SECTION 01 91 00
COMMISSIONING REQUIREMENTS
Construction Specifications

PART 1 GENERAL

1.1 INTRODUCTION

A. Commissioning: Commissioning is a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meet defined objectives and criteria. The Commissioning process begins at project inception (during the pre-design phase) and continues through the life of the facility. The commissioning process includes specific tasks to be conducted during each phase in order to verify that design, construction, and training meets the owner's project requirements.

B. Commissioning Team: The members of the commissioning team consist of the owner contracted commissioning agent (CxA), the owner's representative/construction manager (CM), the general contractor (GC), the architect and design engineers, the mechanical contractor (MC), the electrical contractor (EC), the testing and balancing (TAB) contractor, the control contractor (CC), the facility operating staff, and any other installing subcontractors or suppliers of equipment. The contracted commissioning agent is hired by the owner directly. The CxA directs and coordinates the project commissioning activities and the reports to the owner. All team members work together to fulfill their contracted responsibilities and meet the objectives of the contract documents.

C. Services related to commissioning and testing specified under Title 24 are to be provided by the contractor, verified by the owners CxA.

Commissioning shall:

1. Verify that applicable equipment and systems are installed according to the contract documents, manufacturer's recommendations, and industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.

2. Verify and document proper performance of equipment and systems.

3. Verify that O&M documentation left on site is complete.

4. Verify that the owner's operating personnel are adequately trained.

D. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Supplementary Conditions and other Division 1 specification sections, apply to this section.

B. Owner's Project Requirements and Basis of Design documents are included by reference for information only.

C. ASHRAE Guideline 0-2013 or superseding ASHRAE guideline

D. Title 24/2016 Section 120.8 or superseding CA Title 24 requirement

1.3 SUMMARY

A. This section includes general requirements that apply to the implementation of the commissioning process without regard to specific systems, assemblies, and components.

B. Related sections include the following:

1. Division 22 Section 220800 "Plumbing Commissioning Requirements" for commissioning process activities for building systems, assemblies, equipment, and components.

2. Division 23 Section 230800 "HVAC Commissioning Requirements" for commissioning process activities for building systems, assemblies, equipment, and components.

3. Division 25 Section 255500 "Facility Management Systems" for commissioning process activities.

4. Division 26 Section 260800 "Electrical Commissioning Requirements" for commissioning process activities for building systems, assemblies, equipment, and components.

1.4 DEFINITIONS

Acceptance - A formal action, taken by a person with appropriate provider (which may or may not be contractually defined) to declare that some aspect of the project meets defined requirements, thus permitting subsequent activities to proceed.

Approval - Acceptance that a piece of equipment or system has been properly installed and is functioning in the tested modes according to the contract documents.

Basis of Design - A document that records the concepts, calculations, decisions, and product selections used to meet the owner’s project requirements and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.

Checklists - Verification checklists that are developed and used during all phases of the commissioning process to verify that the owner’s project requirements are being achieved. This includes checklists for general verification, plus testing, training, and other specific requirements.

Commissioning Authority (CxA) - The entity identified by the owner who leads, plans, schedules, and coordinates the commissioning team to implement the commissioning process.

Commissioning Plan - An overall plan developed by the commissioning agent that provides the structure, schedule and coordination planning for the commissioning process.

Commissioning Process - A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements.

Commissioning Process Activities - Components of the commissioning process.

Commissioning Process Progress Report - A written document that details activities completed as part of the commissioning process and significant findings from those activities that is continuously updated during the course of a project. Usually it is incorporated into the commissioning plan as an ongoing appendix.

Commissioning Team - The individuals who through coordinated actions are responsible for implementing the commissioning process.

Construction Checklist - A form used by the contractor to verify that appropriate components are on-site, ready for installation, correctly installed, and functional.

Construction Documents - This includes a wide range of documents, which will vary from project to project, with the owner's needs and with regulations, laws, and countries. Construction documents usually include the project manual (specifications), plans (drawings) and general terms and conditions of the contract.

Continuous Commissioning Process - A continuation of the commissioning process well into the occupancy and operations phase to verify that a project continues to meet current and evolving owner's project requirements. Continuous commissioning process activities are on-going for the life of the facility. Also see On-Going Commissioning Process.

Contract Documents - This includes a wide range of documents, which will vary from project to project, with the owner's needs and with regulations, laws, and countries. Contract documents frequently include price agreements, construction management process, sub-contractor agreements or requirements, requirements and procedures for submittals, changes, and other construction requirements, timeline for completion, and the construction documents.

Coordination Drawings - Drawings showing the work of all trades to illustrate that equipment can be installed in the space allocated without compromising equipment function or access for maintenance and replacement. These drawings graphically illustrate and dimension manufacturers' recommended maintenance clearances.

Control system - A component of environmental, HVAC, security, and fire systems for reporting/monitoring and issuing of commands to/from field devices.

Data logging -The monitoring and recording of flows, currents, status, pressures, etc., of equipment using stand-alone data recorders separate from the control system or the trending capabilities of control systems.

Deferred Performance Tests (DPTs) - Performance tests that are performed, at the discretion of the CxA, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design, or other site conditions that disallow the test from being performed.

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.

Factory Testing - Testing of equipment on-site or at the factory, by factory personnel, with or without an owner's representative present.

Issues Log - A formal and ongoing record of problems or concerns – and their resolution – that have been raised by members of the commissioning team during the course of the commissioning process.

Nominal Group Technique - A formal, structured brainstorming process used to obtain the maximum possible ranked input from a variety of viewpoints in a short period of time. The typical approach is a workshop session where a question is presented, the attendees each record their responses on a piece of paper, the individual responses are recorded on a flip chart without discussion in a round robin fashion, all of the responses are discussed, and the participants rank their top five responses.

Non-Compliance - See Deficiency.

Non-Conformance - See Deficiency.

On-Going Commissioning Process - A continuation of the commissioning process well into the occupancy and operations phase to verify that a project continues to meet current and evolving

owner's project requirements. On-going commissioning process activities occur throughout the life of the facility. Some of these will be close to continuous in implementation, and others will be either scheduled or unscheduled (as needed).

Owner's Project Requirements - A written document that details the functional requirements of a project and the expectations of how it will be used and operated. This includes project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information. (The term "Project Intent" is used by some owners for their commissioning process owner's project requirements or design.)

Over-ridden Value -Riding over a sensor value in the equipment's controls to observe the response of the equipment's operation.

Phased Commissioning - Commissioning that is completed in phases as required by the phasing plan as approved for the project and other scheduling issues.

Quality Based Sampling - A process for evaluating a sub-set (sample) of the total population. The sample is based upon a known or estimated probability distribution of expected values; an assumed statistical distribution based upon data from a similar product, assembly, or system; or a random sampling that has scientific statistical basis.

Re-Commissioning - An application of the commissioning process requirements to a project that has been delivered using the commissioning process. This may be a scheduled re- commissioning developed as part of an ongoing commissioning process, or it may be triggered by use change, operations problems, or other needs.

Retro-Commissioning -The commissioning process applied to an existing facility that was not previously commissioned. This guideline does not specifically address retro-commissioning. However, the same basic process needs to be followed from pre-design through occupancy and operations to optimize the benefits of implementing the commissioning process philosophy and practice.

Seasonal Performance Tests - Performance tests that are deferred until the system(s) will experience conditions closer to their design conditions based on weather conditions.

Simulated Condition - Condition that is created for the purpose of testing the response of a system (e.g., raising/lowering the setpoint of a thermostat to see the response in a VAV box).

Simulated Signal - Disconnecting a sensor and using a signal generator to simulate a sensor value for the purpose of testing a full range of conditions.

Startup - The initial starting or activating of dynamic equipment, including completing construction checklists.

Systems Manual - A system-focused composite document that includes the operation manual, maintenance manual, and additional information of use to the owner during the occupancy and operations phase.

Test Procedure - A written protocol that defines methods, personnel, and expectations for tests conducted on components, equipment, assemblies, systems, and interfaces among systems. The test procedures are specified in the Technical Specifications sections of the contract documents. Performance testing covers the dynamic functions and operations of equipment and systems using manual or monitoring methods. Performance testing is the dynamic testing of systems under full operation. Systems are tested under various modes, such as during low cooling loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to respond as the sequences state.

Training Plan - A written document that details the expectations, schedule, budget, and deliverables of commissioning process activities related to training of project operating and maintenance personnel, users, and occupants.

Verification - The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the Owner's Project Requirements.

Trending – The monitoring, by a building management system or other electronic data gathering equipment, and analyzing of the data gathered over a period of time.

Vendor - Supplier of equipment.

Warranty Period - Refer to General Conditions.

1.5 COORDINATION

A. Project Commissioning Team - The members of the project commissioning team will consist of the commissioning authority and any support personnel, the construction manager, the owner's facility staff (FS) or designee, the general contractor, subcontractors and/or vendors as required, and the architect/ engineer (A/E).

B. Management - The CxA coordinates the commissioning activities through the construction manager. All members shall work together to fulfill their contracted responsibilities and meet the objectives of the contract documents. Refer to Paragraph 1.06 for additional management details.

C. Scheduling - The CxA, through the owner or CM, will provide sufficient notice to the contractor for scheduling commissioning activities with respect to the owner's participation. The contractor will integrate all commissioning activities into the overall project schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.

1.6 COMISSIONING PLAN

A. The CxA will develop the commissioning plan which shall be included in the project schedule when approved by the owner or CM. 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 an initial commissioning meeting conducted by the CxA where the commissioning process is reviewed with the project commissioning team members.

2. Additional meetings will be required throughout construction, scheduled by the CxA, through the owner or CM, with necessary parties attending to plan, scope, coordinate, schedule future activities and resolve problems.

3. Equipment documentation is submitted to the CxA, through the owner or CM, during normal submittals, including detailed startup procedures.

4. The construction checklists and pre functional checklists are to be completed by the contractor (or its subcontractors), before and during the startup process.

5. Construction checklists, TAB and startup must be completed before performance testing.

6. Items of non-compliance in material, installation, or setup shall be corrected at no

expense to the owner.

7. The contractor ensures that the subcontractors' construction checklists are executed and documented and that startup, pre functional checks and initial checkout are performed. The CxA verifies that the TAB, construction checklists and startup were completed according to the approved plans. This includes the CxA approving TAB, checklists and startup plans and pre functional tests. This also includes witnessing startup of selected equipment. Any testing failure is to be corrected at no additional cost to the owner, and a re-test is to be performed, observed, and documented.

8. The CxA develops functional performance test procedures. The forms and procedures are approved by the owner, EOR and the executing contractor.

9. The performance tests are executed by the contractor under the direction of the CxA with the assistance of the facility staff. All documentation is by the CxA.

10. The CxA reviews the O&M documentation for completeness and provides the commissioning record for the O&M manuals.

11. Commissioning should be completed before substantial completion

12. The CxA reviews, pre-approves, and reviews the training provided by the contractor. The contractor is responsible to coordinate the logistics and timing of the training with the owner, considering the ongoing operation of the facilities, if required.

13. Deferred testing is conducted as specified or required.

1.7 COMMISSIONING TEAM

A. Members appointed by contractor(s): Individuals, each having authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated actions. The commissioning team shall consist of, but not be limited to, representatives of each contractor, including project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.

B. Members appointed by owner:

1. CxA - An entity identified by the owner who leads, plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the CxA under a separate contract.

2. Representatives of the facility user and operation and maintenance personnel.

3. Architect and engineering design professionals.

1.8 RELATED REQUIREMENTS

A. General Conditions - Submittal Procedures

B. General Conditions - Progress Schedules and Reports

C. General Conditions - Contract Closeout

D. General Conditions - Project Record Documents

E. General Conditions - Guaranty

1.9 RESPONSIBILITIES

A. The general responsibilities of various parties in the commissioning process are provided in this sub-section. The specific responsibilities are in the Technical Specifications.

B. All Parties

1. Follow the commissioning plan.

2. Attend initial commissioning meeting and additional meetings as necessary.

C. Architect (of A/E)

Design Phase

1. Perform a design phase review of the design by an independent engineer not involved in the design process independent from the size of the project. For project larger then 50,000sf provide the results to an independent third party reviewer and/or the CxA.

2. Respond and manage all issue raise by the owner and their representatives, including but not limited to CM, A&E, and the CxA.

Construction Phase

3. Attend the commissioning scoping meeting and selected commissioning team meetings.

4. Perform normal submittal review, construction observation, as-built drawing preparation, O&M manual preparation, etc., as contracted.

5. Provide any design narrative documentation requested by the CxA.

6. Coordinate resolution of system deficiencies identified during commissioning, according to the contract documents.

7. Prepare and submit final as-built design intent documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.

D. Mechanical and Electrical Designers/Engineers (of the A/E or DB entity)

Construction Phase

1. Perform normal submittal review, construction observation, as-built drawing preparation, etc., as contracted. One site observation should be completed just prior to system startup.

2. 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.

3. Attend commissioning scoping meetings and other selected commissioning team meetings.

4. Participate in the resolution of system deficiencies identified during commissioning, according to the contract documents.

5. Prepare and submit the final as-built design intent and operating parameters documentation for inclusion in the O&M manuals. Review and approve the O&M

manuals.

6. From the contractor's red-line drawings, edit and update one-line diagrams developed as part of the design narrative documentation and those provided by the vendor as shop drawings for the chilled and hot water, condenser water, domestic water, steam and condensate systems; supply, return and exhaust air systems and emergency power system.

7. Provide a presentation at one of the training sessions for the owner's personnel.

8. Review and approve the construction checklists for major pieces of equipment for sufficiency prior to their use.

9. Review and approve the performance test procedure forms for major pieces of equipment for sufficiency prior to their use.

10. Witness testing of selected pieces of equipment and systems

Occupancy and Operations Phase

11. Participate in the resolution of non-compliance, non-conformance and design deficiencies identified during commissioning during warranty-period commissioning.

12. Attend lessons learned session

E. Commissioning Authority (CxA)

The contractors will provide all tools or the use of tools to start, check-out and test equipment and systems, except for specified testing with portable data-loggers, which shall be supplied and installed by the CxA.

The CxA will verify the execution of commissioning process activities using random sampling. The sampling rate may vary from 1 to 100 percent. Verification will include, but is not limited to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, CxA will report the failure in the "Issues Log."

Design Phase

1. Review the design provided by the A/E team for compliance with OPR. Provide at least one check and one back check during design development and for the 90% construction documents.

2. Assist in the creation of the owner developed OPR as needed

Construction Phase

1. Coordinates and directs the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.

2. Coordinate the commissioning work and, with the GC and owner/CM, provide assistance in integrating commissioning activities into the master schedule.

3. Revise the Construction Phase Commissioning Plan as necessary.

4. Plan and conduct a commissioning scoping meeting and other commissioning meetings.

5. Request and review additional information required to perform commissioning tasks, including O&M materials, contractor startup and checkout procedures.

6. Before startup, gather and review the current control sequences and interlocks and work with contractors and design engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.

7. Review and approve normal contractor submittals applicable to systems being commissioned for compliance with commissioning needs, concurrent with the A/E reviews whenever possible.

8. Review and approve the startup and initial systems checkout plan with subcontractors. The plan shall be developed by the contactor and presented at least 4 weeks prior to startup

9. Perform site visits, as necessary, to observe component and system installations. Attend selected planning and job-site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.

10. Witness parts of the HVAC piping test and flushing procedure, sufficient to be confident that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify owner/CM of any deficiencies in results or procedures.

11. Witness part of ductwork testing and cleaning procedures, sufficient to be confident that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify owner's project manager of any deficiencies in results or procedures.

12. Approve construction checklist and pre functional testing completion by selected site observation and spot checking.

13. Recommend approval of systems startup by reviewing startup reports and by selected site observation.

14. Review TAB execution plan.

15. Oversee sufficient testing of the control system and approve it to be used for TAB, before TAB is executed.

16. Recommend approval of air and water systems balancing by spot testing, by reviewing completed reports and by selected site observation.

17. With necessary assistance and review from installing contractors, write the performance test procedures for equipment and systems, including energy management control system trending, stand-alone data logger monitoring or manual performance testing.

18. Analyze any performance trend logs and monitoring data to verify performance where needed.

19. Coordinate, witness, and recommend approval of manual performance tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved

20. Maintain a master Issues Log and a separate testing record. Provide the owner/ CM with written progress reports and test results with recommended actions.

21. Review equipment warranties to ensure that the owner's responsibilities are clearly defined.

22. Oversee and approve the training of the owner's operating personnel.

23. Review and approve the preparation of the O&M manuals.

24. Provide a final commissioning report (as described in this section).

25. Coordinate the development of a systems manual

Occupancy and Operations Phase

1. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.

2. Return to the site at 10 months into the 12 month warranty period and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. Also interview facility staff and identify problems or concerns they have operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract. Assist facility staff in developing reports, documents and requests for services to remedy outstanding problems.

3. Assist in the development of a preventative maintenance plan, a detailed operating plan or an energy and resource management plan or as-built documentation.

4. Attend lessons learned session

F. Owner or Owner's Representative (CM)

Construction and Acceptance Phase

1. Facilitate the coordination of the commissioning work by the CxA, and, with the GC and CxA, ensure that commissioning activities are being scheduled into the master schedule.

2. Review and approve the final Commissioning Plan—Construction Phase.

3. Attend a commissioning scoping meeting and other commissioning team meetings.

4. Perform the normal review of contractor submittals.

5. Furnish a copy of all construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CxA.

6. Review and approve the performance test procedures submitted by the CxA, prior to testing.

7. When necessary, observe and witness startup and performance testing of selected equipment.

8. Review commissioning progress and deficiency reports.

9. Coordinate the resolution of non-compliance and design deficiencies identified in all

phases of commissioning.

10. Sign-off (final approval) on individual commissioning tests as completed and passing. Recommend completion of the commissioning process to the Project Manager.

11. Assist the GC and CxA in coordinating the training of owner personnel.

12. Provide the OPR documentation to the CxA and the A/E team for information and use.

13. Provide the BoD documents, prepared by Architect and approved by owner, to the CxA and all contractor for use in developing the commissioning plan, systems manual, and operation and maintenance training plan.

14. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.

Occupancy and Operations Phase

1. Assist the CxA as necessary in the seasonal or deferred testing and deficiency corrections required by the specifications.

2. Attend lessons learned session

G. Owner's Project Manager (PM)

Construction Phase

1. Manage the contract of the A/E and of the GC.

2. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions.

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

Occupancy and Operations Phase

1. Ensure that any seasonal or deferred testing and any deficiency issues are addressed.

2. Attend lessons learned session

H. Contractor.

Each Contractor and their subcontractors and vendors shall assign representatives with expertise and authority to act on their behalf and schedule them to participate in and perform commissioning process activities including, but not limited to, the following:

Construction Phase

1. Facilitate the coordination of the commissioning and incorporate commissioning activities (the Commissioning Plan) into the Overall Project Schedule (OPS).

2. Provide detailed startup and pre functional test procedures to the CxA for review and approval.

3. Include the cost of commissioning in the total contract price.

4. Ensure that all subcontractors and vendors execute their commissioning responsibilities according to the contract documents and the OPR.

5. Provide copies of all submittals as required including all changes thereto.

6. Attend and participate in commissioning team meetings held as requested by the CxA.

7. No later than 30 days prior to startup of the first piece of major equipment, meet with the CxA, CM, A/E, PM and owner to finalize the detailed commissioning procedures/ schedule.

8. Assist in the coordination for the training of owner personnel.

9. Execute previously submitted and approved construction checklists and pre functional tests.

10. Provide and log construction checklists and pre functional tests records as work is completed and provide the records to the CxA and CM weekly.

11. Execute CxA provided commissioning functional test procedures with CxA present during testing.

12. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.

13. Cooperate with the CxA for resolution of issues recorded in the “Issues Log” or “Deficiency Log”.

14. Prepare O&M manuals, according to the contract documents, including clarifying and updating the original sequences of operation to as-built/as-tested conditions.

Occupancy and Operations Phase

1. Ensure that subcontractors provide assistance for seasonal or deferred performance testing, performed by the CxA, according to the specifications.

2. Ensure that subcontractors correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

3. Perform all guarantee work for materials furnished under the contract for the time specified in the contract, including all warranties and curing all latent defects within the time period provided in the contract.

I. Vendors/Subcontractors

1. Provide all requested submittal data, including detailed startup procedures and specific responsibilities of the owner to keep warranties in force.

2. Assist in equipment testing per agreements with subcontractors and/or contractor.

3. Include cost of all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing, operating, and maintaining equipment according to these contract documents in the base bid price to the contractor.

4. Analyze specified products and verify that the A/E has specified the newest, most current equipment reasonable for this project’s scope and budget.

5. Provide requested information regarding equipment sequence of operation and testing

procedures.

6. Review construction checklists and test procedures for equipment installed by factory representatives.

1.10 EQUIPMENT/SYSTEMS TO BE COMMISSIONED

A. Consult the individual specifications regarding systems to be commissioned the intent is to cover at least all systems consuming or producing resources such as power, gas or water and meet or exceed T24/2013 or other applicable standards such as LEED by USGBC.

1. Division 22 Section 220800 "Plumbing Commissioning Requirements" for systems being tested.

2. Division 23 Section 230800 "HVAC Commissioning Requirements" for systems being tested.

3. Division 25 Section 255500 "Facility Management Systems" for commissioning process activities.

4. Division 26 Section 260800 "Electrical Commissioning Requirements" for systems being tested

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

A. All testing equipment required to perform startup and initial checkout, pre-functional and functional testing shall be provided by the contractor for the equipment being tested. This includes, but is not limited to, two-way radios, meters, and data recorders. Additional data recorders may be provided by the CxA at the option of the CxA,

B. Special equipment, tools, and instruments required for testing equipment according to these contract documents shall be included in the contractor's base bid price and shall be turned over to the owner at project close-out.

C. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance within the tolerances specified in the specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration to NIST traceable standards within the past year to an accuracy of 0.5 degree F and a resolution of + or - 0.1 degree F. Pressure sensors shall have an accuracy of + or - 2.0% 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.

PART 3 EXECUTION

3.1 MEETINGS

A. Initial Meeting. Within 10 days of the Notice to Proceed (NTP), the CxA, through the owner/CM, will schedule, plan and conduct an initial commissioning meeting. The contractor and its responsible parties are required to attend.

B. Miscellaneous Meetings. Other meetings will be planned and conducted by the CxA as construction progresses. These meetings will cover coordination, deficiency resolution, and planning issues. These meetings will be held at least monthly, until the final 3 months of construction, when they may be held as frequently as one per week.

3.2 STARTUP, CONSTRUCTION CHECKLISTS, PRE FUNCTIONAL TESTING AND INITIAL CHECKOUT

A. The following procedures apply to all equipment/systems to be commissioned, according to Paragraph 1.10 Equipment/Systems to be commissioned.

B. General. Construction checklists are important to verify that the equipment and systems are fully connected and operational. It ensures that performance testing (in-depth system checkout) may proceed without unnecessary delays. The construction checklists for a given system must be successfully completed and approved prior to startup and formal performance testing of equipment or subsystems of the given system.

C. Startup and Checkout Plan. The CxA will assist the project commissioning team members responsible for startup of any equipment. The primary role of the CxA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures has been completed. The contractor shall provide construction checklists and pre functional checklists and startup shall be identified in the commissioning scoping meeting and on the checklist forms.

1. These equipment checklists 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 trade is responsible for executing and documenting each of the line item tasks and transmit the checklists to the responsible subcontractors. Each form may have more than one trade responsible for its execution.

3. The contractor/subcontractor with assistance from the CxA responsible for the purchase of the equipment shall develop the full startup plan by combining the manufacturer's detailed startup and checkout procedures and the construction checklists.

4. The contractor/subcontractor shall submit the full startup plan to the CxA for review and approval.

5. The CxA will review and approve the procedures and the documentation format for reporting. The CxA will return the procedures and the documentation format to the contractor, through the CM.

6. The contractor will transmit the full startup plan to the subcontractors for their review and use.

D. Sensor and Actuator Calibration. All field-installed temperature, relative humidity, CO, CO_2, refrigerant, O_2, and/or pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated. Verify that all locations are appropriate and away from causes of erratic operation. Submit to the CxA through the CM the calibration methods and results. All test instruments shall have had a certified calibration within the last 6 months to NIST traceable standards, and comply with all local, state and/or federal requirements/certifications, as required. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated. Provide bench testing as required at the direction of the CxA.

E. Sensor Calibration Methods

1. All Sensors-- Verify that all sensor locations are appropriate and away from causes of erratic operation. Verify that sensors with shielded cable, are grounded only at one

end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading, of each other, for pressure. Tolerances for critical applications may be tighter.

2. Sensors Without Transmitters-- Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, install offset in BAS, calibrate or replace sensor.

3. Sensors With Transmitters-- Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the BAS. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

4. Applications-- For critical applications (process, manufacturing, etc.) more rigorous calibration techniques may be required for selected sensors. Describe any such methods used on an attached sheet.

F. Tolerances, Standard Applications

Sensor	Required Tolerance (+/-)	Sensor	Required Tolerance (+/-)
Cooling coil, chilled and condenser water temps	0.4F	Flow rates, water Relative humidity	2% of design 4% of design
AHU wet bulb or dew point	2.0F	Combustion flue temps	5.0F
Hot water coil and boiler water temp	1.5F	Oxygen or CO_2 monitor	0.1 % pts
Outside air, space air, duct air temps	0.4F	CO monitor	0.01 % pts
Watthour, voltage & amperage	1% of design	Natural gas and oil flow rate	1% of design
Pressures, air, water and gas	3% of design	Steam flow rate	3% of design
Flow rates, air	10% of design	Barometric pressure	0.1 in. of Hg

1. Valve and Damper Stroke Setup and Check FMS Readout-- For all valve and damper actuator positions checked, verify the actual position against the BAS readout. Set pumps or fans to normal operating mode. Command valve or damper closed, visually verify that valve or damper is closed and adjust output zero signal as required. Command valve or damper open, verify position is full open and adjust output signal as required. Command valve or damper to a few intermediate positions. If actual valve or damper position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

2. Closure for heating coil valves (NO) -- Set heating setpoint 20°F above room temperature. Observe valve open. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set heating setpoint to 20°F below room temperature. Observe the valve close. For pneumatics, by override in the EMS, increase pressure to valve by 3 psi (do not exceed actuator pressure rating) and verify valve stem and actuator position does not change. Restore to normal.

3. Closure for cooling coil valves (NC)-- Set cooling setpoint 20°F above room temperature. Observe the valve close. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set cooling setpoint to 20°F below room temperature. Observe valve open. For pneumatics, by override in the EMS, increase pressure to valve by 3 psi (do not exceed actuator pressure rating) and verify valve stem and actuator position does not change. Restore to normal.

G. Execution of Construction Checklists and Startup

1. Four weeks prior to the scheduled startup, the contractor shall coordinate startup and checkout with the CM, A/E, and CxA. The execution and approval of the construction checklists, startup, and pre functional tests shall be directed and performed by the contractor, subcontractor or vendor. Signatures are required of the applicable subcontractors for verification of completion of their work.

2. The owner/CM, and A/E as necessary, shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, in which case a sampling strategy may be used. The CxA will observe all testing.

3. For lower-level components of equipment, (e.g., sensors, controllers), the CxA shall observe a sampling of the startup procedures.

4. The subcontractors and vendors shall execute startup and provide the CxA and A/E, through the owner/CM, with a signed and dated copy of the completed startup and construction checklists.

5. Only individuals of the contractor (technicians, engineers, tradesmen, vendors, etc.) who have direct knowledge and witnessed that a line item task on the construction checklist was actually performed shall check off that item. It is not acceptable for witnessing supervisors to fill out these forms.

H. Deficiencies, Non-Conformance, and Approval in Checklists and Startup(Master Issues Log)

1. The contractor shall ensure that the subcontractors clearly list any outstanding items of the initial startup and construction checklist procedures that were not completed successfully, on an attached sheet. The form and any outstanding deficiencies shall be provided, through the owner/CM, to the CxA within two days of test completion.

2. The CxA will review the report and issue either a non-compliance report or an approval form, through the CM, to the contractor. The installing subcontractors or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, shall notify the owner/CM as soon as outstanding items have been corrected, and resubmit an updated startup report with a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CxA will recommend approval of the execution of the checklists and startup of each system.

3. Items left incomplete, which later cause deficiencies or delays during performance may result in backcharges to the contractor. Refer to Paragraph 3.05, herein, for details.

3.3 SUBMITTALS

A. The CxA will provide appropriate contractors with a specific request for the type of submittal documentation the CxA requires facilitating the commissioning work. These requests will be integrated into the normal submittal process and protocol of the construction team. At minimum, the request will include the manufacturer and model number, the manufacturer's printed installation and detailed startup procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of owner contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the commissioning authority. All documentation requested by the CxA will be included by the subcontractors in their O&M manual contributions.

B. The CxA will review and approve submittals related to the commissioned equipment for conformance to the contract documents as it relates to the commissioning process, to the performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of performance procedures and only secondarily to verify compliance with equipment specifications. The commissioning authority will notify the owner/CM, PM or A/E as requested, of items missing or areas that are not in conformance with contract documents and which require resubmission.

C. The CxA may request additional design narrative from the A/E and controls contractor, depending on the completeness of the OPR documentation and sequences provided with the specifications.

D. These submittals to the CxA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the contractor, though the CxA will review and approve them.

3.4 PHASED COMMISSIONING

The project requires TAB, startup and performance testing to be executed in phases. Phasing shall be coordinated with the owner/CM, CxA, and A/E and be reflected in the overall project schedule and commissioning schedule by the contractor. Final performance testing of all systems will be as required by the phasing plan. The performance testing of the "systems as a whole" will be performed before final turnover of the entire project.

3.5 PERFORMANCE TESTING

A. Requirements. The performance testing shall demonstrate that each system is operating according to the documented design intent and contract documents. Performance testing facilitates bringing the systems from a state of individual substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance

are identified and corrected, improving the operation and functioning of the systems.

B. Coordination and Scheduling. The contractor shall provide sufficient notice, regarding their completion schedule for the construction checklists and startup of all equipment and systems to allow the performance testing to be scheduled The commissioning team shall oversee, witness, and document the performance all equipment and systems. The CxA in association with the contractor/subcontractors and facility staff shall execute the tests. Performance testing shall be conducted after the construction checklists, and startup has been satisfactorily completed. The control system shall be sufficiently tested and approved by the CxA before it is used, to verify performance of other components or systems. The air balancing and water balancing shall be completed before performance testing of air or water-related equipment or systems. Testing proceeds from components to sub-systems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems shall be checked.

C. Development of Test Procedures. Before test procedures are finalized, the contractor shall provide to the A/E and the CxA all requested documentation and a current list of changes affecting equipment or systems, including an updated points list, program code, control sequences, and testing parameters. Using the testing parameters and requirements in the technical specifications, the CxA shall update/develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each contractor/subcontractor or vendor, as appropriate, shall provide assistance to the CxA in developing the final procedures. Prior to finalization, the A/E shall review and concur with the test procedure.

D. Test Methods.

1. Performance testing and verification may be achieved by manual testing or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone data loggers. The CxA may substitute specified methods or require an additional method to be executed other than what was specified, with the approval of the A/E and owner/CM. The CxA will determine which method is most appropriate for tests that do not have a specified method.

2. Simulated Conditions. Simulating conditions shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.

3. Overridden Values. Overriding sensor values to simulate a condition, such as overriding the outside air temperature reading in a control system to be something other than it really is, is acceptable.

4. Simulated Signals. Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overridden values.

5. Altering Setpoints. Rather than overriding sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable.

6. Indirect Indicators. Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the test parameters, that the indirect readings through the control system represent actual conditions and responses.

7. Setup. Each performance test shall be performed under conditions that simulate actual conditions as closely as is practically possible. The contractor/subcontractor(s) assisting the CxA in 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/subcontractor(s) shall return all affected equipment and systems to their approved operating settings.

E. Test Equipment. Refer to Part 2 for test equipment requirements.

F. Problem Solving. The burden of responsibility to solve, correct, and retest malfunctions/failures is with the contractor, with A/E OR CxA approval as required.

3.6 DOCUMENTATION, NON-COMFORMANCE, AND APPROVAL OF TESTS

A. Documentation. The CxA shall witness and verify/pre-approve the documentation of the results of all performance tests. The CxA shall complete all documentation for performance testing.

B. Non-Conformance.

1. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the procedure

2. As tests progress and a deficiency is identified, the CxA shall discuss the issue with the commissioning team, and the contractor.

a. When there is no dispute on the deficiency and the contractor accepts responsibility to correct it:

1) The CxA will document the deficiency and the contractor's response and intentions. After the day's work, the CxA will submit the non-compliance reports to the CM. The contractor corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying that the equipment is ready to be retested and sends it back to the CxA.

2) The contractor shall reschedule the test; and the test repeated.

b. If there is a dispute about a deficiency, regarding whether or not it is a deficiency:

1) The dispute shall be documented on the non-compliance form with the contractor's response.

2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the construction manager.

3) The CxA documents the resolution process.

4) Once the interpretation and resolution have been decided, the contractor corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CxA, through the CM. The contractor shall reschedule the test and the test repeated until satisfactory performance is achieved.

3. Cost of retesting a performance test is the contractor's.

4. The contractor shall submit in writing to the CM at least as often as commissioning meetings are being scheduled, the status of each outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreement and proposals for their resolutions.

    a. The CxA retains the original non-conformance forms until the end of the project.

    b. Retesting shall not be considered a justified reason for a claim of delay or for a time extension by the contractor.

C. Failure Due to Manufacturer Defect. If 10% (or three, whichever is greater) of identical pieces of equipment fail to perform to the contract documents (mechanically or substantively) due to a manufacturing defect, not allowing it to meet its submitted performance specification, all identical units may be considered unacceptable by the A/E or CxA. In such case, the contractor shall provide the owner with the following:

1. Within one week of notification from the owner/CM, the contractor or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the CM within two weeks of the original notice.

2. Within two weeks of the original notification, the contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc., and all proposed solutions. The proposed solutions shall not significantly exceed the specification requirements of the original installation.

3. The A/E will determine whether a replacement of all identical units or a repair is acceptable.

4. Two examples, where applicable, of the proposed solution shall be installed by the contractor and the A/E shall be allowed to test the installations for up to one week, upon which the A/E will decide whether to accept the solution.

5. Upon acceptance, the contractor and/or manufacturer shall replace or repair all identical items, at their expense. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

D. Approval. The CxA notes each satisfactorily demonstrated function on the test form. Final approval of the performance test by the owner is made after review by the CxA and CM, following recommendations by the A/E.

3.7 DEFERRED TESTING

A. Unforeseen Deferred Tests. If any check or test cannot be completed due to the project completion level, required occupancy condition or other deficiency, execution of checklists and performance testing may be delayed upon approval of the CxA and CM. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.

B. Seasonal Testing. During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CxA shall coordinate this activity through the owner/CM. Tests will be executed, documented by the CxA and deficiencies should be corrected by the appropriate contractor/ subcontractors with the CxA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing shall be made by the contractor.

3.8 TRAINING OF OWNERS PERSONNEL

A. The contractor shall provide training coordination, scheduling of subcontractors, and

ensure that training is completed. All training shall be coordinated, through the CM, with the CxA.

B. The contractor shall ensure that each subcontractor and vendor (mechanical, plumbing, fire, electrical, specialty, etc.) shall have the following responsibilities:

1. Provide, to the CxA through the CM, a training plan sixty days before the planned training covering the following elements:

   a. Equipment

   b. Intended audience

   c. Location of training

   d. Objectives

   e. Subjects covered (description, duration of discussion, special methods, etc.)

   f. Duration of training on each subject

   g. Instructor for each subject

   h. Methods (classroom lecture, manufacturer's quality video, site walk-through, actual operational demonstrations, written handouts, etc.).

2. Provide designated owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of equipment that makes up the system.

3. Training shall normally start with classroom sessions followed by hands-on demonstration/training on each piece of equipment.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system shall be repaired or adjusted as necessary and the demonstration repeated at another scheduled time, if necessary.

5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The controls contractor shall attend sessions other than the controls training, as specified, to discuss the interaction of the controls system as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the table of contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

8. Training shall include:

   a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.

   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and

spare parts inventory suggestions. The training shall include startup, operation in all modes possible, shutdown, seasonal changeover and any emergency procedures.

c. Discussion of relevant health and safety issues and concerns.

d. Discussion of warranties and guarantees.

e. Common troubleshooting problems and solutions. Explanatory information included in the O&M manuals.

f. Discussion of any peculiarities of equipment installation or operation.

g. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.

h. Hands-on training shall include startup, operation in all modes possible, including manual, shut-down, alarms, power failure and any emergency procedures, and preventative maintenance for all pieces of equipment.

9. The contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls not controlled by the central control system.

C. At the discretion of the CxA, training may occur before performance testing is complete if required by the facility operators to assist the CxA in the performance testing.

D. Videotaping of the training sessions will be provided by the contractor and added to the O&M manuals. In addition, factory training videos identifying key troubleshooting, repair, service and/or replacement techniques shall be provided and reviewed with the owner.

E. The CxA at the beginning of each training session presents the overall system narrative and the design concept of each equipment section.

3.9 OPERATIONS AND MAINTANENCE MANUALS/DATA

A. The commissioning process requires detailed O&M documentation as identified in this section and technical specifications.

B. Contractor shall submit two draft copies of the complete operating and maintenance manual to the CM for review by the architect/engineer and CxA within 60 calendar days after review of equipment shop drawings. One copy will be returned to the contractor within 30 days after receipt by the A/E.

C. Contractor shall submit corrected final approved manuals prior to substantial completion. Prior to final submittal, the CxA shall review the O&M manuals (in addition to the initial draft O&M manual), and documentation, with redline as-builts, for systems that were commissioned to verify compliance with the specifications. The CxA will communicate, through the CM, deficiencies in the manuals to the contractor or A/E, as requested. Upon a successful review of the corrections, the CxA will recommend approval and acceptance of these sections of the O&M manuals to the CM. The CxA will also review each equipment warranty and verify that all requirements to keep the warranty valid are clearly stated. This work does not supersede the A/E's review of the O&M manuals according to the A/E's contract.

D. The contractor shall compile O&M manuals for every piece of equipment and building operating or electrical system being commissioned with the following format:

1. Quantity: 6 (Unless more are required by the technical specifications). Not all systems

listed in this section will be commissioned by the CxA but are required to be included in the O&M documents if the systems are part of the building.

2. Format: 8 1/2 x 11 3 ring loose-leaf binders, 3-inch maximum, and electronic format that is compatible with owner's system. Each binder shall be clearly labeled on the spine. Use as many binders as required. Do not overload binders. Dividers with permanently marked tabs of card stock shall separate each section and sub section. Tab labels shall not be handwritten. A separate manual or chapter shall be provided for each system.

3. There shall be a title page and table of contents in the front of each binder for each binder's contents. In each binder, there shall be a main tab for each specification section. Behind the section number tab there shall be the equipment ID tag sub-tab for each piece of major equipment (or group, if small or numerous). These sub-tabs shall be similar to the specification number tabs but of a different color. Behind each equipment name tab shall be the following sections, in the given order, divided by a double weight colored sheet labeled with the title of the section.

    a. Contractor. The first page behind the equipment tab shall contain the name, address and telephone number of the manufacturer and installing contractor and the 24-hour number for emergency service for all equipment in this section, identified by equipment.

    b. Submittal and Product Data. This section shall include all approved submittal data, cut sheets, data base sheets and appropriate shop drawings. If submittal was not required for approval, descriptive product data shall be included.

    c. Operation and Maintenance Instructions. These shall be the written manufacturer's data with the model and features of this installation clearly marked and edited to omit reference to products or data not applicable to this installation. This section shall include data on the following:

        1) Model number, serial number and nameplate data for each piece of equipment and any subcomponent.

        2) Installation, startup and break-in instructions.

        3) All starting, normal shutdown, emergency shutdown, manual operation and normal and emergency operating procedures and data, including any special limitations.

            a) Step-by-step procedure for system startup, including a pre-start checklist. Refer to controls and indicators by nomenclature consistent with that used on panels and in control diagrams.

            b) Sequence of operation, with detailed instruction in proper sequence, for each mode of operation (i.e., day-night; staging of equipment).

            c) Emergency operation: If some functions of the equipment can be operated while other functions are disabled, give instructions for operations under these conditions. Include here only those alternate methods of operations (from normal) which the operator can follow when there is a partial failure or malfunctioning of components, or other unusual condition.

            d) Shutdown procedure: Include instructions for stopping and

securing the equipment after operation. If a particular sequence is required, give step-by-step instructions in that order.

4) O&M and installation instructions that were shipped with the unit.

5) Preventative and corrective maintenance, with service procedures and schedules:

   a) Provide a schedule for preventive maintenance in a printed format and an electronic format compatible with owner's system. State, preferably in tabular form, the recommended frequency of performance for each preventive maintenance task, cleaning, inspection and scheduled overhauls.

   b) Cleaning: Provide instructions and schedules for all routine cleaning and inspection with recommended lubricants.

   c) Inspection: If periodic inspection of equipment is required for operation, cleaning or other reasons, indicate the items to be inspected and give the inspection criteria for: motors; controls; filters and any other maintenance items.

   d) Provide instructions for minor repairs or adjustments required for preventive maintenance routines. Identify test points and give values for each. Include sensor calibration requirements and methods by sensor type.

   e) Corrective maintenance instructions shall be predicated upon a logical effect-to-cause troubleshooting philosophy and a rapid replacement procedure to minimize equipment downtime.

   f) Troubleshooting: Troubleshooting tables, charts, or diagrams shall be used to present specified procedures. A guide to this type shall be a three-column chart. The columns shall be titled: malfunction, probable cause and recommended action.

   g) Repair and Replacement: Indicate repair and replacement procedures most likely to be required in the maintenance of the equipment.

6) Safety Precautions: This subsection shall comprise a listing of safety precautions and instructions to be followed before, during and after making repairs, adjustments or routine maintenance.

7) Manufacturers' brochures (including controls): Manufacturers' descriptive literature covering devices and equipment used in the system, together with illustrations, exploded views and renewal parts lists. Manufacturers' standard brochures and parts list shall be corrected so that information applying to the actual installed equipment is clearly defined.

8) Supply any special tools required to service or maintain the equipment.

9) Performance data, ratings and curves.

10) Warranty and guarantee, which clearly lists conditions to be maintained to keep warranty in effect and conditions that would affect the validity of the warranty.

11) Any service contracts issued.

d. Supplemental Data. Prepare written text and/or special drawings to provide necessary information, where manufacturer's standard printed data is not available and information is necessary for a proper understanding and operation and maintenance of equipment or systems, or where it is necessary to provide additional information to supplement data included in the manual or project documents.

e. Control Diagrams/Drawings. Include the as-built control diagrams/drawings for the piece of equipment and its components, including full points list, full print out of all schedules and set points after testing and acceptance of the system, and copies of all checkout tests and calibrations performed by the contractor (not commissioning tests).

f. Specifications. This section is comprised of the component or system specification section copied and inserted complete with all addenda.

g. System Description. This section shall include the individual equipment portion of the overall system Design Basis Narrative.

E. COMMISSIONING RECORD IN O&M MANUALS

1. The GC is responsible to compile, organize and index the following commissioning data by equipment into labeled, indexed and tabbed, three-ring binders and deliver it to the GC, to be included with the O&M manuals.

a. Commissioning Plan

b. System reports including design narratives and criteria including sequences. Each system shall contain the startup plan and report, approvals, corrections, construction checklists, completed performance tests, trending and analysis, training plan and recommended recommissioning schedule.

c. Final Commissioning Report including an executive summary, list of participants and roles, brief building description, overview of commissioning and testing scope and a general description of testing and verification methods. For each piece of commissioned equipment, the report should contain the disposition of the commissioning authority regarding the adequacy of the equipment, documentation and training meeting the contract documents in the following areas: 1) equipment meeting the equipment specifications, 2) equipment installation, 3) performance and efficiency, 4) equipment documentation and design intent, and 5) operator training. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. shall also be listed. Each non-compliance issue shall be referenced to the specific performance test, inspection, trend log, etc. where the deficiency is documented. The performance and efficiency section for each piece of equipment shall include a brief description of the verification method used (manual testing, BAS trend logs, data loggers, etc.) and include observations and conclusions from the testing.

F. Electronic submittal requirements

1. All working documents shall be provided in electronic format whenever feasible. Hard copies are only permissible if soft copies of the documents are not available

2. In addition to the hard copy requirements required in this section, at least all final documents shall be provided in pdf format, organized and tabulated identical to the hard copies provided. Coordinate media requirements with the owner at the time of submission.

END OF SECTION