

COMMISSIONING

Section: 01 91 00

PART 1 – GENERAL

1.1. SUMMARY

This Section includes the requirements for Commissioning the Project including:

- A. Start up and testing of equipment and systems.
- B. Identification and documentation of all infrastructure, systems, and equipment (Systems) issues and failures.
- C. Corrective Actions and acceptance of corrected Systems.
- D. Coordination of Commissioning requirements.

1.2 DESCRIPTION

A. Purpose

To obtain an approved Commissioning Plan and final Commissioning Report accepted by the Airport Commissioning Authority as required by Airport Board Policy (ABP).

B. Design and Construction Phase Commissioning Goal

Issuance of a Commissioning Plan to reflect the design intent of the final system configurations and operations necessary to obtain a permit for construction.

C. Post-Construction Phase Commissioning Goal

Issuance of an approved final Commissioning Report to reflect all Systems commissioned have been installed, operated, and tested to meet the construction specification requirements and have met the minimum operational and training requirements of the Owner as necessary for the Owner acceptance and issuance of a Certificate of Occupancy (CO).

D. Systems to be commissioned will be listed in the approved Commissioning Plan and in PART 3 of this Section, when applicable with the Project's Scope of Work:

- 1. Division 33 – Utilities

E. REFERENCES

- 1. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
 - a. ASHRAE Guideline 0-2013 – The Commissioning Process
 - b. ASHRAE Guideline 1.1 - 2007 –HVAC&R Technical Requirements for the Commissioning Process
- 2. ACG - Associated Air Balance Council Commissioning Group
 - a. ACG Commissioning Guideline 2005
- 3. USGBC – U.S. Green Building Council
 - a. LEED v4 BD+C – Green Building Rating System for New Construction & Major Renovations

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1.3 DEFINITIONS

- A. Basis of Design: The Basis of Design (BOD) is a document that details the Architect/Engineer's design plan to achieve the Owner's Project Requirements (OPR). This document includes assumptions, existing conditions, and performance boundaries.
- B. Commissioning: A systematic process of verifying and documenting that the performance and maintainability of Systems fulfill the operational and functional requirements of the Owner and the Owner's representatives, users, and operators. Commissioning is intended to achieve the following specific objectives according to the Contract Documents.
 - 1. Verify that all applicable Systems are installed according to the Contract Documents, manufacturer's recommendations, and to industry accepted minimum standards and that they receive adequate operational checkout by the Installing Subcontractor(s).
 - 2. Verify and document proper performance of all Systems.
 - 3. Verify that all Operations and Maintenance (O&M) documentation is complete.
 - 4. Verify that the Owner's operating personnel are adequately trained.
- C. Commissioning Agent (CxAg): The person selected to chair the Commissioning Team and coordinates and oversees the development and execution of the Commissioning Plan. The CxAg will be a selected and employed by the Owner. The CxAg will be a licensed professional engineer in the State and experienced in the Commissioning of mechanical and electrical systems of the type and complexity installed in this Project. The CxAg will have experience in construction process, direct digital control systems, and test adjust and balance operations. The CxAg shall not be associated with or employed by the Contractor, or any Subcontractor or equipment/system supplier connected with the Project.
- D. Commissioning Coordinator: An authorized representative of the Contractor or Installing Subcontractor(s) designated in writing to the Commissioning Team, who attend Commissioning meetings and who act as the responsible central point of contact between the Contractor and the Commissioning Team.
- E. Commissioning Authority (CxAu) or Designee (CxAuD). DFW Airport Board manager responsible for ensuring compliance with the DFW Airport Board Commissioning Policy and approving proponents for commissioning, the project commissioning plan, and the Final Commissioning Report.
- F. Commissioning Plan: The plan prepared by the CxAg providing guidance and outlines the execution of the Commissioning process, verifying that the Systems perform at or above the expected level as specified in the Contract Documents. The Commissioning Plan is a detailed account of the Commissioning activities as they relate to the Project. The plan includes a listing of Commissioning Team members, phases of the Project, each team member's Commissioning related responsibilities during each phase and the expected deliverables from each team member. Communication protocols between the members of the team and their respective companies are defined in the plan. As a living document, the plan will be continuously updated to reflect the evolving process as developed by the Commissioning Team. The Final

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Commissioning Plan is inclusive of the completed initial approved Commissioning Plan plus all approved and completed commissionable items associated with construction phase changes based on the following:

1. Requests For Information
 2. Design Change Notices
 3. Approved Addenda or Alternatives
 4. Approved final submittals, including control systems sequences of operation.
- G. Commissioning Team: The group responsible for working together to implement the Commissioning process. The group can consist of all, or part of the following members as dictated by the complexity and length of a Project:
1. Commissioning Authority (CxAu)
 2. Senior Commissioning Manager (Sr. CxM)
 3. Senior or Implementation Project Manager
 4. Project Manager
 5. Commissioning Manager (CxM)
 6. Commissioning Agent (CxAg)
 7. Architect/Engineer
 8. Construction Manager at Risk (CMAR)
 9. Contractor Commissioning Coordinator
 10. Contractor
 11. Owner's Authorized Representative (OAR)
 12. Owner's Authorized Facility Manager
 13. Quality Assurance (QA) Inspectors
 14. Design Code and Construction Department (DCC) Inspector
 15. Design Code and Construction Department (DCC) Representative
 16. Energy, Transportation and Asset Management (ETAM) Representative
 17. Other Installing Subcontractors or equipment suppliers.
- H. Contractors Test Report: The Contractors' tests are defined as any form of start-up, adjustment, or calibration performed on individual pieces of equipment as specified within the Contract Documents. The Contractor shall provide test reports developed by the Subcontractors and any manufacturer developed forms used during equipment installation and start-up. The Contractor is responsible to upload the digital documents to the Owner's designated electronic project management system, the Skier Unifier software application, or as otherwise directed by the OAR for the Project.

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- I. Deficiency: An issue or observation that prohibits the successful passing of any step on the verification test procedure for any Systems that are specified in the Commissioning scope of the Project.
- J. Issue: An observable item reported as a possible risk or concern to the Project.
- K. Installing Subcontractor: The Subcontractor or supplier responsible for the actual installation of the System.
- L. Owners Project Requirements (OPR): A written document detailing the functional requirements of the Project and the expectations of how it will be used and operated by the Owner. The document may include Project and design goals, measurable performance criteria, budgets, schedules, success criteria, and supporting information. This document may evolve as the Project progresses.
- M. Pre-Functional Checklist (PFC)/Installation Completion Checklist: A checklist created by the CxAg designed to demonstrate that the system is completely installed and ready for operational testing. At the end of installation, the Installing Subcontractor completes the operational checklist to certify that the work is complete, and the system is ready for independent testing.
- N. Functional Performance Test (FPT): A test that confirms each system will perform as specified functionally. The Installing Subcontractor shall perform each FPT. The CxAg will coordinate, witness, and document the FPT. During the FPT, the Installing Subcontractor shall sequence the system as outlined in the approved FPT procedure and provide the required test equipment and building automation system access as required.

1.4 COMMISSIONING AIRPORT BOARD POLICY and COMMISSIONING PLAN

- A. Under Airport Board Policy ET.001 – Commissioning, it is the policy of the Board that all Board buildings and other appropriate facilities and Systems be commissioned. The policy provides the requirements for commissioning acceptance by the Airport's Commissioning Authority and the Commissioning Authority Designees.
- B. The Commissioning Plan provides guidance in the execution of the Commissioning process based on the Project Scope of Work.
- C. Commissioning Process

The following provides a brief overview of typical Commissioning tasks during construction and the general order in which they should occur on the Project.

 - 1. The CxAg modifies the commissioning specification and works with the A/E to incorporate into the project's construction documents.

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2. The CxAg develops a preliminary Cx Plan that outlines the general commissioning approach and provides templates for certain commissioning documents to be used in the execution of the work.
3. The CxAg performs design reviews of select design submittals, as required. This consists of reviewing A/E plans and specifications related to equipment and systems for installation, integration, testing, operations, maintenance, training, and warranty requirements. For LEED projects, the design reviews include an additional compliance check to evaluate consistency of the design documents with the Owner's Project Requirements (OPR).
4. Commissioning during construction begins with a kick-off meeting conducted by the CxAg where the Commissioning process is reviewed with the Commissioning Team members. Additional meetings may be required throughout construction to plan, scope, coordinate, schedule future activities and resolve problems.
5. Equipment documentation including Architect/Engineer approved submittals are provided to the CxAg including detailed start-up procedures.
6. The CxAg works with the Commissioning Team in developing start-up documentation formats, including PFCs to be completed during the start-up process.
7. The checkout and performance verification proceeds from simple to complex, from component level to Systems and intersystem levels with PFCs being completed prior to functional testing.
8. The Installing Subcontractor(s), under their own direction, execute and document the PFCs and perform start-up and initial checkout. The Contractor documents that the PFCs and start-up were completed according to the approved plans. The Installing Subcontractor(s) will provide a minimum three (3) Working Days, notification to the CxAg, OAR, and other Owner's personnel of the date and time scheduled for performing start-up and initial checkout processes prior to the start up, so that they may witness start-up and the initial checkout.
9. The CxAg, in cooperation with the Installing Subcontractor(s), suppliers, and manufacturers develops specific equipment and system FPT procedures for all designated divisions and any other Systems identified as requiring Commissioning as part of the Project.
10. All other Divisions shall have the Contractor and the Installing Subcontractor(s), in cooperation with the suppliers and manufacturers; develop specific equipment and system FPT procedures to be submitted for Architect/Engineer approval and in accordance with the Project Specifications for use by the Commissioning Team for

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review, comment, and report form development. The FPT procedures are executed by the Installing Subcontractor(s), witnessed and documented by the CxAg after completion of the Installing Subcontractor(s) start-up procedures.

11. Items or issues associated with non-compliance in material, installation, setup, or sequence of operation are corrected at the Contractor's expense and the system retested.
12. The Contractor reviews the O&M documentation for completeness and schedules and coordinates the Owner's personnel training. All O&M documentation must be submitted in accordance with Section 01 78 23 and approved prior to the start of training. Refer to Section 01 79 00 for additional requirements.
13. The Contractor reviews and coordinates the training provided by the Installing Subcontractor(s), suppliers, manufacturers, the CxAg documents and verifies that the training was conducted and met the minimum requirements of the Owner. Refer to Section 01 79 00 for demonstration and training requirements.
14. Deferred testing is conducted, as specified for standard testing.
15. Final Commissioning Plan shall be completed and documented prior to Substantial Completion.
16. A tracking log, as developed by the Contractor, shall identify all Systems designated to have warranties and their warranty duration. Refer to Section 01 78 33 for acceptance procedures for generic and final warranty manual submissions. The final log shall be included in the Final Commissioning Report.
17. 10-months after substantial completion (if applicable to the project) the CxAg shall meet with the Owner and facility maintenance personnel to review the facility operating procedures and determine if any warranty related issues shall be resolved by the contractor(s).

1.5 RESPONSIBILITIES

A. The Contractor shall:

1. Develop and provide a complete list of Systems requiring Owner personnel training. The list will be provided to the CxAg for review and inclusion into the Commissioning Documents.
2. Facilitate the coordination of the Commissioning work and ensure that Commissioning activities are being incorporated into the master schedule.
3. Include the cost of supporting Commissioning in the Contract Amount.

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4. Furnish a copy of all Contract Documents, Addenda, Requests for Information (RFI), Change Orders, and approved submittals and Shop Drawings related to commissioned Systems to the CxAg.
 5. Ensure each purchase order or subcontract written, includes requirements for submittal data, O&M data, Commissioning tasks and training.
 6. Assist with the development and documentation of Commissioning test procedures for all Systems with the Installing Subcontractor(s).
 7. Ensure that all Installing Subcontractor(s) execute their Commissioning responsibilities according to the Commissioning Plan, Contract Documents, and schedule.
 8. Designate a Commissioning Coordinator who shall attend Commissioning scoping meetings and other necessary meetings scheduled by the CxAg to facilitate the Commissioning process.
 9. Coordinate the training of the Owner's personnel, including reviewing and approving the training plans and coordinate the digital recordings of the Owner's personnel training including clear audio recording of all questions and inquiries and their associated responses, in accordance with Section 01 79 00.
- B. The Contractor shall ensure that all Installing Subcontractor(s):
1. Include the cost of supporting Commissioning as a line item in the sub-contract price.
 2. Provide submittal data, O&M data, Commissioning tasks and training according to Contract Documents in each purchase order or subcontract written.
 3. Designate a Commissioning Coordinator who shall attend Commissioning scoping meeting and other meetings scheduled and required by the Commissioning Agent to facilitate the Commissioning process.
 4. Provide normal cut sheets and shop drawing submittals of approved equipment as part of the submittals.
 5. Provide documentation prior to normal O&M Manual(s) submittal to the Contractor and CxAg for development of start-up and FPT procedures.
 - a. Provide the following to the Contractor and CxAg:
 - 1) Detailed manufacturer installation and start-up instruction.
 - 2) Operating, troubleshooting and maintenance procedures.
 - 3) Full details of any Owner-contracted tests.
 - 4) Full factory test reports.

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- 5) Full warranty information which clearly identifies all responsibilities of the Owner to keep the warranty in force.
 - 6) Installation, start-up and checkout materials that are shipped with the equipment.
 - 7) Actual field checkout sheet forms to be used by the factory or field technicians.
- b. Provide the proposed O&M Manual(s) format, organization, and content to the CxAg for review and comment. The manual shall follow the guidelines in accordance with Section 01 78 23.
- c. Provide additional documentation, deemed necessary by the CxAg, for the Commissioning process.
6. Prepare and provide a copy of the O&M Manual(s) and submittals of the installed systems using normal submittal procedures through the Contractor to the CxAg for review and comment.
7. Assist in clarifying the operation and control of commissioned Systems in areas where the Project Specifications, control drawings, or equipment documentation are insufficient for writing detailed testing procedures. Coordinate efforts with the Architect/Engineer as required.
8. Coordinate with the CxAg and provide comments on the FPT procedures (developed by the CxAg for systems indicated in the commissioned systems section Part 3, section 3.3) to ensure feasibility, safety, equipment protection, and provide necessary written alarm limits to be used during the tests to the CxAg through the Contractor.
9. Develop a full start-up and initial checkout plan using the manufacturer's start-up procedures and the PFCs for all commissioned Systems. Submit through the Contractor to the CxAg for review and comment prior to start-up.
10. Execute the CxAg provided PFCs for all commissioned Systems during the start-up and initial checkout process. Provide completed copies to the CxAg in their native digital format for approval.
11. Perform and clearly document all completed start-up and system operational checkout procedures, providing a copy to the Contractor and the CxAg.
12. Address and resolve current Punch List and commissioning issue log items prior to beginning FPTs.
13. Provide skilled technicians to execute starting of equipment and to execute the FPT. Ensure that technicians are available and present during the agreed

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upon schedules and for sufficient duration to complete the necessary tests, adjustments, and problem solving.

14. Perform FPTs for specified Systems. Assist the CxAg in interpreting the monitoring data, as necessary.
 15. Correct all deficiencies which include differences between specified and observed performance as interpreted by the Contractor and/or CxAg and the Architect/Engineer and retest the equipment.
 16. Prepare the O&M Manual(s) according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
 17. Prepare redline and CAD (electronic) drawings for all final as-built drawings for Contractor-generated coordination drawings.
 18. Provide training of the Owner's operating personnel as required in the Contract Documents. Refer to Section 01 79 00 for demonstration and training requirements.
 19. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty. Develop, execute and document Contractor maintenance plans for Systems placed into service prior to beneficial occupancy. Provide records and reports of all pre-turnover maintenance.
 20. Provide the equipment for testing in accordance with the Project Specifications.
- C. The Contractor shall ensure that equipment suppliers:
1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep all applicable warranties in force.
 2. Include all special tools, including software and instruments only available from the supplier and specific to a piece of equipment, required for testing equipment according to these Contract Documents in the base bid price provided to the Contractor. This bid price does not include stand-alone data logging equipment that may be used by the CxAg.
 3. Provide information requested by the CxAg regarding Systems sequence of operation and testing procedures.
 4. Review test procedures for Systems installed by factory representatives.
- D. Architect/Engineer

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1. Designate a team member who shall attend the Commissioning kick-off meeting and other necessary meetings scheduled by the CxAg to facilitate the Commissioning process.
2. Provide the Basis of Design (BOD) documentation to the Contractor for inclusion in the O&M Manual(s).
3. Review PFCs and FPTs for Systems to be commissioned.
4. Assist in clarifying the operation and control of commissioned Systems in areas where Project Specifications, control drawings, or equipment documentation are insufficient for writing detailed testing procedures.
5. Review O&M Manual(s) according to the Contract Documents.
6. Provide technical assistance for resolution of non-conformances or deficiencies as appropriate.

E. Commissioning Agent (CxAg)

The primary role of the CxAg is to coordinate the development and execution of the Commissioning Plan, and to observe and document performance of commissioned Systems, in particular, whether Systems are functioning in accordance with the documents design intent and in accordance with the Contract Documents. The CxAg is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CxAg may assist with problem solving non-conformances or deficiencies, but ultimate responsibility for such corrections are the responsibility of the Contractor, Installing Subcontractor(s), manufacturer, and/or Architect/Engineer, as appropriate.

The CxAg will:

1. Develop and maintain the Commissioning Plan.
2. Coordinate the Commissioning activities.
3. Coordinate the Commissioning work and work with the Commissioning Team to ensure that Commissioning activities are being incorporated into the master schedule.
4. Assist with the revisions to the Commissioning Plan.
5. Plan and conduct Commissioning kick-off and coordination meetings.
6. Request and review information required to perform Commissioning tasks, including O&M materials, Contractor start-up and checkout procedures.
7. Prior to start-up operations, gather and review the current control sequences and interlocks and work with the Installing Subcontractor(s) and the

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Architect/Engineer until sufficient clarity has been obtained, in writing, to be able to assure detailed testing procedures are written.

8. Review the submittals of the Contractor and Installing Subcontractor(s) applicable to Systems being commissioned for compliance with Commissioning requirements, along with normal construction submittals.
9. Create, review, approve, and distribute preliminary PFCs.
10. Review the start-up and initial checkout plan for Systems as developed by the Installing Subcontractor.
11. Perform site visits, to observe component and system installations. Attend selected planning and Project construction meetings to obtain information on construction progress. Review Project construction meeting minutes for revisions/substitutions relating to the Commissioning process. Assist in resolving any discrepancies.
12. Review and approve Contractor completed PFC and by selected site observations and spot-checking.
13. Witness system startup by reviewing start-up reports and by selected site observations.
14. Analyze any automation data as well as trend logs and monitoring data to verify performance.
15. Coordinate, witness, and approve FPTs performed by the Installing Subcontractor(s). Coordinate re-testing as necessary until satisfactory performance is achieved.
16. Review equipment warranties to ensure that the Owner's responsibilities are clearly defined and provide a listing of warranties indicating equipment and duration of warranty.
17. Witness and document the training of the Owner's operating personnel. Ensure a sign in sheet for each session is provided and conduct survey after each session.
18. Compile and maintain a Commissioning issues record log. Acceptance of the Commissioning process is dependent on the resolution of all Commissioning issue log items.
19. Review and approve the preparation of the Systems O&M Manual(s) in accordance with Section 01 78 23 as applicable. Compile and provide listing of equipment for the O&M Manual(s).

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20. Provide a final Commissioning Report including suggestions for improvement in the process.
21. Provide benefit and value matrix and identify the Commissioning value matrix in final Commissioning Report.
22. Identify additional areas or Systems that should be included in the warranty manual information provided or in other areas under the Contract Documents.
23. Assist the Owner's personnel in developing reports, documents, and requests for services to remedy outstanding problems.

1.6 SCHEDULING

The CxAg will work with the Commissioning Team to schedule the Commissioning activities. The CxAg will provide sufficient notice to the Commissioning Team for scheduling Commissioning activities. The Contractor shall integrate all Commissioning activities into the master schedule. All parties will address scheduling problems and provide the necessary notifications in a timely manner in order to expedite the Commissioning process.

1.7 QUALITY ASSURANCE

The Contractor and each Subcontractor involved with the commissioning process on the Project will assign a Commissioning Coordinator with at least five (5) years' experience with coordination of construction disciplines and verification testing of complete systems. This position is not a full-time position unless the complexity of the job requires such a full-time position. The Commissioning Coordinator(s) responsibilities shall include:

- A. Coordination meetings.
- B. Planning.
- C. Scheduling.
- D. Documentation.
- E. Maintain close communication and coordination with the CxAg.
- F. Development of testing procedures in coordination with the Installing Subcontractor(s).
- G. Submitting the Contractor's test report submittal to the CxAg.
- H. Completed PFC submittal.
- I. Perform functional performance tests.
- J. Corrective Actions rectification and documentation.
- K. Specified training planning and coordination.

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1.8 QUALITY CONTROL

- A. Ensure that the Contractor and each Installing Subcontractor follows the established Contractor's Quality Control (QC) program and procedures.
- B. Ensure that the Contractor and each Installing Subcontractor corrects all deficiencies and incorporate the necessary adjustments to O&M Manual(s) and as-built drawings for applicable issues identified in any seasonal testing.

1.9 SUBMITTALS

- A. The CxAg will provide the Contractor with specific requests for the type of submittal documentation required to facilitate the Commissioning work. These requests include the submission of electronic versions of all submittals, documents, manuals, etc. and will be integrated into the normal submittal process and protocol of the construction personnel and added to the Contractor's submittal register. At a minimum, each request will include:
 - 1. Manufacturer and model number.
 - 2. Manufacturer's printed installation and detailed start-up procedures.
 - 3. Full sequences of operation.
 - 4. O&M data.
 - 5. Performance data.
 - 6. Any performance test procedures.
 - 7. Control drawings.
 - 8. Details of Owner contracted tests.
 - 9. List of installation materials that are shipped with the equipment.
 - 10. Field checkout sheet forms to be used by the factory or field technicians.
 - 11. Factory test results.
- B. All documentation requested by the CxAg will be included in each Installing Subcontractor(s) contributions to the O&M Manual(s).
- C. The CxAg will review and comment on submittals related to the commissioned Systems for conformance to the Contract Documents as it relates to the Commissioning process, to the functional performance of the Systems, and to adequacy for developing test procedures. This review is intended primarily to aid in the development of FPT procedures and only secondarily to verify compliance with the Systems specifications.
- D. The Contractor shall ensure that each Installing Subcontractor(s) designates a Commissioning Coordinator and provides information facilitating the incorporation

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- and coding identification of Commissioning activities in the Construction Schedule within four (4) weeks of the Notice to Proceed (NTP).
- E. The Contractor shall submit a detailed verification testing schedule to the CxAg at least four (4) weeks prior to start of testing.
 - F. The Contractor shall ensure that each Installing Subcontractor(s) submits test reports through the Contractor to the CxAg upon successful completion of each test.
 - G. The Contractor shall ensure that each Installing Subcontractor(s) submits information for the O&M Manual(s) (format, content, and organization) through the Contractor to the Architect/Engineer and the CxAg for review within at least ninety (90) Calendar Days prior to Substantial Completion and/or commencement of training.
 - H. The Contractor and each Installing Subcontractor(s) shall submit the O&M Manual(s) in accordance with the individual Specification Sections requiring an O&M Manual(s) and Section 01 78 23.
 - I. The supplier and Installing Subcontractor shall certify that the installed and operating Systems have been completed (with all deficiencies corrected) and that they are performing to in accordance with the Contract Documents including all tests and other requirements stipulated therein.

1.10 TRAINING

- A. The Contractor shall coordinate O&M training activities through the Commissioning Team.

The Contractor shall provide training plans for equipment software systems and major components as specified in individual Project Specifications a minimum of ninety (90) Calendar Days prior to Substantial Completion.
- B. The Training Plan shall include:
 - 1. Equipment or Systems involved in training session.
 - 2. Trainer's name, company, and experience.
 - 3. Course outline/syllabus and list of training materials.
 - 4. Time required for the training session(s).
- C. Suggested Training Topics:
 - 1. Preventive maintenance procedures and frequencies.
 - 2. Visual inspection parameters including operating sound and noise warnings.
 - 3. Normal range of gauge and meter readings.
 - 4. Use of special tools.
 - 5. Source of operating supplies, lubricants, cleaning materials, etc.
 - 6. Manufacturer contact names and telephone numbers.

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7. Warranty periods and enforcement procedures.
 8. Design and normal functional operating parameters (capacities, flows, temperatures, speeds, energy consumption, etc.
 9. Breakdown or malfunction conditions and troubleshooting.
 10. Routine testing procedures.
- D. The Contractor shall document performance of training session by completing the O&M training form provided by the OAR. Indicate on the form:
1. Date of training.
 2. List of attendees and their affiliation.
 3. Planned duration of training (hours and/or minutes).
 4. Topics agenda, instructor names & company affiliation, instructor contact information.
 5. Detailed list of planned handouts.
- E. The Contractor shall record all training sessions and submit for review and approval in accordance with Section 01 79 00 and submit the final documentation after incorporating all edits required by the review in accordance with Section 01 79 00 with a fully executed O&M training form.

PART 2 – PRODUCTS

2.1 TEST EQUIPMENT

- A. The Contractor or Installing Subcontractor shall provide all standard testing equipment required to perform startup and initial checkout and as required by the FPTs.
- B. The Contractor or Installing Subcontractor shall provide special equipment, software, tools, and instruments that are only available from the supplier and specific to a piece of testing equipment (test tools) required for adequate testing. The cost of such test tools shall be included in the base bid price to the Contractor and will become the property of the Owner when testing is complete.
- C. The Contractor or Installing Subcontractor shall repair any damage to these test tools and calibrate the tools so they are fully functional when turned over to the Owner and provide full documentation on the use, maintenance and calibration with these test tools.
- D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Contract Documents.

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- E. Calibration records for all testing equipment shall be provided to the CxAg through the Contractor.

PART 3 – EXECUTION

3.1 MEETINGS

A. Commissioning Kick-Off Meeting

Approximately 30-60 Calendar Days prior to start-up of construction or installation of the Systems to be commissioned, the CxAg will schedule, plan and conduct a Commissioning Kick-off meeting with the entire Commissioning Team in attendance. Multiple meetings may be required due to multiple features of systems as the construction progresses. The Contractor shall prepare and distribute meeting minutes to all parties. Information gathered from this meeting will allow the CxAg to revise the Commissioning Plan to its “final” version, which will also be distributed to all parties.

B. Miscellaneous Meetings

Additional meetings may be planned and conducted by the CxAg as construction progresses covering such topics as coordination, deficiency resolution, and planning issues with the respective Installing Subcontractor(s).

3.2 REPORTING

- A. The CxAg will provide regular updates and reports to the Commissioning Authority and OAR.

- B. The CxAg will regularly communicate with all members of the Commissioning Team to apprise them of the Commissioning progress and scheduling changes through memos, progress reports, etc.

- C. The CxAg will prepare Field Observation Reports (FORs) and issues log records with the review and testing as described in this Section.

- D. A final Commissioning Report by the CxAg will be provided focusing on evaluating the Commissioning process issues and identifying areas where the process could be improved. All acquired documentation, logs, minutes, reports, FORs, communications, findings, unresolved issues, etc., will be compiled in appendices and provided with the report. PFCs, FPTs, and monitoring reports will be part of the final Commissioning Report.

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3.3 SYSTEMS TO BE COMMISSIONED

A. The systems to be commissioned by the CxAg are listed below:

System	Quantity	Sampling Rate
Drain Inlets ¹	1	100%
Storm Drain Piping ¹	1 Lot	100%

1. Commissioning of the drainage systems will be limited to visual observations of installation and sloping.

B. The systems to be commissioned listed above are based on the Contract Documents provided at the time of this Specification development. Reference the Commissioning Plan for any alterations or changes made during the design and construction processes.

3.4 CONTRACTOR TESTS

- A. The Contractor shall ensure that each Installing Subcontractor and suppliers provide a list and schedule of specified Contractor tests to the CxAg.
- B. The Contractor shall provide a minimum of three (3) days' notice to the CxAg prior to QA/QC inspection of installed drainage systems.
- C. Unless specified otherwise, the Contractor shall provide a minimum of four (4) weeks' notice to the CxAg prior to execution of specified Contractor's tests.
- D. The Contractor shall submit test reports to the CxAg and the Architect/Engineer within one (1) week of completion of each test.

3.5 SUBSTANTIATING SYSTEM READINESS

The Contractor shall:

- A. Construct or install Systems and confirm readiness for testing prior to start of verification test procedures.
- B. Inform the CxAg in writing of the System readiness for verification testing at least four (4) weeks prior to the scheduled start of testing. Complete the PFCs and submit to CxAg.
- C. Perform and document instrumentation and digital controller calibration or provide documentation verifying manufacturer's performance of calibration prior to verification testing. The CxAg may observe calibration procedures.
- D. Not commence with any system verification testing until such System is documented ready for testing via submittal of the PFC to the CxAg.

3.6 START-UP, PRE-FUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

The following procedures apply to all equipment and systems to be commissioned as part of the Project.

A. The Installing Subcontractor(s) responsible for startup of any System shall develop detailed start-up plans for all equipment which are a part of that System. Each piece of equipment will receive a full pre-functional checkout. The CxAg will assist in the development of detailed start-up plan to ensure that each of the manufacturer-recommended procedures has been completed. The parties responsible for the PFC and startup will be identified in the Commissioning kick-off meeting and in the PFC. The party responsible for executing FPTs are identified in the testing requirements.

1. The CxAg will assist in the development of checklists that indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.
2. The Contractor shall determine which Installing Subcontractor is responsible for executing and documenting each of the line items tasks and shall note the responsible party on the form. Each form may have more than one party responsible for its execution.
3. The Contractor shall ensure that the Installing Subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining or adding to the Architect/Engineer checklists with the manufacturer's detailed start-up and checkout procedures from the O&M Manual and the normal field checkout sheets.

The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.

The full start-up plan may consist of:

- a. The PFCs.
- b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
- c. The manufacturer's normal field checkout sheets.
4. The Contractor shall ensure that the Installing Subcontractor submits the full start-up plan to the CxAg for review and approval.
5. The CxAg will review and approve the procedures and the format for documenting them, noting any procedures that need to be added.

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6. The full start-up procedures and the approval form may be provided to the Contractor for review and approval, depending upon the management protocol.
- B. Execution of PFCs and Start-up.
1. Two (2) weeks prior to start-up, the Contractor, the Installing Subcontractor(s) and suppliers will schedule start-up and checkout with the CxAg. The performance of the PFCs, startup, and checkout are directed and executed by the Installing Subcontractor or supplier with oversight by the Contractor. When checking off PFCs, signatures may be required of other Installing Subcontractors for verification of completion of work.
 2. The CxAg shall observe the procedures for each piece of primary equipment, unless there are multiple units, whereby a statistical sampling strategy may be used as approved.
 3. The CxAg may observe a sampling of the PFCs and start-up procedures for lower-level components of System equipment.
 4. The Contractor, in conjunction with Installing Subcontractor(s), and suppliers shall execute start-up and provide the CxAg with a signed and dated copy of the completed start-up and pre-functional tests and PFCs.
 5. Only individuals with direct knowledge and witnessed that a line-item task on the PFC was actually performed shall initial or check that item off.
- C. Deficiencies, Non-conformance and Approval in Checklists and Start-up.
1. The Contractor shall ensure that the Installing Subcontractor clearly lists any outstanding items of the initial start-up and pre-functional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies shall be submitted to the CxAg within two (2) Working Days of the test completion.
 2. The Contractor and the CxAg shall review the report and submit either an NCR or an approval to the Installing Subcontractor. The Contractor and CxAg shall work with the Installing Subcontractor to correct test deficiencies or incomplete items. The Installing Subcontractor or suppliers shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CxAg as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original NCR. When satisfactorily completed, the CxAg will recommend approval of the execution of the checklists and start-up of each system using a standard form.

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D. Pre-functional Test Form

After the initial Systems submittal phase, the CxAg shall prepare Pre-Functional Test forms for each item of Systems equipment as part of the Commissioning process.

The Contractor shall review the respective Pre-Functional Test forms for accuracy, completeness, and provide comments to the CxAg.

3.7 VERIFICATION/FUNCTIONAL PERFORMANCE TESTS

A. Objective

The objective of Functional Performance Tests (FPTs) and verification tests is to demonstrate that each System is operating according to the documented design intent and the requirements within the Contract Documents. Functional testing facilitates bringing the Systems from a state of Substantial Completion to full dynamic operation. Each System shall be operated through all modes of operation where there is a specified System response. The Contractor or Installing Subcontractor shall verify each sequence within the sequences of operation.

B. FPTs and verification testing may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results. The CxAg will determine which method is most appropriate for tests that do not have a method specified. Simulating conditions shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical. Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Contractor and the Installing Subcontractor executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Contractor and the Installing Subcontractor shall return all affected Systems, due to these temporary modifications, to their pre-test condition.

C. The Contractor and the Installing Subcontractor shall perform verification test procedures as outlined in the approved Commissioning Plan and FPTs.

D. The Installing Subcontractor shall provide input into the Contractor's master scheduling process with regards to timing and duration of verification test procedures.

E. The CxAg will review any comments provided by the Contractor on the FPT procedures. The CxAg will schedule FPT review meetings as necessary to clarify any open items from the FPT review. The CxAg will provide feedback on the

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efficiency of the procedures and possible alternate approaches to achieving the same results.

3.8 FUNCTIONAL PERFORMANCE TEST FORMS

- A. The Contractor and the Installing Subcontractor(s) shall provide personnel and equipment, to perform the FPT procedures. After the completion of the Pre-Functional Checklist forms, the CxAg will prepare FPT forms for each System which is a part of the Commissioning process. The Contractor shall review the respective FPT forms for accuracy, completeness, and provide comments to the CxAg.
- B. Sample FPT forms are required with each Commissioning Plan submission for acceptance.

3.9 CORRECTIVE ACTIONS

- A. The Contractor shall perform or ensure the Installing Subcontractor(s) or suppliers provide Corrective Actions for the resolution of deficiencies identified in the Commissioning Issue Log.
- B. The CxAg will document deficiencies discovered during the Commissioning process on an Issue Log within one (1) Working Day of discovery.
 - 1. Deficiency Identification Process:
 - a. Document date of identification.
 - b. Describe nature of deficiency.
 - c. Distribute original Issue Log to the Installing Contractor's Commissioning Coordinator.
 - d. Distribute copies to:
 - 1) Contractor
 - 2) Architect/Engineer
 - 3) Other contractors impacted by deficiency.
 - 2. The Contractor shall ensure the Installing Subcontractor performs the following:
 - a. Obtains the original form.
 - b. Records the date of direction.
 - c. Provides a description of Corrective Action required.
 - d. Records the name of person issuing the direction.
 - e. Determines the estimated date to complete the Corrective Action.
 - f. Distributes the original form to CxAg.
 - g. Distributes copies of the form to:
 - 1) Architect/Engineer
 - 2) Contractor

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- 3) Installing Subcontractor's Commissioning Coordinator
 - 4) Other contractors impacted by the deficiency
 - 3. The Contractor shall ensure the Installing Subcontractor or supplier completes the following actions when Corrective Actions are completed by the Installing Subcontractor, supplier, and/or the Contractor:
 - a. Obtains the original form.
 - b. Records date of correction.
 - c. Provides a description of final equipment status or Corrective Action performed.
 - d. Records the name of Installing Subcontractor that performed the work.
 - e. Submits the original form using normal submittal procedures through the Contractor to the CxAg.
 - f. Distributes copies of the form:
 - 1) Architect/Engineer
 - 2) Contractor's Commissioning Coordinator.
 - 3) Commissioning Coordinator for the Installing Subcontractor or the supplier
 - 4) Other contractors impacted by the deficiency.
 - 4. The CxAg will perform a verification of the Corrective Action completion and record:
 - a. Date of the retest.
 - b. Determined status - Resolved or Corrective Action required.
 - c. Name of person performing verification.
 - d. Distributes copies to:
 - 1) Architect/Engineer
 - 2) Installing Contractor's Commissioning Coordinator.
 - 3) Contractor.
 - 4) Other contractors impacted by deficiency.
- C. Cost of Retesting

The cost for retesting a FPT due to the action of, or a deficiency caused by, the Contractor or Installing Subcontractor shall be the sole responsibility of the Contractor. Any costs for retesting not due to the actions of, or a deficiency caused by, the Contractor or Installing Subcontractor, may be negotiated with the Owner in accordance with the Contract Documents.
- D. Failure Due to Manufacturer Defect

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If ten (10) percent or three (3) of any individual item (size alone does not constitute a difference), whichever is greater, fails to perform in accordance with the Contract Documents (mechanically or substantively) due to manufacturing defect, which in the sole determination of the OAR renders the item unable to meet its performance requirements, all identical units will be considered unacceptable. In such a case, the Contractor shall provide the OAR and CxAg with the following:

1. Within one (1) week of notification, the Installing Subcontractor or manufacturer's representative shall examine all other identical units and record the findings. The findings shall be provided within two (2) weeks of the original notice.
2. Within two (2) weeks of the original notification, the Installing Subcontractor or manufacturer's representative shall provide a signed and dated, written explanation of the problem, cause of failure, and all proposed solutions including full equipment submittals of the original installation.
3. The OAR is solely responsible to determine whether a replacement of all identical units or a repair is acceptable.
4. Upon acceptance of a solution to the deficiency or non-conformance, the Contractor, Installing Subcontractor, and/or manufacturer's representative shall replace or repair all identical items and extend the warranty accordingly, if the original equipment warranty had begun, at no cost to the Owner. The replacement/repair work shall proceed with reasonable speed beginning within one (1) week from when parts can be obtained.

E. Approval

The CxAg notes each satisfactorily demonstrated FPT on the test form. The CxAg recommends acceptance of each test using a standard form. The OAR will provide any final approval on each test using the same form and will provide a signed copy to the CxAg and the Contractor.

3.10 SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

Not Used.

3.11 OPERATION AND MAINTENANCE MANUALS

- A. The following O&M Manual requirements do not replace O&M Manual documentation requirements elsewhere in the respective Project Specification Sections. Reference specification section 01 78 23 for additional O&M submission requirements.

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- B. The Architect/Engineer shall compile and prepare design documentation for all Systems specified in each division of the Specification Sections and deliver this documentation to the Contractor for inclusion in the O&M Manual(s) prior to the training of Owner personnel.
- C. The CxAg shall receive a digital copy of the O&M Manual(s) related to the commissioned systems for review.

3.12 TRAINING OF OWNER PERSONNEL

- A. The Contractor shall be responsible for training coordination, scheduling, and ultimately to ensure that training of the Owner's personnel is completed in accordance with the requirements of this Section.
- B. The CxAg shall be responsible for witnessing the content and adequacy of the training of the Owner personnel for commissioned Systems.

3.13 WRITTEN WORK PRODUCTS

The Contractor's written work products shall consist of the start-up and initial checkout plan described and the completed start-up, initial checkout and PFCs, manufacturer's factory documentation and testing; field testing inspection forms, Contractor inspection forms, and O&M Manual(s) both in electronic and hard copy in accordance with this Section. These work products shall be submitted to the CxAg to be included in the final Commissioning Report as required.

PART 4 – FORMS

The forms and documents to be used for the Commissioning processes shall be in accordance with the Building Commissioning Association (BCA), AABC Commissioning Group (ACG), National Environmental Balancing Bureau (NEBB), American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), or the University of Wisconsin or as otherwise provided or approved for the Project by the CxAg and the OAR.

- A. Provide pictures of equipment and issues identified in the field.
- B. Provide demonstration of trend logging performance of the building automation system.
- C. Maintain consistency throughout Commissioning Plan and final Commissioning Report for all approved forms.
- D. Provide digital hyperlinks for all Commissioning Report sections

PART 5 – MEASUREMENT AND PAYMENT

Not Used.

– END OF SECTION –