Point database (points (monitored points, software points, naming conventions, alarms, report format)
      c. Sequences of operation and setpoints (clarity, completeness, design intent, functionality, and enhancements for control, energy and O&M)
d. Interlocks to packaged controls and other systems, including filling in the fire alarm and emergency power response matrices  
e. Operator workstation graphics  
f. Field sensor and panel locations  

4. A site walk-through with the Controls Contractor, Commissioning Authority and Engineer shall be conducted where precise locations of panels, sensors, thermometers, flow meters and stations and valve taps will be identified.  

E. The Commissioning Authority takes minutes at these meetings, which may include marked up data base forms and sequences of operation.  

PART 3 - PRODUCTS – NOT USED  

PART 4 - EXECUTION  

4.1 COMMISSIONING PROCEDURE  

A. Objectives and Scope:  
1. The objective of testing is to demonstrate that each system is operating according to the documented Owner’s Project Objectives and Contract Documents. For dynamic systems, testing facilitates bringing the systems from a state of initial operation to full dynamic operation. For static elements, testing verifies the performance of the assembly in its installed state under conditions specified in the testing requirements. Additionally, during the testing process, areas of deficient performance are identified and corrected.  
2. In general, testing shall include testing each sequence in the sequence of operations, and other significant modes, sequences and control strategies not mentioned in the written sequences; including, but not limited to startup, shutdown, unoccupied and manual modes, power failure, alarms, component staging and backup upon failure, interlocks with other equipment, and sensor and actuator calibrations. All interlocks and interactions between systems shall be tested.  

B. Sequence of testing: Commissioning shall proceed from lower to higher levels of complexity. For each discrete subsystem or system, testing at the lower level shall be completed prior to starting the next higher level of tests. In general, the order of testing from lowest to highest is:  
1. Static tests (such as duct leakage tests).  
2. Component functional performance tests (of motors, actuators, sensors, etc.) and start-up.  
5. Intersystem functional performance tests.
C. Re-testing: The Contractor shall repeat, at no additional cost to Owner, the complete functional test procedure for each test for which acceptable results are not achieved. Repeat tests until acceptable results are achieved. The CxA shall track commissioning deficiencies until correction.

D. Correction of deficiencies:
   2. Corrections during functional performance tests are generally prohibited to avoid consuming the time of personnel waiting for the test, but not involved in making the correction. Exceptions will be allowed if the cause of the failure is obvious and corrective action can be completed in less than five minutes. If corrections are made under this exception, the failure shall be noted on the functional performance test data form. A new functional performance test data form, marked “retest”, shall be initiated after the correction has been made. The entire functional performance test procedure shall be repeated.

E. The commissioning agent shall also perform the following work:
   1. Review the design and submit any required clarification requests for development of pre-functional and functional performance verification procedures
   2. Review the controls documentation and interface with other systems.
   3. Review contractor submittals and submit clarification requests for variances from the design documents and incomplete submittal data.
   4. Review the operation and maintenance information and as-built drawings provided by the various sub-contractors and vendors.
   5. Review the contractor submittals for equipment/items to be commissioned.
   6. Review the MEP O&M manuals.

4.2 SYSTEMS TO BE COMMISSIONED

A. General: The systems to be commissioned shall generally include:
   1. Division 22 systems.
   2. Division 23 systems.
   3. Division 26 systems.

B. The following equipment, systems, assemblies and features will be commissioned utilizing the traditional construction phase commissioning process. All general references to equipment in this document refer only to equipment that is to be commissioned. The responsibility for developing and reviewing forms, overseeing, documenting and witnessing execution and reviewing reports of checks and tests is distributed among constructors, designers and differs for different equipment types.
   1. Mechanical and Plumbing Systems (100% unless noted otherwise):
      a. Domestic Water Heaters and associated domestic hot water circulation systems
      b. Roof-top Units
      c. VAV Boxes

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d. Variable speed drives
e. Exhaust fans/systems
f. Facilities Monitoring and Control System

2. Electrical Systems:
a. Lighting controls, including occupancy sensors.

4.3 INSTALLATION VERIFICATION

A. During construction, assist the Contractor and coordinate the A/E’s observation the work of the Contractor and subcontractors to ensure that all installations are being made in accordance with the intent of the contract documents.

B. Before system start-up begins, coordinate and attend a final installation verification walk thru with the A/E. The walk thru shall include, but not be limited to, a check of:
   1. Piping specialties including balance, control and isolation valves.
   2. Ductwork specialty items including turning devices; balance, fire, smoke and control dampers; and access doors.
   3. Control sensor types and locations.
   4. Identification of piping, valves, starters, gauges, thermometers, etc.
   5. Documentation of pre-start-up tests performed, including manufacturers’ factory tests.
   6. Accessibility to MEP items that require access.

C. If any work is found to be incomplete, inaccessible, incorrect or non-functional, make note of deficiencies and correct the deficiencies before system start-up work proceeds.

4.4 SYSTEM START-UP

A. Assist the Contractor in the development a start-up plan and deficiency list. Commence with system start-up after approval has been given to the start-up plan and the pre-functional checklists have been signed off by the Contractor and subcontractors. The CxA and/or delegated representative shall witness system start-up and list all system and equipment deficiencies noted during start-up. The Contractor shall take corrective action on all system deficiencies noted and demonstrate suitable system operation to the CxA.

B. Prepare start-up deficiency list forms to report deficiencies discovered in conjunction with system start-up. Start-up deficiency forms shall indicate the system being started up; the location and identification of the deficient equipment/material; date of observation; initials of the observer; observed deficiency; date of correction; initials of person making the correction; and corrective action taken.

C. Issue start-up deficiency report forms to the Contractor for corrective action. The Contractor shall advise the CxA when all start-up deficiency list items have been corrected.
4.5 TEST AND BALANCE

A. Assist the Contractor in the coordination the air and hydronic balancing. Advise the TAB firm when systems are complete and ready for balancing. Start TAB as early as possible following systems start-ups and component functional performance tests, in order to be essentially complete prior to system functional performance tests. Coordinate TAB activities with other construction schedule activities.

B. Verify the accuracy of the TAB work prior to commencing any FPT activities that may be adversely affected by improper balancing.

4.6 FUNCTIONAL PERFORMANCE TEST PROCEDURES

A. The CxA shall develop the functional performance test (FPT) commissioning procedures and documentation to be used. Personnel experienced in the technical aspects of each system to be commissioned shall be engaged if necessary to augment the expertise of the CxA. Include functional performance test procedures and functional performance test data sheets for each system based upon actual system configuration.

B. Emphasis shall be placed on testing procedures that will conclusively determine actual system performance and compliance with the design.

C. The test procedures shall fully describe system configuration and steps required for each test, appropriately documented so that another party can repeat the tests with virtually identical results.

D. The FPT procedures must confirm the performance of systems to the extent of the design intent/basis of design and applicable code under which the project was permitted. When a system is accepted, the Owner and A/E must be assured that the system is complete, works as intended, is correctly documented and that the designated Owner staff is trained in the operation and maintenance of the system.

E. The majority of mechanical equipment requires integral safety devices to stop/prevent equipment operation unless minimum safety standards or conditions are met. This could include adequate oil pressure, proof-of-flow, non-freezing conditions, maximum head pressure, etc. Functional performance test procedures shall demonstrate the actual performance of safety shutoffs in real or closely simulated conditions 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 installed via software. Functional performance test procedures shall demonstrate these interlocks.

G. The CxA shall inform appropriate subcontractors and vendors before commissioning is started as to what the test and expected results will be. Whereas some test results and interpretations may not become evident until the actual tests are performed, all participants should have a reasonable understanding of the requirements. The
Commissioning plan must address the requirements and be distributed to all participants involved with that particular system.

4.7 COMMISSIONING REPORT

A. Documentation – General:
1. The Commissioning Authority shall record and maintain detailed testing data. The data record shall be comprehensive and concise.
2. All data must be recorded as soon as possible during the course of the testing.
3. All documentation shall have the date, time, and names of persons participating in the inspection and testing.
4. All test instruments shall be documented for valid calibration.
5. The recording work sheets, inspection check lists and performance testing plans must all be approved by the Engineer and Commissioning Authority prior to the start of Functional Performance Testing.

B. Installation verification walk thru: Prior to start-up, the CxA shall maintain a report of installation verification walk thru activities. Identify equipment and components verified, deficiencies noted, corrective action taken and the dates and initials of the persons making the entries.

C. Start-up deficiency report: Within five days following start-up of each system or equipment, the CxA shall maintain start-up deficiency report forms. Identify systems and/or equipment started up, deficiencies noted, corrective action taken and the dates and initials of the persons making the entries.

D. Test, adjust and balance (TAB) progress reports: After TAB activities have begun, the TAB shall submit weekly TAB progress reports to the CxA. Identify:
1. Systems or subsystems for which preliminary balancing is complete.
2. Systems or subsystems for which final balancing is complete.
3. Status of deficiencies and balancing problems encountered, including corrective actions taken.
4. Updated schedule of remaining TAB activities.

E. Deficiencies and Issues Report: At the end of each day, in which functional performance tests are conducted, the CxA shall maintain a deficiencies and Issues (D&I) log for tests for which acceptable results were not achieved during the day.
1. Identify tests for which acceptable results were not obtained by test number and description, and equipment identification and location. Briefly describe observations about the performance that was associated with failure to achieve acceptable results. Identify the cause of failure if such is apparent.
3. When corrections have been completed, the CxA shall update the functional performance test deficiency report forms. Identify corrective action taken and the dates and initials of the persons making the entries.
4. Identify the schedule for re-testing.

F. Final Commissioning Report: The CxA shall prepare and submit a final report with the closeout package. The binding format shall be 8 ½ x 11 bound documents with 11 x 17 fold outs. This report shall contain:
1. The report shall verify performance of HVAC equipment and systems.
2. Document any field modifications to the testing process and why these modifications were made.
3. The organization of the final commissioning report shall be as follows:
   a. Executive Summary of each mechanical system and problems encountered and resolved.
   b. System Overview summarizing the system design.
   c. Post Commissioned Controls Sequences and Points Lists.
   d. Pre-functional Testing Checklists.
   e. Functional Testing Procedures and Results.
   f. Deficiencies and Issues Logs.
   g. Appendix of letters, meeting minutes, memos and notes occurring during the commissioning process.

G. Hardcopy and Electronic Versions:
1. The Commissioning Plan provided prior to the on-site commissioning and the Final Commissioning Report provided at the conclusion shall be provided in electronic format.
2. The Commissioning Plan CD shall include files developed in the most current MS Word or Excel format.
3. The Final Commissioning Report CD shall contain printed and scanned copies of all documentation developed and gathered during the Commissioning Process in PDF format.

4.8 FACILITY O&M PROBLEM SOLVING TECHNIQUES TRAINING

A. General:
1. A critical part of optimizing the benefits and long-term value of new construction and existing building commissioning is providing an advanced training, beyond the basics they receive from equipment vendors.
2. Provide hands-on, mind-engaged curriculum that teaches problem-solving skills, critical thinking, and trouble-shooting techniques to ensure building systems operate optimally.
3. The training shall be provided in a classroom setting located within the Reservation.

B. Objectives:
2. Identify how individual component problems and adjustments of one system interact with other mechanical systems.

4.9 EXCLUSIONS

A. The CxA shall not be responsible for construction means, methods, job safety or any management function related to commissioning on the job site.

B. The Contractor shall provide all technician services requiring tools or the use of tools to test, adjust or otherwise bring equipment into a full operational state.

C. The CxA shall not be responsible for any Civil or Structural testing required.

D. The CxA shall not be responsible for Division 23 Test and Balance contractor tasks or Division 26 Electrical Acceptance Testing contractor tasks.

E. The CxA shall not be responsible for training the Owner.

END OF SECTION