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SECTION 01 91 00_COMMISSIONING STANDARD

PART I - GENERAL

1.1 SCOPE OF WORK

- A. Systems to be commissioned include those identified in each respective Section of this Project and at minimum the following:
1. HVAC System
 - a. BAS/DDC and non-integrated control systems
 - b. HVAC energy metering including interface with energy monitoring system (EMS)
 - c. Chilled Water and Heating Water Systems.
 - d. Steam Pressured Reducing Valves including all components of the pneumatic operating system
 - e. Steam to hot water heat exchanger systems including review of system steam traps and safety relief devices.
 - f. Mechanical piping systems including pipe anchors and expansion loops
 - g. Chemical cleaning of pipe and water treatment
 - h. Air handling equipment including but not limited to exhaust fans, air handling units, fan coil units and unit heaters.
 - i. Heat transfer equipment
 - j. Humidifiers
 - k. De-humidifiers
 - l. Variable Air Volume Terminals
 - m. Air and Water Balancing and Duct and Pipe Leak Testing
 2. Electrical Systems
 - a. Witness Arc Testing
 - b. Witness Megger Testing
 - c. Lighting, and lighting controls including occupancy sensors
 - d. All electrical systems, metering and distribution
 - e. All electrical grounding systems
 - f. Electrical metering

- g. Energy monitoring system
 - h. Emergency Generator and distribution including automatic transfer switches
 - i. Variable Frequency Drives (VFD's)
 - j. Electrical Switch Gear and Motor Control Centers
 - k. Transformers
 - l. Lightning Protection Systems
 - m. Verification that electrical outlets are working properly (including ground fault and arc fault)
 - n. Elevators including all controls
3. Plumbing
- a. Domestic hot water heaters
 - b. Domestic Water Fixtures
 - c. Eyewashes and Safety Showers
 - d. Domestic Water Booster Pumps including all Controls
 - e. Storm Water Lift Pumps including all Controls
 - f. Sanitary Lift Pumps including all Controls
 - g. Domestic Water Meters including interface with EMS and verification that domestic water utility is receiving data.
 - h. Domestic Water Fixtures, Sinks, Faucets and Drinking Fountains
 - i. Domestic Water Filtration Systems
 - j. Purified Water Systems including all water treatment equipment
 - k. Laboratory Gas Systems
 - l. Natural Gas Systems including gas regulator and safety relief devices
 - m. Natural Gas Meters including interface with EMS and verification that natural gas utility is receiving data.
 - n. Vacuum Pumps
 - o. Compressed Air Systems including air compressor and filter driers
 - p. Leak testing all plumbing piping systems
 - q. Chemical cleaning of pipe and water treatment
4. Fire Protection Systems:
- a. Fire Alarm System including integration with new/existing control panel, BAS, Lighting, metering and lighting controls

- b. Sprinkler Systems including fire pump and flow test
 - c. Leak testing sprinkler systems
5. Specialty Duct and Pipe Systems
- a. If pipe welds are specified for X-Ray examination, The Cx agent shall monitor X-Ray examination to verify examination was completed per specifications. The Cx agent shall report results of X-Ray examination in the Cx log. The Cx agent shall monitor and document all subsequent examinations until all welds pass X-ray examination.
 - b. Specialized piping and duct systems require factory authorized training for the fabrication and installation of these systems. The Cx agent shall verify that all relevant technicians have received training and that the training is documented.
 - c. Specialized piping and duct systems require factory inspections of the fabrication and installation. The Cx agent shall verify that contractors provide factory inspection of the specialized piping and duct systems and that the inspection is documented.
6. Security Systems
- a. Security System Controls and Components
 - b. Access Control
 - c. Security Cameras
 - d. Duress Signaling Systems
7. Dining (When included in the Project):
- a. Kitchen, Servery and related food preparation equipment/systems
 - b. Food cold storage, Prep and cooking equipment
 - c. Dishwashing equipment
 - d. Related HVAC Mechanical including make-up, exhaust and Control Systems
8. Laboratory (When included in the Project):
- a. Laboratory Ventilation Systems including Fume Hoods, Bio Hoods, Ventilated Enclosures and Fume Extractors.
 - b. Cold Boxes
 - c. Growth Chambers
 - d. Incubators
 - e. Autoclaves, Dishwashers and Sterilization Equipment
 - f. Freezers and Refrigerators

1.2 RELATED REQUIREMENTS (Commissioning of all University of Delaware Buildings shall comply with the following industry standards)

- A. Industry standards and guidelines are a guide to the commissioning process and are hereby incorporated and will be applied as appropriate. Reference standards and guidelines include, but are not limited, to the following:

ASHRAE Standard 202 Commissioning Process for Buildings and Systems

ASHRAE Application Handbook – 1995: Chapter 39 – Building Commissioning

ASHRAE Guideline 0: The Commissioning Process

ASHRAE Guideline 1: The HVAC Commissioning Process

ASHRAE Guideline 4: Preparation of Operating and Maintenance Documentation for Building Systems.

ASHRAE Guideline 5: Commissioning of Smoke Management Systems

DOE: Commissioning Guide Specification Version 2.5, Section 17100.V18, prepared by PECL.

USGBC LEED current version as of Project registration. (If LEED certification is a project requirement)

1.3 COMMISSIONING PLAN

- A. The Commissioning Specification, initiated by the Owner and updated by the AE, outlines the roles and responsibilities of the Contractors. As a separate document, the Commissioning Plan will provide a broader outline of the entire commissioning process, including the following:

1. Design Phase Commissioning Activities
2. Occupancy & Operation Commissioning Activities
3. Roles and Responsibilities of all Commissioning Team Member.

The Owner will forward the Commissioning Plan to the **[CM/GC]** via the PM, who then makes the Plan available on request to the Contractor.

- B. Impact on Contractor Responsibility: The Cx Process does not reduce the responsibility of the installing contractors to provide a finished and fully functioning product. The CxA does not have the authority to provide direction to the Contractors. Any issues arising during the Commissioning Process which impact schedules, costs or contractual obligations shall be addressed to the Owner for resolution.

- C. Commissioning Process:

1. The documented procedures which comprise the construction-phase commissioning process include the following:
 - a. Pre-Commissioning consists of normally specified check-outs or testing, wiring and controls point-to-point verification, etc. to be completed by the respective

Contractor before the formal commissioning process outlined in this document begins.

- b. Pre-Functional Procedures (PFPs) consist of a series of field observations conducted during the installation of equipment yet to be commissioned to verify that equipment is installed per the contract documents and the manufacturer's installation manuals and is ready for startup.
- c. Contractor Pre-Startup Testing consists of normally specified Contractor testing such as leak testing of ductwork and piping and meter testing of electrical equipment. The commissioning process is used to ensure that this testing is rigorously executed and documented in preparation for equipment startup.
- d. Equipment Startup Procedures ensure that startup is performed per the equipment manufacturer's recommended procedures and those startup activities and data are documented for future reference.
- e. Contractor TAB (Test and Balance) Plan submitted to the Owner (via the [CM/GC]) no later than 30 days prior to scheduled Start up shall include sufficient narrative and technical detail identifying the relevant systems, components, instrumentation and sequence of work. This Plan shall also indicate evidence of all presets in preparation.
- f. Contractor Post-Startup Testing consists of normally specified contractor testing activities occurring after startup including test, adjust and balance (TAB) of ventilation and hydronic systems, control system point-to-point testing and testing of BAS sequences of operation. The commissioning process provides oversight during the execution and documentation of these tests to ensure successful system operation.
- g. Witnessing Functional Performance Procedures (FPPs) consists of determining if equipment, sub-systems and major systems operate in accordance with the design intent and the contract documents. Specific issues, which will be evaluated in these procedures, include equipment capacity & efficiency, operation of safeties and interlocks, control system operation, stability and tuning. All post start-up work including debugging is to be completed prior to Functional Performance Witnessing by the Owner.
- h. Operation and Maintenance Manuals will be reviewed by the Owner for both content and organization. The objective of the review process is to provide the Owner with useful, complete, project-specific information needed to successfully operate and maintain the facility after turnover.
- i. Operator Training will be provided and coordinated by the Contractor / [CM/GC] and overseen by the Owner to help ensure that the Owner is adequately prepared to operate and maintain the facility at turnover. Scheduling of Training is to be confirmed in writing no later than the earlier of either Substantial Completion or as this Project requires.

1.4 CONTRACTOR RESPONSIBILITIES

A. General

1. Contractors providing and/or installing equipment and systems included in the 'Scope of Work' above are required to participate fully in the Commissioning Process.
2. Participating Contractors shall include all costs to complete the Cx requirements in their contract price including all costs for Sub-Contractors, vendors and suppliers.
3. Participating Contractors shall ensure acceptable representation, with the means and authority to prepare, coordinate and execute the Commissioning Process as described in the contract documents.
4. Contractors shall participate in the resolution of system deficiencies identified during the commissioning process, according to the contract documents and the Owner's Project Requirements.
5. Contractors shall prepare & submit the final as-built design intent and operating parameter documentation for inclusion in the O&M manuals.

B. Contractor's Commissioning Representative (CCR)

1. Each Contractor participating in the Cx Process will each designate a single-point contact person to work with the Owner and the Commissioning Team to coordinate commissioning activities, ensure timely execution of Cx Procedures and prompt resolution of commissioning issues.
2. The CCR shall be the Contractor's Project Manager, Field Superintendent or similar with authority to do the following:
 - a. Make decisions regarding commissioning activities and issues
 - b. Schedule technicians for participation in commissioning activities
 - c. Interface between the Commissioning Team and the Contractor's Sub-Contractors, vendors and suppliers.
 - d. Commit to commissioning schedules and completion dates.
3. The CCR will be responsible for coordinating the Contractor's participation in the Cx Process. As part of this role, the CCR shall:
 - a. Attend all Commissioning Meetings
 - b. Keep the [CM/GC], AE, and Owner apprised of the Contractor's progress, schedules and other matters impacting execution of the Commissioning Procedures.
 - c. Coordinate the Contractor's work schedules and staffing to ensure that the qualified technician(s) are available and present during the agreed upon schedules and for sufficient duration to complete procedures, tests, adjustments, and/or problem resolutions.
 - d. Ensure that the Contractors Commissioning Notebook(s) and Contractor Commissioning Documents are being maintained on-site, well organized and

current as required in item the 'Commissioning Documentation' paragraph of this specification. Notebooks and Contractor Commissioning Documents shall be turned over to the Owner as part of the required deliverables for Final acceptance.

4. The Owner reserves the right to question the appropriateness and qualifications of the Contractor's Commissioning Contact. Qualifications shall include expert knowledge of the equipment and systems being commissioned and a willingness to work cooperatively with Commissioning Team.

C. Field Technicians

1. Each Contractor shall provide qualified field technicians who are trained and familiar with installation, operation and troubleshooting of systems and equipment being commissioned for participation in the commissioning activities outlined in this document.
2. These same technicians shall be made available to assist the Owner in resolving commissioning issues (as reported on the Issue Tracking Report) and for repeat and follow-up commissioning tasks as required
3. Contractors shall arrange for and provide technicians from their Sub-Contractors, vendors and suppliers where specified and where Contractor's own personnel lack the required training or experience necessary to ensure that all commissioned equipment and systems are correctly installed and fully functional.
4. System performance problems and discrepancies may require additional technician time, Owner time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent Cx periods at no cost to the Owner until the required system performance is obtained
5. The Owner reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians shall include expert knowledge relative to the specific equipment involved.

1.5 COMMISSIONING AUTHORITY RESPONSIBILITIES

A. General

1. Organize and monitor the commissioning team.
2. Prepare an initial commissioning plan. Collaborate with each Contractor and with subcontractors to develop test and inspection procedures. The Commissioning Plan (Cx Plan) is a dynamic document that is continuously updated through Design, Construction and Warranty. Updates shall be provided by the AE / Contractor during and post construction. The Cx Plan shall identify commissioning team member(s) / their responsibilities, by name, firm, and trade specialty, for performance of each

commissioning task. Scheduled commissioning activities shall be coordinated with overall Project schedule.

3. Lead the commissioning team meetings for the purpose of monitoring progress, coordination, communication, and conflict resolution.
4. At the beginning of the construction phase, the Owner shall coordinate through the [CM/GC] and conduct an initial construction-phase coordination meeting for the purpose of reviewing the commissioning activities and establishing tentative schedules for operation and maintenance submittals; operation and maintenance training sessions; TAB Work; and Project completion.
5. The Owner will be responsible for observing and inspecting construction, and reporting progress and deficiencies. In addition to compliance with the OPR, BoD, and Contract Documents, inspecting systems and equipment installation for adequate accessibility for maintenance and component replacement or repair.
6. The Owner will preview Project-specific test and inspection procedures and checklists provided by equipment manufacturer / Contractor and assist in scheduling and documenting tests, inspections, and systems startup.
7. The Owner will collect Engineering test data, inspection reports, and certificates from the Contractor and include them in the Systems Manual and Commissioning Report.
8. The Owner will coordinate with the Owner to certify the date of acceptance and startup for each item of equipment for start of warranty periods. Document Extended Warranties due to “early” start-up from approved request and subsequent necessary changes to sequence of operations.
9. The Owner will assemble the final commissioning documentation, including the commissioning report and AE provided Project Record Documents.

1.6 COORDINATION & SCHEDULING

A. Commissioning Meetings

1. Commissioning Orientation (Kick-Off) Meeting

- a. This meeting will be scheduled by the Contractor and coordinated with the AE and Owner after awarding of contracts but prior to the start of construction of the systems included in the commissioning scope.
- b. The Owner will work with the Contractor who coordinates this initial Commissioning Orientation Meeting for the Prime Contractors and selected Sub-Contractors to familiarize all parties with the Cx process, and to ensure that the roles and responsibilities of each party are clearly understood.

2. On-going Commissioning Progress Meetings

- a. These meetings will be scheduled by the Cx Agent and coordinated with the GC/CM, AE and Owner. The purpose of these meetings will be to coordinate and schedule Cx activities, review Cx activity status, verify Owner’s Project

Requirement achievements, and discuss status and resolution of Cx issues. Cx Progress Meetings will start soon after installation of systems to be commissioned begins. Meeting frequency will be determined by the Project Team. Minutes from the commissioning meetings will be recorded and distributed by the Contractor to the full commissioning team.

B. Scheduling of Cx Activities

1. The GC/CM shall schedule all Cx activities and coordinate the Cx activities with all subcontractors. The Cx agent shall provide input to the schedule including duration of tasks to GC/CM.

C. Notification of Field Activities

1. The Cx agent shall provide the GC/CM with advanced notification of its field activities. The Cx agent shall coordinate all of its field activities including interaction with subcontractors through the GC/CM.

1.7 COMMISSIONING DOCUMENTATION

A. General

1. Contractor Commissioning Documents which will be completed by the Contractors include the following:
 - a. Pre-Functional Checklists
 - b. Pre-startup Contractor Procedure / Test Forms
 - c. Equipment Startup Plans and Forms
 - d. Post-startup Contractor Test Forms & Reports
 - e. Functional Procedures / Tests (Contractor may use these for debugging purposes prior to eventual Owner Witnessing). Owner witnesses the Functional Tests/Procedures and documents using these forms.
 - f. Weekly Cx Status Report
 - g. Commissioning Notebooks
 - h. All supporting documentation
2. Documentation which, at the Owner's discretion, is incomplete or less than fully legible shall be unacceptable. Signatures by the respective individual having authority shall be provided on all forms to certify completion.
3. Commissioning procedures and tests which are rejected by the Owner due to incomplete or illegible Contractor documentation shall be repeated by the Contractor and new Contractor Commissioning Documents shall be prepared to the Owner's satisfaction at no additional costs to the Owner.
4. All Contractor Commissioning Documents shall be completed on the job-site concurrent with the activities being documented. "After-the-fact" documentation of commissioning activities is unacceptable.

5. All Contractor Commissioning Documents will be promptly submitted to the Owner for review and acceptance upon completion of each respective CC or startup or FPT/FTP.
- B. Contractor Commissioning Process Status Tracking System
1. Contractors shall be responsible for maintaining a tracking system to monitor the progress of their commissioning activities. This tracking system will be submitted to the Owner and will include spreadsheet-based tracking forms and/or sets of drawings which will be marked-up by the contractor to indicate status of specified commissioning activities.
 2. The Contractors shall regularly update their tracking system forms and/or drawings as commissioning activities are completed so as to provide a readily available report to the [CM/GC] and Owner regarding current status of the Contractors commissioning activities. Updates shall be provided weekly commencing with respective Startups.
- C. Commissioning Notebook(s)
1. All Contractor Commissioning Documents (including both in-progress and completed documentation) and Contractor Commissioning Process Status Tracking System forms shall be kept on-site in the Contractor's field office, neatly organized, in 3-ring notebooks known as Commissioning Notebooks.
 2. Commissioning Notebooks shall be labeled on both cover and spine to indicate the Contractor's name, the project name and the notebook's contents.
 3. The [CM/GC] will be available to assist the Contractors in setting up, and organizing their Commissioning Notebooks.
 4. Commissioning Notebooks shall be kept available to the Owner and [CM/GC] for their review and shall be turned in at Project Closeout.
- D. Record Drawings, Operation & Maintenance Manuals & Warranties
1. Each Contractor shall be responsible for their section and provide Record Drawings in the required formats per the Bid Documents.
 - a. Contractors shall regularly update a 'redlined' set of record drawings showing commissioned systems as work is being installed so that the drawings remain current with the field work
 - b. Redlining record drawings at the end of construction shall not be acceptable
 - c. The Contractors in-progress redlines shall be kept on-site in the Contractor's field office and available for review by the Owner.
 - d. The Contractor shall submit the "redlined" set of record drawings at the end of the job to the AE firm so that the AE firm can produce as-built CAD files. The AE firm shall submit as-built drawings with the "redlines" record drawings to the Cx agent for review. The Cx agent shall review the as built for completion and shall provide comments on the Cx log.

2. The Cx agent and the owner will periodically review the Contractors in-progress redline drawings for accuracy, completeness and to verify that they are being kept up-to-date.
 3. The Cx agent shall review all warranty documentation submitted and determine if the warranties are in compliance with the project specifications. If the warranty is not in compliance with project specifications.
 4. The Cx agent shall review all Operations and Maintenance Manuals to determine if the manuals contain adequate and accurate information to operate, maintain and repair the related equipment.
- E. Access to Contractor Documentation
1. Contractors shall provide access to the shop drawings, coordination drawings, equipment cut-sheets, schematics, in-progress record drawings, etc. to assist the Owner in execution of the Cx process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT – GENERAL

- A. The party responsible for each Commissioning Procedure shall furnish all tools, equipment and instrumentation required for execution of that Procedure.
- B. A list of all tools and equipment to be used during Cx shall be submitted to the Owner for review and approval prior to the start of execution.
- C. Standard tools, testing equipment and instrumentation required for execution of Pre-Functional Procedures, Pre-startup Testing, Startup Procedures, and Post-startup Testing shall be provided by the Contractor responsible for the equipment being tested.
- D. Temporary Data-logging equipment and software required to monitor/test equipment (with the exception of medium and higher voltage electrical equipment) will be provided by the Owner.
- E. Testing equipment and instrumentation used for execution of Commissioning Procedures shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the *Specifications*. If not otherwise noted, the following minimum requirements apply:
 1. Temperature sensors and digital thermometers: certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F.
 2. Pressure sensors: accuracy of + or - 2.0% of the value range being measured (not full range of meter) and calibrated within the last year.
 3. Electrical meters (voltage, current, etc.) shall be true RMS and shall have been calibrated within the last year.
 4. All other sensors and meters (RH, CO, CO₂, etc.) shall have been calibrated within the last 6 months.

- F. All test equipment and instrumentation used for Commissioning Procedures shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged.
- G. Calibration tags shall be affixed or certificates readily available.

2.2 TEST EQUIPMENT - Special, proprietary, or unique

- A. Equipment and software including that for testing required by any contractor, vendor or equipment manufacturer for programming, start-up, or other commissioning activity whether specified or not, shall be provided by the manufacturer of the equipment for use during commissioning and at no additional cost to the Owner.
- B. Equipment, tools and instruments required for testing equipment shall be included in the base bid price to the Contractor and left on site, except for stand-alone temporary data logging equipment that may be used by the Owner.
- C. Equipment (and software) including that for testing, shall become the property of the owner upon completion of the Cx process and free of royalties and / or other fees or rental charges.

2.3 BAS HARDWARE AND SOFTWARE SUPPORT

- A. The BAS Contractor shall furnish the Owner with two (2) copies of all proprietary hardware and software needed to connect to, communicate with and command the BAS from both the front-end operator workstation and the field panels and controllers at no additional charge to the Owner. Use of hardware and software provided under this section may be limited to the duration of the Cx Process at the BAS Contractor's discretion, but shall not be terminated until final completion of the Cx Process including resolution of all outstanding construction phase FONs issues and successful execution of Post-Occupancy phase commissioning activities.
- B. Hardware and software covered under this requirement includes, but is not limited to:
 - 1. Communication modules, software keys, and similar hardware needed for communication from a laptop computer or PDA to field panels or controllers
 - 2. Proprietary cables required for communication between laptop computers or PDAs to field panels or controllers
 - 3. Proprietary software needed to communicate to field panels or controllers such
 - 4. Passwords, access levels and similar software permissions necessary for execution of the Cx Process.
 - 5. Software and hardware manuals for all control system hardware and software provided to the Owner.
- C. The BAS Contractor shall also provide technical support to the Owner as reasonably requested by the Owner regarding BAS hardware and software.

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL PROCEDURES

A. Scope

1. The Pre-Functional Procedures (PFP) consists of a series of field observations conducted during the installation of commissioned equipment to verify the following:
 - a. Installed equipment matches the specifications and approved submittals
 - b. Equipment is installed per the specifications, drawings and manufacturer's recommendations
 - c. Utility connections to equipment, such as electrical, steam, chilled water, etc. have been successfully completed
 - d. Equipment is ready for start-up
2. Complete at a minimum one (1) Pre-Functional Checklist for each major piece of equipment covered by the commissioning process such as pumps, fans, air handling units, control panels, switchgear, substations, and electrical distribution panels. The Owner reserves the right to reject incomplete PFCs (CCs) or otherwise questionable answers and at no additional cost to the Project may cause the Contractor to resubmit and/or complete PFCs / CCs for all related components and systems for that Division.
3. Additional checklists will be required to verify installation of distribution systems such as piping, ductwork, electrical wire and conduit, etc. The number of required Pre-Functional Checklists will vary from system to system, but will typically be limited to one form per system per floor or zone.

B. Pre-Functional Checklists

1. The Pre-Functional Checklists will be provided by the Owner after receipt of equipment Installation and Operation & Maintenance (IOM) Manuals from the Contractors (see paragraph entitled "Contractor Requirements" below).
2. A copy of all completed Pre-Functional Checklists completed that week shall be forwarded to the Owner at the end of that week. The completed originals shall be maintained on-site per the requirements of this specification, paragraph entitled "Commissioning Documentation".

C. Contractor Requirements

1. The Contractors shall provide Installation Operation and Maintenance (IOM) Manuals.
2. The Contractors furnishing and/or installing the equipment being commissioned will be responsible for the execution of the Pre-Functional Procedures and accurate completion of the Pre-Functional Checklists for that equipment.
3. The Owner will provide oversight to the Contractors during the execution of the Pre-Functional Procedures and will periodically review the Contractors' in-progress Pre-Functional Checklists for accuracy, completeness and to verify that checklists are being kept up-to-date.

4. The Contractors shall regularly review and update the appropriate Pre-Functional Checklists so that installation issues are identified early in the construction process. The Owner will periodically review the Contractor's in-progress Pre-Functional Checklists to verify that they are current with the project status.
5. Issues observed during the PFPs will be immediately reported in accordance with the procedures outlined in this specification, paragraph entitled "Issue Resolution Log".
6. PFPs shall be substantially complete, reviewed and accepted by the Owner prior to equipment start-up. Exceptions to this requirement will be at the Owner's discretion.
7. Contractors shall regularly update their Contractor Commissioning Process Status Tracking System.
8. The Contractor shall furnish all tools, test equipment and instrumentation required for completion of the PFPs. All instruments shall meet the requirements of Part 2 of this specification.

3.2 CONTRACTOR PRE-STARTUP PROCEDURES

A. Scope

1. Commissioning activities and requirements related to Contractor/vendor pre-startup procedures are in addition to the testing requirements specified in other Divisions of these specifications. These do not reduce the Contractor's responsibility for successfully completing and documenting all testing requirements outlined elsewhere in these specifications.
2. The goal of these activities is to help ensure that the specified testing is rigorously executed using sound test procedures and that all tests are thoroughly documented.

B. Contractor Pre-startup Documentation / Forms

1. The Contractor Pre-startup Procedures shall be documented using test forms which, at a minimum, will record the following information:
 - a. Type of test or procedure being performed (hydrostatic or pneumatic leak test, megger test, in-wall inspections, etc.)
 - b. System or equipment being tested
 - c. Technician(s) performing the test or procedure
 - d. Test or procedure date and time
 - e. Detailed description of section of system being tested (if applicable)
 - f. All data collected during the test or procedure to quantify test performance (static and differential pressures, test duration, electrical resistance, etc.)
 - g. Signature of technician(s) performing test or procedure
 - h. Signature of **[CM/GC]** and CxA witnessing the test or procedure

2. Contractors and vendors may use their standard testing forms; providing these forms meet the requirements outlined above and have been previously reviewed and approved by the Owner.
3. All test forms will be fully completed and maintained by the Contractor per the requirements of this specification, paragraph entitled "Commissioning Documentation".
4. All test forms will be promptly submitted to the Owner for review and acceptance upon completion of the respective test.

C. Contractor Requirements

1. Prior to initiating any of the Pre-startup Procedures covered by this specification, the Contractor shall meet with the Owner to review the Contractor's proposed test procedures and test forms.
2. The Owner will provide oversight in Contractor's test procedures and test forms.
3. The Owner will witness selected Pre-startup Tests.
4. All Pre-startup Tests must be witnessed by either the [CM/GC] or the Owner. It is the Contractor's responsibility to coordinate with the [CM/GC] and Owner in advance of each test to ensure that the appropriate personnel will be available to witness the test. Tests which are not witnessed by the [CM/GC] or Owner are incomplete and shall be re-tested.
5. Issues observed during the Contractor Pre-startup Procedures will be immediately reported to the [CM/GC] and Owner in accordance with procedures outlined in this specification, paragraph entitled "Issue Resolution Log".
6. All Contractor Pre-startup Procedures shall be substantially complete, reviewed and accepted by the Owner prior to equipment start-up. All exceptions to this requirement will be at the Owner's discretion.
7. Contractors shall regularly update their Contractor Commissioning Process Status Tracking System. The Owner will periodically review the Contractor's in-progress test forms and tracking system.
8. The Contractor shall furnish all tools, test equipment and instrumentation required for completion of the Pre-startup Procedures. All instruments shall meet the requirements of Part 2 of this specification.

3.3 START-UP PROCEDURES

A. Scope

1. Commissioning activities and requirements related to Equipment Startup are meant to help ensure the following:
 - a. Equipment installation and Pre-startup Testing has been fully completed and documented prior to startup.
 - b. Startup procedures meet the equipment manufacturer's recommendations.

- c. Startup activities are fully documented.
 2. Equipment Startup requirements covered by this section of the commissioning specification include the following:
 - a. All commissioned equipment requiring startup by the equipment manufacturer, vendor or representative.
 - b. All rotating equipment including, but not limited to, pumps, fans, compressors, and generators with a motor or engine size greater than 3hp.
 - c. All electrical equipment including, but not limited to switchgear, substations, transformers and distribution panels operating at 208 Volts or greater.
- B. Equipment Startup Plan
1. Prior to Equipment Startup, the responsible Contractor shall prepare and submit a written Startup Plan which will include the following:
 - a. Personnel required for startup including vendors, other trades, etc.
 - b. Prerequisites required for startup (utility connections, PFPs, Pre-startup Testing, and other as applicable)
 - c. Startup procedures
 - d. Forms to be used for documenting startup procedures
 2. The equipment manufacturer's standard startup procedures and forms should be used as the basis of the Contractor's Startup Plan.
 3. The Owner will review the Contractor's proposed Startup Plan(s).
 4. Startup of equipment shall be documented using Startup Forms, which have been previously reviewed and approved as part of the Contractor's Startup Plan.
 5. All Startup Forms will be fully completed and maintained by the Contractor per the requirements of this specification paragraph entitled "Commissioning Documentation".
 6. All Startup Forms will be submitted to the Owner for review and acceptance upon completion.
- C. Contractor Requirements
1. The Cx team will, in a joint effort, coordinate and schedule startup activities. This will include the following:
 - a. Ensuring that all PFPs and Contractor Pre-startup Testing are completed and documented prior to startup.
 - b. Ensuring that all required utilities are available prior to startup.
 - c. Ensuring that the appropriate personnel have been identified and scheduled to participate including vendors, manufacturer's representatives, other trades, etc.
 - d. Tools, test equipment and/or instrumentation required for startup will be available.

2. No unscheduled startups shall be allowed.
3. The Owner will witness selected startups to ensure that approved procedures are being followed and properly documented.
4. All Startup Procedures must be witnessed by the [CM/GC]. The Owner may participate. It is the Contractor's responsibility to coordinate with the [CM/GC] and Owner in advance of each startup to ensure that the appropriate personnel will be available. Startup Procedures that are not witnessed by the [CM/GC] or Owner are incomplete and shall be re-done.
5. Issues observed during execution of the Startup Procedures will be immediately reported to the [CM/GC] and Owner in accordance with procedures outlined in this specification, paragraph entitled "Issue Resolution Log".
6. Contractors shall regularly update their Contractor Commissioning Process Status Tracking System.
7. The Contractor shall furnish all tools, test equipment and instrumentation required for completion of the Startup Procedures. All instruments shall meet the requirements of Part 2 of this specification.

3.4 CONTRACTOR POST-STARTUP TESTING / PROCEDURES

A. Scope

1. Commissioning activities and requirements related to Contractor Post-startup Testing / procedures are in addition to the testing / procedures requirements specified in other Divisions of these specifications. These do not reduce the Contractor's responsibility for successfully completing and documenting all testing / procedures requirements outlined elsewhere in these specifications.
2. The goal of these activities is to help ensure that the specified testing and procedures are rigorously executed using sound test procedures and that all tests are thoroughly documented.

B. Contractor Post-startup Procedure Reports

1. The Contractor Post-startup Testing / procedures shall be documented using test forms which, at a minimum, will record the following information:
 - a. Type of test being performed (duct traverse, point-to-point checkout, etc.)
 - b. System or equipment being tested
 - c. Technician(s) performing the test
 - d. Test date and time
 - e. Detailed description of system or section of system being tested
 - f. All data collected during the test to quantify test performance (pressures, flow rates, rpm, volts, amps, temperatures, etc.)
 - g. Signature of technician(s) performing test

- h. Signature of [CM/GC] and CxA witnessing the test (where applicable)
 2. Contractors may use their standard testing / procedures forms; providing these forms meet the requirements outlined above and have been previously reviewed and approved by the Owner.
 3. All test forms will be fully completed and maintained by the Contractor per the requirements of this specification, paragraph entitled "Commissioning Documentation".
 4. All test forms shall be promptly submitted to the Owner for review and acceptance.
- C. General Requirements
1. Prior to initiating any of the Post-startup Testing / Procedures, the Contractor shall meet with the Owner to review the Contractor's proposed test procedures and test forms.
 2. The Contractor shall be responsible for successful completion and documentation of all specified Post-startup Testing / Procedures.
 3. The Owner will provide oversight to the Contractors in developing their test procedures and test forms.
 4. The Owner will witness selected Post-startup Tests / Procedures.
 5. Issues observed during the Contractor Post-startup Testing will be immediately reported to the [CM/GC] and Owner.
 6. Contractors shall regularly update their Contractor Commissioning Process Status Tracking System.
 7. The Contractor shall furnish all tools, test equipment and instrumentation required for completion of the Post-startup Testing / Procedures. All instruments shall meet the requirements of Part 2 of this specification.
 8. The Contractor shall provide a written list of instrumentation which will be used for Post-startup Testing / Procedures indicating instrument make, model number, serial number, range, accuracy and calibration date to the Owner prior to the start of testing.
- D. Test and Balance
1. Testing, Adjusting, and Balance Contractor (TAB) Requirements
 - a. The TAB Contractor shall be responsible for successful completion and documentation of all TAB as per project specifications.
 - b. Thirty (30) Days prior to the start of TAB activities, the TAB Contractor shall submit proposed TAB Plan (procedures and documentation) to the Owner and AE for review.
 - c. After this review, and prior to start of field work, the TAB Contractor will attend one or more planning meetings as required with the Commissioning Team to review and discuss outstanding issues relating to TAB procedures and forms, discuss resolution

of issues identified during the TAB Contractor's plan review and field inspections, and to coordinate field work.

- d. Prior to the start of field work, the TAB Contractor shall issue a final set of TAB procedures and TAB forms incorporating comments received from the Commissioning Team review.
- e. The TAB Contractor shall have at least one certified field technician on site whenever TAB work is being performed.
- f. The TAB Contractor shall notify the Commissioning Team a minimum of two (2) weeks in advance of the time for start of TAB work to allow the Owner and AE time to assess system readiness.
- g. The TAB Contractor shall coordinate with the controls Contractor to ensure that changes made to the control system during TAB (flow coefficients, duct areas, etc.) are archived and become the default or initial values for these parameters.
- h. The TAB Contractor shall provide daily lists of issues and/or problems identified during TAB work to the [CM/GC], Owner and AE for follow-up & resolution with the appropriate Contractors.
- i. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the Owner for sampling or diagnostic purposes.
- j. TAB Contractor shall comply with the requirements listed in the Controls & Instrumentation paragraph below. The TAB Contractor shall coordinate with the controls Contractor to ensure that changes made to the control system during TAB (flow coefficients, duct areas, Temperatures, etc.) are archived and become the default or initial values for these parameters. Both Preliminary Reports for approval and final TAB Reports shall provide physical evidence of Point-to-Point Checkouts i.e.) all DDC Points commands and responses reporting properly and values reflect calibrated adjustments. Final reported values, when accepted by the Owner, will serve as Functional Testing evidence.
- k. The TAB Contractor will provide technicians and instrumentation to support the field verification.
- l. Failure of an item during the TAB field verification is defined as:
 - For all readings other than sound, a deviation of more than 10 percent.
 - For sound pressure readings, a deviation of 3 decibels. (Note: variations in background noise must be considered).
- m. A failure of more than 10% of the readings tested during the field verification shall result in the rejection of the final TAB report and require re-balancing of the system(s) in question (at no additional cost to the Project or the Owner).

E. Controls & Instrumentation System Testing

1. Prior to start of control system Functional Performance Procedures, the Contractor responsible for providing the Building Automation System (BAS) shall verify and document that all control systems are installed and operating properly including the following:
 - a. Point-to-Point Checkout shall be completed and documented per the project requirements
 - b. Control Sequence Checkout. Contractor shall verify that the control system programming matches the specified sequences of operation. For these checkouts, the Contractor shall simulate actual operating conditions for the various operating modes being tested (heating, cooling, etc) by false-loading systems, adjusting setpoints and similar techniques.
 - c. Tune all Control Loops to obtain the fastest stable response without unreasonable hunting, offset or overshoot. Record tuning parameters and response test results for each control loop and provide trend reports to document results. Trend logs shall show both steady-state operation and response to setpoint changes.
 - d. Test All Alarms and Safeties. Record all alarm parameters and alarm messages. Document all alarms and safeties have been tested and are functioning properly.
2. The Contractor responsible for the BAS shall work with the TAB Contractor(s) to make sure that changes to the BAS made during TAB, such as flow coefficients, flow setpoints and duct areas are permanently archived in the BAS and become the initial or default values for their respective controllers.
3. Point-to-Point Checkout Requirements
 - a. Items described in this section apply to and augment the requirements of the project Building Automation System as detailed in the specifications and on the drawings.
 - 1) These procedures will verify the following for each physical control point:
 - (a) Field device is installed per the manufacturer's recommendations and the project drawings and specifications.
 - (b) Field verify calibration of all analog inputs and outputs.
 - (c) Verify labeling of controllers, field devices, and wiring.
 - (d) Physical points are correctly addressed and communicating properly between its controller and the field device.
 - b. Detailed written procedures for execution of Point-to-Point Checkouts shall be submitted to the Owner and AE by the Contractor for review and approval prior to the start of testing. Include proposed test forms as part of this submittal.
 - c. The Contractor shall provide all tools and instrumentation necessary for execution of this testing. All instrumentation must be in calibration and meet the requirements of Part 2 of this specification.

- d. The Owner reserves the right to field verify up to 20% of the Contractor's Point-to-Point Checkout testing. The Contractor shall provide the technicians and instrumentation used for the original testing to assist the Owner with this field verification.

3.5 FUNCTIONAL PERFORMANCE PROCEDURES

A. Scope

1. Functional Performance Procedures (FPP) are executed after commissioned equipment and systems have been installed, started-up and balanced. The goal of these procedures is to verify that commissioned equipment, sub-systems and major systems operate and perform per the design intent and the project specifications.
2. The role of the Owner is to witness FPPs by documenting the performance. During this phase of Construction the systems are to have been fully contractor verified through all sequences and operations normal to the Project. The Owner is not responsible to help resolve non-performance and/or operating issues etc.
3. Equipment-level FPPs will be used to verify operation and capacity of selected equipment such as boilers, chillers cooling towers, pumps, exhaust fans, air handling units, etc.
4. System-level FPPs will verify the following aspects of system operation:
 - a. System operation under both normal and alternate operating conditions and modes
 - b. Interactions between equipment and sub-systems
 - c. Operation of safeties and interlocks
 - d. Control system operation, response time, stability and tuning
 - e. System response to abnormal and/or emergency conditions such as fire, equipment failure and power outages

B. Contractor Requirements

1. In order for Functional Performance Procedures/tests to be recorded by the Owner for this project, ALL Installation O&M Manuals must have been submitted and approved.
2. The Cx team will, in a joint effort, coordinate and schedule FPP activities.
3. Scheduling of FPPs shall be contingent on notification from the affected Contractor(s) to the **[CM/GC]** and Owner that equipment and systems are ready for checkout.
4. Other prerequisites for execution of FPPs shall include the following
 - a. All PFP's, Contractor Pre-startup Testing and Startup Procedures have been completed and documented
 - b. TAB has been completed
 - c. Field Observation Notes affecting equipment or system performance or operation have been resolved

5. Prior to claiming readiness for FPP, the controls Contractor shall ensure that the following items are completed, debugged, validated and forward all documentation:
 - a. Point-to-point checkouts listing command and response values.
 - b. Verify that network communication between all devices and systems is established
 - c. Sequence of Operation checkouts
 - d. Printed and annotated trend logs and histories establishing acceptable operation including
 - 1) Stable control
 - 2) Recovery from upset/changes (e.g., from setback)
 - 3) Special and/or seasonal modes
 - 4) Emergency and alarm modes including loss/restoration of power
6. The Contractors providing and installing the equipment and systems being commissioned shall execute the FPPs.
7. FPPs on individual equipment shall be completed by the installing Contractor. FPPs on complete systems (i.e. chilled water system, hot water heating system, etc.) and sub-systems (i.e. terminal unit controls, etc.) shall be completed by the installing Contractor and the Contractor responsible for providing the BAS in collaboration.
8. The Owner will provide guidance and oversight to the Contractors during their execution of the FPPs and will witness a random sample portion of these procedures.
9. Contractor activities during FPP execution will include the following:
 - a. Starting/stopping equipment
 - b. Energizing/de-energizing electrical distribution gear
 - c. Opening/closing valves and dampers
 - d. Manipulating BAS inputs, outputs and setpoints
 - e. Setup, collection and downloading of BAS trend data
 - f. Taking measurements and recording data and observed issues (deviations from the design documents) onto the FPP checklists.
10. Contractors shall conduct seasonal FPPs. This includes performing FPPs on equipment during the season it is intended to operate (i.e. test cooling equipment during the peak cooling season and test heating equipment during the peak heating season, etc.).
11. Tools, test equipment and instrumentation required for completion of the FPPs shall be provided by the Contractor except for special-purpose or proprietary tools, test equipment and instrumentation which will be provided by the manufacturer of the equipment being tested. All instruments shall meet the requirements of Part 2 of this specification.

3.6 ISSUE RESOLUTION LOG

A. Scope

1. The Cx agent will maintain and periodically publish a separate Issue Tracking Report (ITRca), which will be used to document issues identified during the commissioning process. This ITRca will track the following information for each identified issue:
 - a. Date issue was identified
 - b. Issue priority (high, intermediate, low)
 - c. Party responsible for issue resolution
 - d. Issue description including impacts to system
 - e. Actions taken to resolve issue
 - f. Issue status (open, closed)
 - g. Date issue was resolved
2. The Contractor(s) shall promptly respond to the ITR in writing concerning the status of each open issue identified as their responsibility during execution of the commissioning process. Contractor responses shall include the following information as appropriate:
 - a. Explanations of any disagreements
 - b. Actions taken to resolve issue
 - c. Proposed actions including completion dates
3. The Prime Contractors, including their Sub-Contractors, vendors and suppliers are responsible for resolution of all issues identified during execution of the commissioning process.
4. Issues shall be resolved in a timely manner, typically within 72 hours of notification, to avoid impact to either the construction schedule or commissioning schedule.

B. Failure Due to Manufacturer Defect

1. If 2%, or ten, whichever is greater, of similar types of equipment from one manufacturer or supplier fail to perform to the Contract Documents (mechanically or substantively) due to manufacturing, handling, or similar defect, not allowing it to meet its submitted performance spec, all similar units may be considered unacceptable by the AE or Owner. In such case, the Contractor(s) shall provide the Owner with the following:
 - a. Within one week of notification from the AE or Owner, the Contractor shall cause the manufacturer's representative to examine 10% of other identical units making a record of the findings. The findings shall be provided to the AE and Owner within two weeks of the original notice.
 - b. Within two weeks of the original notification, the manufacturer, through the Contractor, shall provide a signed and dated, written explanation of the issue, cause

of failures, etc. and all proposed solutions, which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.

2. The AE and Owner will determine whether a replacement of all identical units or a repair is acceptable.
3. Sufficient examples to allow adequate evaluation of the proposed solution will be installed by the Contractor. The Owner and AE will determine the performance prior to deciding whether to accept the solution.
4. After such procedures are performed and the results have been accepted as noted above, the Contractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly.

3.7 OPERATION AND MAINTENANCE MANUALS

A. General

1. The Contractor shall provide the Owner with comprehensive, project-specific manuals for the safe and effective Operation and Maintenance (O&M) of the systems and equipment listed, in this specification.
2. O&M Manual requirements included in other Sections of this Specification are in addition to, and do not replace, those required in this Section.
3. Provide (1) complete Electronic Set to the Owner. The format shall be PDF, and / or MS Word, MS Excel, MS Project. On CDRom, or USB 2.0 drive, or DVD readable on Ms Office 2003 (and 2004 Office for MAC) compatible computers.
4. The Cx agent shall review all O&M manuals and determine if systems can be operated, maintained and repaired from the manuals. If manuals are determined to be insufficient, it should noted on the Cx log and subcontractors must resubmit O&M manuals that the Cx agent is satisfied to be sufficient.

B. Submittals

1. Refer to *Section 01 78 23 - Operation and Maintenance Data* for submittal requirements.

C. Content: Note: *Section 01 78 23* provides a general listing of content requirements. As part of the Commissioning documentation, provide the following material:

1. Each chapter shall contain the following information in addition to the requirements specified elsewhere in these specifications.
 - a. Contact list identifying vendors providing equipment and systems covered in the current chapter. This information shall include vendor name, address, name of contact person(s), phone numbers (including 24 hour service numbers where appropriate), fax numbers, and email addresses.

- b. Equipment/material schedule(s) for all covered equipment and systems showing equipment identification (tag) number, manufacturer, model number, serial number, quantities, area/system served, equipment location, etc.
2. References shall be made, as appropriate, to drawings, schematics, sequences of operation and other information included as part of the construction contract drawings and specifications that show distribution system layout, equipment arrangements and items of control.
3. All information included in the final O&M Manuals, including equipment schedules, manufacturer's literature, drawings, etc. shall represent the "as-built" condition.
4. Manufacturer's literature and other information provided in the O&M Manuals shall be for the actual equipment installed under contract for the particular facility. Where literature (standard product catalogs, cut-sheets, etc.) contains data pertaining to parts, equipment or options other than those specifically provided for this project, the Contractor shall clearly indicate the specific products, model numbers, and options provided. Mark-ups made by the Contractor for this purpose shall be made in a manner that will clearly photocopy (no highlighters).
5. Each chapter shall include the information required in the appropriate section of the specifications plus any additional information necessary for the Owner's personnel to successfully operate and maintain the systems and equipment covered in that chapter.
6. Information to be provided in the Operation and Maintenance Manuals includes the following:
 - a. Warranty information
 - 1) Provide copies of all warranty certificates from equipment manufacturers
 - 2) If not included on warranty certificate, provide the start/end dates of warranty period, descriptions of what is and isn't covered and contact information for warranty claims (if different from contact list described above).
 - 3) Provide information of an operations or maintenance nature covering warranty items that have not been discussed elsewhere.
 - b. Product Information.
 - 1) Provide manufacturers' standard, published product literature describing covered materials, equipment and devices including illustrations, exploded views, dimensions, weights, application data, etc.
 - 2) Where manufacturer's product information (catalog cut-sheets, etc.) contain data pertaining to parts, equipment or options other than those specifically provided for this project, the Contractor shall clearly indicate the specific products, model numbers, and options provided. Mark-ups made by the Contractor for this purpose shall be made in a manner that will clearly photocopy (no highlighters).

- 3) Provide manufacturer's standard, published Installation, Operation & Maintenance bulletins pertaining to the specific equipment installed.
 - 4) Provide performance curves and rating data, specific to the equipment installed on the project such as fan and pump curves, sound data, etc.
 - 5) Provide a copy of all approved shop drawings covering approval of equipment for the project with the product information.
 - 6) Include all data concerning changes made during construction.
- c. Preventive Maintenance Procedures & Schedules
- 1) Provide written preventive maintenance procedures describing each required PM task.
 - 2) Procedures shall include lists of tools and parts required and all safety precautions to be taken.
 - 3) State, preferably in tabular form, the recommended frequency for each preventive maintenance task (cleaning, inspection, lubrication, scheduled overhauls, etc.). Task schedules shall be grouped and sorted by frequency (daily, weekly, quarterly, annually, etc.)
 - 4) Procedures for lubrication of equipment shall indicate both the type and quantity of lubricant to be used.
 - (a) If periodic inspection of equipment is required for operation, cleaning, or other reasons, indicate the items to be inspected and give the inspection criteria.
 - (b) Provide instruction for the proper handling, disposal and/or removal of hazardous or otherwise special materials such as used filters, refrigerant, oils, chemicals, etc.
 - (c) Provide instruction for minor repairs or adjustments required for preventive maintenance routines. Minor repair and adjustment shall be limited to repairs and adjustments that may be performed without special tools or test equipment and that require no special training or skills. Identify test points and give values for each.
- d. Corrective Maintenance Procedures
- 1) Corrective Maintenance: Corrective maintenance instructions shall be predicated upon a logical effect-to-cause troubleshooting philosophy and a rapid replacement procedure to minimize equipment downtime. Instructions and data shall appear in the normal sequence of corrective maintenance, for example, troubleshooting first, repair and replacement of parts second, and then the parts list.
 - 2) Troubleshooting: This information shall describe the general procedure for locating malfunctions and shall give, in detail, any specific remedial procedures or techniques. The data shown are intended to isolate only the most common

equipment deficiencies. Troubleshooting tables, charts, or diagrams may be used to present specific procedures. A guide to this type shall be a three-column chart. The columns shall be entitled Malfunction, Probable Cause, and Recommended Action. The information shall be alphabetically arranged by component, and each component shall, in turn, list deficiencies that may be expected. Each deficiency shall contain one or more problems with a recommended correction.

- 3) Repair and Replacement: Indicate the repair and replacement procedures most likely to be required in the maintenance of the systems and equipment. Information included here shall consist of step-by-step instructions for repair and replacement of defective items. Include all information required to accomplish repair or replacement, including information such as torque values. Identify all tools, special equipment, and materials that may be required. Identify uses for maintenance equipment. The paragraphs shall contain headings to identify the topics covered.

7.

a. Spare Parts Lists.

- 1) Provide a list of all spare parts for the covered equipment. The parts list shall include a tabulation of descriptive data for each part including part number and manufacturer. Where available, provide an exploded diagram of the equipment identifying parts listed in the spare parts list.
- 2) Provide a list of recommended spare parts to be kept in inventory by the Owner's maintenance staff for performance of preventive maintenance and typical corrective maintenance tasks.

b. System Descriptions:

- 1) Provide a typewritten narrative describing, in general terms, the covered equipment / system. Topics to be covered in this narrative shall include theory of operation, overall system layout, description of major components, interconnections with utilities and other systems, description of control system layout and operation, identification of unusual features or functions, and major safety precautions. This information should correlate with information provided in the manufacturers' standard published literature.
- 2) Provide a list of recommended spare parts to be kept in inventory by the Owner's maintenance staff for performance of preventive maintenance and typical corrective maintenance tasks.
 - Detailed illustrations and schematic diagrams of each system showing major components, piping, valves, controls, utility connections, and other components, where applicable.
 - Wiring and control diagrams with data to explain detailed operation and control of each component.

- Control sequences describing start-up, all modes of operation, and shut down.
 - Corrected shop drawings.
 - Copies of approved certifications and laboratory test reports (where applicable).
- c. Operating Instructions:
- 1) Provide condensed, typewritten, instructions for operation of the covered systems and equipment. Where more than one (1) common unit is installed, one set of instructions is adequate. The instructions shall provide procedures for:
 - Starting up the equipment/system.
 - Shutting down the equipment/system.
 - Normal operating procedures.
 - Procedures for operating the equipment / system in emergency or unusual conditions.
 - Safety precautions.
 - Procedures for both short-term and long-term equipment lay-up.
 - Other pertinent data applicable to the operation of particular systems or equipment.
 - The instructions shall be suitable for posting adjacent to the equipment.
- d. Factory Test Reports
- 1) Provide copies of factory test reports specified in the covered section of the specifications.
 - 2) Test reports should include a brief description of the test procedures used, test date, names of personnel performing test, names of personnel witnessing test (if any), test results and comparison of test results with specified acceptance criteria.
- e. Field Test Reports
- 1) Provide copies of field test reports specified in the covered section of the specifications. Samples of field testing include, but are not limited to, leak testing of piping and ductwork and megger testing of electrical distribution systems.
 - 2) Test reports shall clearly indicate the type of test performed, test procedures used, system being tested, section or area of equipment being tested, date of test, signatures of personnel performing and witnessing the test, test results and comparison of test results with specified acceptance criteria.
- f. Posted Operating Instructions and Diagrams:

1) Operating Instructions:

- Where specified, copies of operating instructions shall be posted in the near vicinity of each piece of applicable equipment. The instructions shall be mounted neatly in frames under Plexiglas, where they can be easily read by operating personnel. Instructions mounted outdoors shall be suitably protected from weather.
- Coordinate with owner regarding size and location of posted operating instructions.

2) Systems Diagrams:

- Simplified one (1) line diagrams of the systems listed in the attached O&M Manual Matrix shall be developed and posted neatly under Plexiglas in the main or most appropriate equipment room for easy reference by operating and maintenance personnel.
- These drawings shall be done in a professional manner, which is acceptable to the Owner's Facility Management staff. The diagrams shall show each component including all valves installed in the system, with name and identifying number. If space does not permit valve numbers on the diagrams, valve charts shall be provided. Explanatory Coordinate with owner regarding locations of posted operating instructions.
- Coordinate with owner regarding locations of posted operating instructions.
- These diagrams shall be suitable for reduction in size and use in the operating manual system descriptions previously covered.

3.8 OPERATION AND MAINTENANCE TRAINING

A. General

1. The Contractor shall train the Owner's personnel in the operation and maintenance of systems and equipment listed in this Section and as mentioned in other sections.
2. The required training and demonstration required in the technical sections of the specifications is supplemental or in addition to the training required in this Section (where not a duplication).
3. Cx agent in conjunction with the owner shall determine if training is adequate. If the training is determined to be inadequate it shall be noted on the Cx log and tracked as a deficiency until subcontractor provides training that is deemed adequate.

3.9 ACCEPTANCE

- A. Satisfactory completion and documentation of the Commissioning Activities described in this specification shall be considered prerequisites for system acceptance.
- B. At no time will acceptance be made for individual pieces of equipment. Final acceptance will only be for systems that will operate as intended in the basis of design and the design intent.

END OF SECTION

This Commissioning Standard establishes minimum requirements only.