

PART 1 – GENERAL

1.01 SUMMARY

- A. The systems installed under Divisions 23 and 26, as well as pieces of equipment provided under other Divisions that connect to or interface with the systems of Division 23 and 26 will be evaluated, started, and tested (commissioned) to ensure that each performs per the intent of the design and/or representations made relative to performance, efficiency, and suitability for application in this project.
- B. Owner will employ an independent Commissioning Authority (CA). The CA is an independent and knowledgeable third party, hired to verify that the systems work as per the design intent and provide the requirements of the commissioning responsibilities as designated in this specification. The CA will inform the Owner of the results of the commissioning, and provide suggestions, as necessary, to correct deficiencies in observed performance or installation.
- Commissioning Objectives
Commissioning is intended to achieve the following specific objectives:
1. The Owner will ultimately inherit a building that is designed to meet the needs of the user and is built and functions as designed.
 2. Systems performance expectations are clearly established.
 3. The users, project managers, operating personnel, contractors and designers will be protected from any dislocation created by the fragmented corrections and undocumented deficiencies.
 4. Corrective actions will be made in a manner that will not compromise long-term utilization or operating expense.
 5. The Owner's operating personnel will have the integrated system training needed to confidently operate and maintain the systems.
- C. The CA will be employed directly by the Owner or Owner's Representative to perform commissioning duties. Sections 230800 and 260800 outline the specific commissioning responsibilities of each Contractor for that division, and also obligate the General Contractor/Construction Manager to coordinate and manage the commissioning responsibilities of those subcontractors.
1. This section of the specification describes the process for commissioning and defines the responsibilities of the construction team, including the Construction Manager.
 2. The commissioning process shall be applied to all equipment, components, and systems as listed in this section, including specific interfaces to and from equipment and systems provided under separate contracts.
 3. Building Commissioning work is a joint team effort to ensure that all systems function together properly to meet the design intent, and to document system performance parameters for fine-tuning of control sequences and operations procedures. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment start-up, control system calibration, testing and balancing, training, and performance testing. This section does not supersede other requirements of the specifications. It may, though, expand on some of them.
 4. Complementary to the Contractor's responsibility to commission the building systems, it should be noted that an Owner's CA will be involved. This Owner's CA will provide equipment-systems installation inspection and performance verification. **These Owner's verifications will be a prerequisite to final equipment and systems acceptance by the Owner as per design documents.** It should be emphasized that this Owner's systems verification does not negate the Contractor's obligations to fully commission the building systems or relieve them of any contractual obligations. The Contractor's personnel shall be made available to execute all aspects of the Commissioning Process until the Owner and the Engineer of Record accept the final results. Commissioning Program tasks and meetings may be repeated until the Owner and the Engineer of

Record are satisfied and will not be fixed as one time, one chance events for the Contractor.

5. The Owner's CA will verify equipment-systems installation and performance after the Contractor provides written notice that the building equipment and systems have been completed, tested and are fully operational. Upon this notification, Owner's CA will verify the installation and performance of the equipment and system(s). If corrections are required after the initial verification, the Owner's CA will provide one (1) additional installation and performance verification. Subsequent installation and performance verifications will be at the Contractor's expense. The Contractor is responsible for all systems and equipment until final acceptance by both the Engineer of Record and the Owner. All guarantees and warranties shall not begin until final acceptance by both the Engineer of Record and the Owner.

1.02 CONSTRUCTION TEAM RESPONSIBILITIES

- A. Within four (4) weeks of the award of the contract, the Mechanical, and Electrical Contractors shall submit the names of the Project Manager who will be the commissioning coordinator for this project, as well as the names, addresses, phone numbers and qualifications of subcontractors' representatives and factory trained manufacturers' representatives for all equipment and systems required to participate in the commissioning process as specified in this Section.
- B. Each Contractor, and all his sub-trades and suppliers, shall cooperate with the CA in carrying out the commissioning process. In this context, each Contractor shall:
 1. Provide equipment and systems start-up as specified.
 2. Operate equipment and systems as required for initial systems operations and for final functional performance tests as they are performed by the CA, including the on-site participation of approved factory trained manufacturer's representatives for equipment.
 3. Attend commissioning meetings, and attend to action items arising from them, as required to allow the commissioning process to proceed on schedule.
 4. Provide instruction and demonstrations for the Owner's designated operating staff, in conjunction with the CA, in order to meet all specified training requirements in this regard.
 5. The Contractors shall make any and all necessary corrections to systems, equipment, O & M manuals, as built drawings, and procedures as necessary to meet the design intent, contract documents, or performance requirements if errors are discovered during the commissioning process.
 6. The Contractors shall supply all necessary documentation, such as shop drawings, submittal data, maintenance manuals, etc., required for equipment and systems to the CA for preparation of the commissioning plan, checklists, and functional performance plans.
 7. The Contractors shall provide the required names, addresses and qualifications of all specified Manufacturer's Representatives to participate in the commissioning process prior to the initial commissioning meeting.
 8. Subsequent installation and performance verifications, made necessary due to required corrections after initial verification, shall be at the respective Contractor's expense.
- C. Each Contractor shall provide to the CA three (3) copies of the following items as soon as they become available:
 1. Construction schedule, including sub-schedules and milestones for all major mechanical and electrical equipment. (i.e. boilers, motor control center, air handlers, generators, VAV boxes, etc.)
 2. Certified and approved start-up and testing reports for all subsystem equipment that comprise the System.
 3. Control schematics and sequences of operation for the total system and all subsystems.
 4. Records of required inspections for code compliance, and documentation of approved permits and licenses to operate components of the System.

5. Operating data which shall include all necessary instructions to the Owner's operating staff in order to operate the system to specified performance standards.
6. Maintenance data which shall include all necessary information required to maintain all equipment in continuous operation, such as the testing, balancing and adjusting report and the as-built drawings.
7. Written notices that building equipment and systems have been completed, tested, and are fully operational. At the discretion of the CA, this may be the completed pre-functional checklist by the contractor.
8. Checklist of all submitted contract deliverables, such as manuals, spare parts, training, documentation, etc.

1.03 COMMISSIONING TEAM MEMBERS

The members of the commissioning team consist of the CA and support staff, Project Managers (PM), and Maintenance & Operating staff, assigned members of the construction manager (CM), the design team (A/E) (particularly the mechanical / electrical engineer), Testing and Balancing Contractor (TAB), Primary trades and other installing subcontractors or suppliers of equipment (Subs).

1. Commissioning Authority
2. School Operations Staff
3. Construction Manager
4. Architectural and Engineering Design Team
5. HVAC Contractor
6. Control's Contractor
7. Testing and balancing Contractor
8. Plumbing Contractor
9. Electrical Contractor
10. Selected Equipment Manufacturers

1.04 CONSTRUCTION MANAGER'S RESPONSIBILITY

- A. Cooperate with the CA personnel, provide access to work, and provide adequate time in the work for commissioning tasks.
- B. Include the cost for commissioning requirements of construction manager in the contract price.
- C. Ensure cooperation between the subcontractors and the commissioning team
- D. Attend commissioning specific pre-construction, planning and testing meetings. Provide input into the master scheduling process with regard to the timing and duration of the commissioning activities.
- E. Work with the Owner and the CA to schedule each training session with the appropriate O&M personnel.
- F. Provide written documentation that the systems are complete and ready for functional testing verification.
- G. Correct all Contractor related deficiencies identified during any stage of the commissioning process.
- H. Furnish copies of all shop drawings, manufacturers' literature, maintenance information, or other information as may be requested.

- I. Provide qualified personnel for assistance to complete the commissioning tests, including seasonal testing.
- J. Coordinate the trades as per the CA's testing and pre-testing responsibilities.
- K. Provide training with the assistance of the CA as outlined in Divisions 23 and 26.
- L. Provide to the CA all proprietary test equipment required by manufacturers to test their equipment.
- M. Provide casual labor and facilities:
 - 1. To provide access to work to be tested.
 - 2. For CA's exclusive use, for storage of instruments and drawings, and preparation of daily reports.
- N. The CM shall provide a qualified individual to function as the MEP Coordinator to coordinate the Commissioning Program with the CA for those systems included in Divisions 23 and 26.
- O. The CM shall execute the Commissioning Program, through organization of all meetings, tests, demonstrations, training events, and performance verifications described in the Contract Documents and approved Commissioning Program. Organizational responsibilities include preparation of agendas, attendance lists, arrangements for facilities and timely notification to participants for each Commissioning event.
- P. The CM, MEP Coordinator and all Subcontractors shall review the plans and specifications with respect to the completeness in all areas relating to the Commissioning Program. This includes ensuring that there are adequate items included in the design to ensure the ability to properly test, balance, and adjust the systems and to document the performance of each piece of equipment and each system. Any items that are required for Commissioning but not shown shall be brought to the attention of the CA and Engineer of Record (ER) prior to submittal of shop drawings. Likewise, any items that are required for Commissioning but not installed shall be provided at no additional cost to the project as per design intent.
- Q. The CM shall schedule a Pre-Commissioning Coordination Meeting within 90 days of the award of the contract, at the site and at a time suitable to all parties. This Pre-Commissioning Meeting will be for the purpose of reviewing the complete Commissioning Program and establishing tentative schedules for Maintenance Orientation and inspections, O & M submittals, training sessions, system flushing and testing, job completion, system startup, and test, adjust and balance work.
- R. The CM and Coordinator will review and all functional performance tests, results, and documentation required by the contract documents, for all equipment and systems, as performed by subcontractors, vendors, etc. Develop schedules for all testing, integrate testing into the master construction activity schedule, and fully coordinate all subcontractors testing as required.
- S. The CM and Coordinator shall submit Systems Testing Documentation Forms, schedules, and other commissioning documentation using the shop drawing submittal process, for approval by the ER and CA six months prior to starting any testing required by Divisions 23 and 26. The Owner, ER and CA reserve the right to require changes in the personnel assigned at any time to maintain quality assurance within the Commissioning Program at no additional cost to the project.

- T. The CM shall coordinate directly with each subcontractor on the project specific to their responsibilities and contractual obligations. All contractors shall provide qualified personnel for participation in systems tests, including seasonal testing required after the initial testing.
- U. The CM, MEP Coordinator and all Subcontractors shall provide technical expertise to oversee, direct, and implement the correction of deficiencies found during the commissioning process. Observe the start-up and initial testing of equipment by the Contractor and Subcontractors and then all final HVAC, building automation, electrical, etc. The Contractor's personnel shall be made available to execute all aspects of the Commissioning Program until the ER and Owner accepts the final results. Commissioning Program tasks and meetings may be repeated until the ER and CA are satisfied and will not be fixed as one-time, one-chance events for the Contractor.
- V. Note any inconsistencies or deficiencies in system operations and enforce system compliance or recommend to the ER modifications to system design which will improve system performance.
- W. The CM shall coordinate through the Owner, CA and ER testing participation. When performance tests, results, and forms of documentation required by the contract documents are completed by the MEP Coordinator, the Owner, ER, and CA shall be notified. After such time, the CA will conduct systems performance verification.
- X. In the event that a performance verification test by the CA fails, the cause of failure shall be determined by the CM and rectified as soon as possible, and then re-tested.
- Y. The CM shall assemble all record drawings and all records of Code authority inspections and approvals. The CM and MEP Coordinator shall review operation and maintenance information and as-built drawings and obtain all documentation from tests and assemble a final submittal to the ER, Owner, and CA for approval. The CM shall document warranty start and dates.
- Z. The CM shall oversee and/or provide training for the systems specified in Divisions 23 and 26.

1.05 COMMISSIONING AUTHORITY'S DUTIES

- A. The CA is contracted directly with the Owner's representative.
- B. The CA shall develop and submit a detailed commissioning plan that would include all system testing requirements including, pre-functional and functional testing sheets, responsibilities, O&M manual and training requirements and forms.
- C. The CA shall execute the Commissioning Program, through organization of all meetings, tests, demonstrations, performance verification as described within.
- D. The CA shall be responsible for developing Pre-functional and Functional test procedures for all equipment and systems. Test procedures shall be in accordance with the manufacturer's recommendations, and shall fully describe the system configurations and tests for each component and system. Each test procedures shall include: specific criteria to be tested for; measured test results verses design requirements; pre-functional test sheets; approved submittal; and Contractor required testing.
- E. The CA shall develop and maintain the commissioning schedule that shall be updated during each commissioning meeting. The commissioning schedule shall be a copy of the General Contractor/Construction Manager schedule.

- F. The CA shall review all shop drawings, coordination drawings and submittals for completeness, accuracy and operational accessibility. All deficiencies shall be documented and submitted to the engineer for review.
- G. The CA shall coordinate directly with the CM during the commissioning meetings (and the subcontractors) to develop the commissioning requirements and schedules. All Contractors shall provide qualified personnel for participation in the system tests, including seasonal testing.
- H. At their discretion, the CA shall witness all Contractor required testing including; piping hydrostatic and duct leakage tests. The Contractors shall be responsible for coordinating these tests with the CA.
- I. At their discretion, the CA shall participate in any factory testing (i.e. Air-handling factory testing) as identified by the Owner. The CA shall coordinate any factory testing with the subcontractors and the CM.
- J. The CA shall review the record drawings and "as-built" documentation for clarity and accuracy. Any discrepancies identified during this review shall be documented and shall be returned for resubmission.
- K. The CA shall review, if appropriate, all operational and maintenance manuals for pre-approval prior to submission to the Engineer. Any discrepancies identified during this review shall be documentation and returned to the Contractors for resubmission.
- L. The CA will perform regular construction installation inspections during the construction timetable and include any identified deficiencies in the regular commissioning meetings. These items shall be reviewed and discussed during the commissioning meeting.
- M. The CA shall participate in the TAB process and perform random sampling of air and water testing to ensure completeness of services.
- N. The CA shall work with the control's Contractor to perform a point-to-point verification of the building's automation system once the control's Contractor submits in writing that their point-to-point is complete.
- O. The CA shall cooperate with Architect and Contractor; provide qualified personnel when scheduled.
- P. The CA shall promptly notify Architect and Contractor of irregularities or deficiencies of work, which are observed during performance of services.
- Q. The CA will test all systems as defined in the Commissioning Plan and the written functional test procedures.
- R. The CA shall work directly with the Owner's Representative and Commissioning Team to provide resolution of deficiencies and provide recommendations to the team.
- S. The CA is not authorized to:
 - 1. Release, revoke, alter, or expand requirements of Contract Documents.
 - 2. Approve or accept any portion of work.
 - 3. Perform any duties of the Contractor.

1.06 SYSTEMS TO BE COMMISSIONED

- A. Steam to Hot Water Boiler
- B. Elevator

PART 2 - COMMISSIONING PROTOCOLS

2.01 PRE-FUNCTIONAL TEST SHEETS

- A. Pre-functional checklists are important to ensure that the equipment and systems are installed and started up as per the design documents and the manufacturer's start-up procedures. The CA develops the pre-functional test sheets (checklists) for each system and component to be commissioned. **The Contractor then fills out the pre-functional test sheets, and submits it for review.** The pre-functional test sheets and check-out by the CA is a parallel activity, and does not relieve the Contractors from their duties of verifying system installation and proper system start-up. The CA will share the test sheets with the Contractors for their review (if necessary). Once pre-functional test sheets are signed-off by the CA, functional performance testing may proceed without unnecessary delays. Each piece of equipment receives full pre-functional checkout by the CA. In general, the pre-functional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
- B. Pre-functional checklists (or Testing Abstracts) are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., oil levels OK, fan belt tension, labels affixed, gages in place, sensor calibration, etc.). However, some pre-functional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). The word pre-functional refers to before functional testing. Pre-functional checklists augment and are combined with the manufacturer's start-up checklist.

2.02 FUNCTIONAL PERFORMANCE VERIFICATION

- A. Functional Performance Verification (FPV) is the dynamic testing of systems (rather than just individual components) under full, part and seasonal requirements. Systems are tested under various loads and control sequences, such as low cooling and heating loads, component failures, unoccupied modes, etc. The systems are run through all the control sequences of operation and components are verified to be responding as the design intent and documents. Functional performance verification shall include; testing all sequences of operations, verification of system capacity, generating simulated signals to simulate sensor values, conducting simulated conditions to tests all loads and verify system performance during all conditions of operation and verifying design intent. In addition, each system shall be tested through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part and full load). Proper responses, such as power failures, freeze conditions, low-oil pressures, equipment failures, etc., shall also be tested. The CA develops the functional test sheets and procedures in sequential written form, coordinates the testing, conducts the testing and documents the testing. Each Contractor is required to supply personnel to assist during the functional performance testing where applicable.
- B. No system, equipment or component thereof shall be tested until the Contractor and the CM has certified, in writing, that the system, equipment and / or components are complete, have been tested, adjusted and balanced and are ready for validating and performance testing. FPV is scheduled by the CA after the pre-functional testing requirements are complete and signed-off by the CM and the CA. FPV will not be conducted until a written notice of completion

by the CM confirming that the system is ready for FPV. The air balancing and water balancing must be complete and the controls must be debugged prior to the performance verification.

- C. **Deferred Testing.** The Contractor shall be available to assist in seasonal testing, tests delayed until weather or other conditions, until building construction is completed, required building occupancy or loading, or other conditions are suitable for the demonstration of equipment or system's performance, as specified. These deferred tests shall be conducted in the same manner as the seasonal tests as soon as possible. Deferred testing shall be executed, documented and deficiencies corrected as specified herein for functional performance testing. Any adjustments or corrections to the O&M manuals and "As built" documents required by the results of the testing shall be made before the seasonal testing process is considered complete.

2.03 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

- A. The CA shall clearly list any outstanding items of the initial start-up and pre-functional procedures that were not completed successfully. The testing form and any outstanding deficiencies shall be provided to the CM / Owner within two days of test completion. The CA shall review the Contractor's startup testing procedures and reports and shall submit either a non-compliance report or an approval form to the Contractor. The CA shall work with the Contractor and others as necessary, to correct and retest all cost deficiencies or uncompleted items. The Contractor shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CA as soon as outstanding items have been corrected and resubmit an updated start-up report with a Statement of Correction on the original non-compliance report. When all requirements are satisfactorily completed, the CA shall recommend approval of the startup and pre-functional testing of each system and schedule the functional testing of the equipment or system.
- B. As functional performance testing progresses and a deficiency is identified, the CA shall discuss the issue with the executing Contractor and the commissioning team.
 - 1. When there is no dispute of the deficiency and the Contractor accepts responsibility for correcting it, the CA shall document the deficiency and the Contractor's response and intentions and the testing shall proceed, if possible. Corrections of minor deficiencies identified may be made by the contractor during the functional performance testing, at the discretion of the CA. Every effort shall be made or expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the commissioning effort.
 - 2. When the identified deficiency is corrected, the Contractor shall sign the statement of correction at the bottom of the non-compliance form, certifying that the equipment is ready to be retested, and return the form to the CM. The CM shall sign the form and submit to the CA. The CA shall schedule the retest of the equipment or system involved.
 - 3. If there is a dispute about an identified deficiency, the CA shall document the deficiency and the Contractor's response, and provide a copy to the Contractor. Every attempt shall be made to resolve the dispute at the lowest management level possible. When the dispute resolution has been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and returns the form to the CA. The CA shall schedule the retest of the equipment or system involved. Final interpretive authority shall be the A/E. Final acceptance authority shall be the Owner.
- C. During the functional performance testing of multiple units of similar equipment, the CA shall test all of the equipment and components that are to be commissioned. If, under such a testing procedure, three or more, identical pieces of equipment (size alone does not constitute difference) fail to perform to the requirements of the Contract Documents (mechanically or substantively) due to manufacturing or installation defects not allowing it to meet its submitted performance spec, all identical units may be considered unacceptable by the CA. In such case, the Contractor shall provide the CA with the following:

1. Within one week of notification from the CA, 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 CA within two weeks of the original notice.
2. Within two weeks of the original notification, the Contractor shall provide the CA and the A/E a signed and dated, written explanation of the problem, cause of failures, etc. and proposed solution, including full equipment submittals for corrective or replacement equipment, if appropriate. The proposed solution shall not be for less than the specification requirements of the original installation.
3. When approved, two examples of the proposed solution shall be installed by the Contractor and the CA shall schedule and conduct functional testing of the proposed solution. Upon completion of the functional testing of the proposed solution, the CA shall recommend the acceptance or disapproval of the proposed solution to the Owner.
4. Upon acceptance of the proposed solution by the Owner, the Contractor shall replace or repair all identical items, at their expenses and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week of approval of the proposed solution.
5. Where 15% or more of a group of devices or components have failed, it shall be deemed that the entire group failed and will require retesting once the corrections have been made. The CM shall submit a letter to the CA that the corrections have been made by the Contractor and system can be retested.

D. Cost of Retesting

1. The cost for CA and/or Owner personnel to conduct the retesting of a functional performance testing requirements necessitated because a specific pre-functional or startup test item, reported to have been successfully completed, but found to be incomplete or faulty, shall be the responsibility of the Contractor.
2. For a deficiency identified during the functional testing, not related to any pre-functional checklist or start-up fault, the CA and Owner shall direct the retesting of the equipment once all deficiencies have been rectified. However, all costs for any subsequent retesting shall be the responsibility of the Contractor.
3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in backcharges to the responsible party.

2.04 OPERATION AND MAINTENANCE MANUALS

- A. Each Contractor shall submit operational and maintenance manuals to the CA, through the CM, prior to training. The CA reviews the O&M manuals, documentation and redline as-builts for systems that are commissioned to verify compliance with the Specifications. The CA provides written feedback on O&M manuals to the PM. Upon successful review of the corrections, the CA shall recommend approval and acceptance of these sections. The CA also reviews each equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated. This work does not supersede the Architect and Engineers responsibilities according to their contract.
- B. The O&M manuals shall be project specific, include all wiring diagrams and interconnections between trades. O&M manuals must meet at minimum the required checklist before acceptance for each component:
 1. Must be in a three-ring binder, with table of contents and tabbed sections.
 2. Building name, project title, project number, contractor name and contractor project number must appear on both the front cover and the spine of the binder.
 3. Provide a copy of the valve tag schedule at the front of the O&M manual
 4. Except for minor equipment, provide complete nameplate information at the front of the O&M. Include all data: serial numbers as well as complete motor nameplate data of corresponding equipment.

5. Provide a sheet at the beginning of the O&M listing equipment and the local supplier (with address and phone number) of that specific equipment.
6. For all equipment with warranties in excess of one-year (example VSD's), include extended warranty information in the front of the binder.
7. All information must be project specific. Do not provide generic vendor O&M manuals that cover multiple model numbers of equipment. Edit vendor O&M manuals to reflect exact equipment supplied. Cross out extraneous information not applicable to the specific equipment provided. Highlight applicable information for each piece of equipment installed.
8. For each piece of equipment, provide complete data relative to the make/model number, size, capacity data, manufacturer name and address, accessories included, etc. (i.e., provide complete information that would allow ordering the exact piece of equipment supplied). To accomplish this, include portions of the approved submittal for the piece of the equipment submitted. Do not include extraneous submittal information that does not facilitate actually ordering that piece of equipment.
9. If a piece of equipment contains multiple sub-assemblies provided by different manufacturers, include make/model number, size, capacity data, etc., to allow the ordering of the exact replacement. For example: for an air-handling unit, provide information on each coil, filter, damper, fan etc.
10. Job specific, as-built, wiring diagrams, piping diagrams, etc., must be supplied for all equipment. All external connections must be shown on these diagrams. Example #1: for VSD's, terminal strip numbers where external control signal is landed must be indicated. Example #2: A piece of equipment is supplied with controls that interface with the museum DDC system. Wiring diagram must be project specific and indicate interface with the existing DDC system.
11. For all pumps and fans, include performance curves, accessories and motor manufacturer information.
12. For all flow elements (pitot tubes, triple duty valves, circuit setters, etc.) provide all flow curves.
13. For all air-handling systems, include sound power data (normally this was included in the equipment submittal).
14. For all filters, clean and dirty filter drops must be provided.
15. For all electrical equipment sensor calibration and setup requirements must be detailed in the O&M manuals.
16. Provide a list of all manufacturer spare parts for major equipment installed.
17. Provide an approved copy of the air and water balancing reports in the O&M.
18. Provide an as-built copy of the project control drawings in the O&M, along with the installation and maintenance information on individual control components.
19. Provide a copy of the equipment vibration test report in the O&M.
20. For equipment requiring a factory start-up, a start-up report is required for the O&M.

2.05 TRAINING REQUIREMENTS

- A. Each Contractor is responsible for the training requirements. The CA shall be responsible for overseeing and approving the content of training the Owner's personnel for the equipment being commissioned. The CA will provide supplemental training if required by the Owner. Owner training and orientation on equipment and systems provided by the Contractor is accomplished in three general steps.
 1. Training Plan. After reviewing the specifications, and after interviewing facility staff, the Owner and CA document equipment for which training or orientation will be provided and designate responsible parties. This document lists, among other things, the type and number of trainees, rigor of training desired by the Owner, the primary responsible subcontractor, the trainer's company and columns for tracking training agendas. The Commissioning authority provides this form to the Contractor for reference.

2. Training Syllabus & Agendas. For each piece of equipment or system for which training is provided, the contractor shall develop a Training Syllabus and Agenda for review and approval by the Owner and CA. The syllabus and agenda includes information regarding the scope of training, intended audience, training materials, etc. The training shall include a plan for including in the training session contractors/trainers from different disciplines, when appropriate. For example, the controls contractor may be asked to provide brief training on controls in the same session with the mechanical training for equipment controlled by the building automation system. Approved syllabus and agendas shall be utilized and followed during each training session, with copies provided to each trainee.
3. Training Record. The contractor shall document the training session by means of a signed attendance sheet by both the trainer(s) and the attendees. The trainer checks off subjects covered on the Agenda. When the training is complete, the Contractor provides a copy of the training record, and the trainer's agenda to the Owner and CA. The Owner and CA review the training record and make final approval by signing it. The CA will, as appropriate, witness the training sessions. Where required by other sections of the specifications, the contractor shall video (DVD) the training session and provide to the CA and Owner the final and edited copy of the video for review and acceptance.

2.06 SCHEDULING REQUIREMENTS

- A. The As-Built drawings shall be updated to date and reviewed with the CA for approval no more than 45-days after all material is installed and in place.
- B. Testing and Start-ups schedules shall be kept up to date. Advise the CA and the Owner (in writing) with a minimum of 60 hours prior to commencement.
- C. Notify the CA and the Owner with a minimum of 2-weeks prior to the commencement of the TAB work for both the air and the hydronic systems. Follow requirements set forth in section 230800.

END OF SECTION