



Facility Commissioning Group

109 Springdale Drive, Suite 7 | Nicholasville, KY 40356 | Tel. (859) 278-5552 | Fax (859) 278-6501

SPECIFICATION 15995 COMMISSIONING OF HVAC SYSTEMS

OWNER FURNISHED

The owner directly contacts an independent third party commissioning agent for this project. This specification has been included for reference only to define contractors' responsibilities. Each contractor should review this procedure and include adequate time in their proposal.

RELATED DOCUMENTS

Contract drawings and specifications, general provisions of the contract, including general and supplementary conditions, mechanical provisions and Division-1 Specification sections apply to work of this section.

DESCRIPTION OF WORK

The purpose of the commissioning process is to provide the owner/operator of the facility with a high level of assurance that the mechanical systems have been installed in the prescribed manner, and operate within the performance guidelines set in the Design Intent Documents (DID). The CA shall provide the owner with an unbiased, objective view of the system's installation, operation, and performance. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the owner. The CA will be a member of the construction team, administering and coordinating commissioning activities with the design team, construction manager, subcontractors, manufacturers and equipment suppliers.

REFERENCES

ASHRAE Guideline 0 - 2005

ASHRAE Guideline 1-1996

ACG Commissioning Guideline - 2005

ROLES AND RESPONSIBILITIES OF THE COMMISSIONING AGENCY

1. **Mission:** The primary point of responsibility is to inform the General Contractor, the owner and design team on the status, integration, and performance of mechanical and electrical systems within the facility.
2. **Information:** The CA shall function as a catalyst and initiator to disseminate information and assist the design and construction teams in implementing completion of the construction process. This shall include system verification, functional performance testing, and conformance with the intended design of each system. Services include documenting construction observations, verification and functional performance testing, and documenting proper distribution of performance and operating information to the owners O&M staff.
3. **Quality Assurance:** Assist the responsible parties to maintain a high quality level of installation by meeting or exceeding prevailing standards and specifications.
4. **Observation of Tests:** The CA shall observe and coordinate testing as required to assure system performance meets the design intent.
5. **Documentation of Tests:** The CA shall document the results of the performance testing directly and/or assure that the appropriate technicians document testing. The CA shall compile standard forms to be used by the commissioning team for consistency of approach and type of information to be recorded.
6. **Deficiencies:** The CA shall provide technical expertise to facilitate and verify the correction of deficiencies found during the commissioning process.
7. **Resolution of Deficiencies:** The CA is to remain an independent party with specific technical knowledge of the project. The CA shall investigate the scope and extent of problems and facilitate communication to determine responsibilities by delineating specifications. The CA shall monitor resolution for conformance with design intent and prevailing industry standards.
8. **Acceptance:** The CA shall document the date of acceptance as determined by the General Contractor, owner and design team. System Verification Checklists and Functional Performance Test results may be used in determining the start of the warranty period for HVAC systems and subsystems.
9. **O&M Material:** The CA will review operating and maintenance materials for HVAC systems.
10. **Phasing:** The CA will review phasing plans as provided by the GC relating to temporary use of HVAC equipment, O&M considerations, warranty issues, impact of construction sequencing on occupied areas, and interruption of services from the existing equipment.
11. **Independence:** The CA shall be an independent third party agency and shall work under a separate contract, and report directly to the owner. The CA shall not be financially associated with any of the Division 2 through 16 installing contractors on this project to avoid potential conflicts of interest.

ROLES AND RESPONSIBILITIES OF THE OWNER

Assign maintenance personnel and schedule them to participate in the various meetings, training sessions and inspections as follows:

1. Pre-commissioning coordination meeting.
2. Contractors' commissioning kick-off meeting.
3. Initial Owner training session at initial placement of major equipment.
4. Maintenance orientation and inspection at initial placement of major equipment
5. Maintenance orientation and inspection at connection of distribution systems.
6. Schedule start-up events.
7. Piping and ductwork test and flushing verification meetings.
8. Procedures meeting for Testing, Adjusting and Balancing.
9. Owners training session.
10. Verification demonstrations and Functional Performance Tests.
11. Final review and acceptance meeting.

ROLES AND RESPONSIBILITIES OF THE DESIGN TEAM

1. Provide HVAC system Design Intent and Basis of Design Narrative. Incorporate in the appropriate sections of the O&M Manual.
2. Attend initial pre-commissioning coordination meeting to be scheduled by the Commissioning Agent within 30 days of the award of the contract.
3. Verify adequate maintenance accessibility for each piece of equipment in shop drawings and actual installation. Visit site periodically and inspect construction.
4. Conduct the first HVAC training session on the overview of the system design, the system design goals and the reasoning behind the selection of equipment.
5. Participate in first HVAC Maintenance orientation and inspection following the first training session.
6. Review O&M Manuals submitted by the Mechanical Contractor. Insert Design Narrative.
7. Participate in second HVAC Maintenance orientation and inspection at the Distribution Completion stage.
8. Attend initial meeting with TAB Trade Representative as scheduled by Commissioning Agent.
9. Attend the classroom portion of the owner training session.
10. Review TAB report from Contractor against design requirements. Issue a report noting deficiencies requiring correction to the Commissioning Agent.

MECHANICAL SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS

1. Outside Air Unit
2. Remote Chiller
3. Hydronic Pumps
4. Blower Coil Units
5. Fan Coil Units
6. Cabinet Heaters
7. Exhaust Fans
8. Control Systems
9. HVAC Systems Integration

ELECTRICAL SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS

10. Labeling of Circuits and Connected Equipment
11. Main Switchboard Overcurrent Protection Performance
12. Panelboard Installation and Branch Circuit Labeling
13. Distribution Transformer Performance
14. Motor Controllers Compliance
15. Grounding System Performance
16. Interior Lighting System Performance

HVAC AND ELECTRICAL COMMISSIONING PLAN

1. Commissioning Team

- A. The Commissioning Team (CT) shall consist of key parties involved in design, construction and testing of this facility. It is necessary for each agency to appoint team members that will have long-term commitments to this project. Switching team members during the project will reduce the ability of the CT to provide continuity and acceptable results to the building owner. Team members must maintain an ongoing supervisory position on this project. One team member shall be provided by each of the parties listed below:
 - 1) Program Manager – Owner (PrM)
 - 2) Facilities Management Division – Owner’s Maintenance Engineer (FMD)
 - 3) Commissioning Agent (CA)
 - 4) Design Team – Engineer of Record (DT)
 - 5) General Contractor – General Construction Trade Representative (GC)
 - 6) Mechanical Contractor – Mechanical Trade Representative (MC)
 - 7) Sheet Metal Contractor – Sheet Metal Trade Representative (SM)
 - 8) Controls Contractor – Control System Trade Representative (CC)
 - 9) Testing, Adjusting and Balancing Contractor – TAB Trade Rep. (TABC)
 - 10) Electrical Contractor – Electrical Trade Representative (EC)

2. Design Intent Document

- A. The Design Intent Document (DID) represents a composite of design drawings, project specifications, submittals, change orders and industry standards, prepared by the designer of record, that describe the systems of this facility. References to design intent will be taken from the DID. The DID is an evolving manuscript maintained by the design professional to track and incorporate design alterations that occur throughout the construction process. Any industry standards used for this project will be specifically noted when referenced.
- B. The CA will review the DID documents for commissioning provisions, functional performance, optimization of performance, accessibility, TAB provisions, and O&M considerations.

3. Commissioning Meetings

- A. Commissioning meetings will be held in conjunction with progress meetings as necessary. The CA will be on site for the Cx meetings. Commissioning meetings will be used to address any problems that alter the design intent or affect the commissioning process. These meetings provide an open forum for exchange of ideas between contractors, vendors, designers, users and owners.

4. Resolution Tracking Forms (RTF)

- A. The use of Resolution Tracking Forms is a method employed by the CA to monitor and record problems, their causes, and solutions. The use of these lists promotes communication between the installing contractors, design team, commissioning agent, and owner, in order to expedite their resolution in a timely manner.
- B. The CA will regularly submit RTF's to the CT in order to document and resolve deficiencies as quickly as possible. The frequency of RTF submission will be adjusted as project conditions dictate.

5. System Verification Checklists (SVC) / Manufacturer's Checklists

- A. The CA will write SVC's based on the DID. These tests will be created for systems and subsystems. See *SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS* above. Draft copies will be submitted to the CT for review and comment prior to placement on the job site. A master copy of the SVC's will be bound in a three-ring binder and placed on the job site for use by the installing contractors. No system will be started until the appropriate SVC's have been completed.
- B. The CA will review the SVC for each piece of equipment prior to start-up. Equipment will be released for start-up only after these checklists have been completed by the installing contractor and reviewed by the CA.
- C. Prior to start-up, the CA must also review the equipment manufacturer's checklists. These lists must be completed by the installing contractor, and reviewed by the CA before start-up can commence.

6. Start-Up

- A. The CA will witness start-up of major systems. The appropriate contractors and/or manufacturer's representative will be required on site to perform start-up. No system will be started until the appropriate SVC's have been completed. No system will be started until the manufacturer's checklists have been completed. Start-up will be performed according to the manufacturer's recommended procedures. The CA will visit the site to review completeness of installation in conjunction with progress meetings prior to starting equipment.

- B. CT members involved in installation, fabrication, manufacture, control, or designs of equipment are required to be present at the time of start-up. A factory-authorized technician will be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment on line and expedite acceptable functional performance in accordance with the DID.

7. Controls Monitoring

- A. Close monitoring of the Control Contractor's progress will promote efficient coordination of the TAB work. The CC will be expected to submit point-to-point checklists verifying that his work has been completed and all systems are ready for TAB work and Functional Performance Testing. Programming and graphics will be surveyed by the CA for completeness and conformance with the DID and the owner's scheduling requirements.

8. TAB Monitoring

- A. The preliminary TAB report set-up will be reviewed prior to HVAC equipment start-up, in order to assure that the final TAB report format and content is acceptable.
- B. TAB work will be monitored so that any problems that prevent or hinder proper air and water balance can be addressed and corrected with minimal delays. By addressing these problems as quickly as possible, we can assure that functional performance testing and owner training will take place on schedule.
- C. A pencil copy of the TAB report will be reviewed prior to submission of the final TAB report. A written review will be submitted to the TAB contractor and to the DT for their comments. A TAB report approved by the DT will be required before Functional Performance Testing can be carried out. The CA will visit the site during the TAB process in order to assist TABC and CC in the effective completion of their scope of work.

9. Functional Performance Tests (FPT)

- A. The CA will write FPT's based on the DID. These tests will be created for systems and subsystems. See SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS above.
- B. Each major system will be tested. A random sample of each subsystem will be tested. This will be coordinated and witnessed by the CA and the owner's maintenance staff. Witnessing the FPT's will serve as a compliment to the O&M Training. No FPT's will be performed until the system and related subsystems have been started, the TAB report has been submitted and reviewed, and the completion of the control system has been documented through point-to-point checklists and other documentation.
- C. The Functional Performance Tests shall include HVAC and electrical equipment.
 - 1) Outside Air Unit will be tested in designed operating modes.
 - 2) Remote Chiller will be tested under relevant operating conditions.
 - 3) Hydronic pumps will be tested under relevant operating conditions.
 - 4) Blower Coil Units will be tested under relevant operating conditions.
 - 5) Fan Coil Units will be tested under relevant operating conditions.

- 6) Cabinet Heaters will be tested for conformance to DID.
- 7) Exhaust fans will be tested for conformance to DID.
- 8) Control systems will be tested as necessary to achieve DID conformance.
- 9) HVAC systems will be tested to assure that the building as an integrated system operates properly, and to verify that interlocks and interactions between new and existing equipment and systems function according to design intent.
- 10) The electrical trade representative, with the CA present, will field test for correct labeling of circuits and equipment by breaking current and observing loss of power at circuits or equipment. An "Incorrect Equipment Circuit Identification" report will be prepared by the CA and included in the Final Commissioning Report.
- 11) The electrical trade representative will demonstrate to the CA: main power disconnect switch and feeder disconnect switches overcurrent and ground fault sensor trip settings by the primary injection method and in accordance with NETA-ATS Section 7.6, switchboard assemblies megger tested in accordance with NETA-ATC Section 7, switchboard metering instrumentation tests in accordance with NETA-ATC Sections 7.10 and 7.11, and switchboard single-phase monitor tests for operation upon loss of a phase voltage.
- 12) The electrical trade representative, with the CA present, will field test for correct labeling panelboards and branch circuits, including grounding continuity of up to 10% of all circuits in each panel, by breaking current and observing loss of power. An "Incorrect Branch Circuit Wiring" report will be prepared by the CA and included in the Final Commissioning Report.
- 13) The electrical trade representative will demonstrate to the CA: distribution transformer performance voltage and current measurements in accordance with NETA recommendations, grounding conductor impedance to the building structure measured between two points other than the location of the grounding conductor connections, and ventilation clearance from transformer enclosures to partitions in accordance contract documents requirements.
- 14) Motor controllers will be demonstrated by the electrical trade representative to the CA for compliance with prevailing codes and the contract documents.
- 15) Grounding System Performance tests shall be performed by the electrical trade representative for the CA in accordance with NETA-ATS Section 7.13.
- 16) The electrical trade representative will demonstrate to the CA: luminaire/lamp combinations by inspection, operational tests for lighting control/dimming systems, illumination level measurements in up to 20% of the building area, and interior lighting control performance, including operation of occupancy sensors, automatic time controls, energy management control override timers, manual dimming control, multi-level switching, and other specified lighting controls. The CA will submit an "Incorrect Light Lamping" report in the Final Commissioning Report.

D. Off-season mode testing will be implemented as necessary to assure conformance with the DID. Installing contractors will be expected to participate as required by the project specifications.

10. Building Turn-Over / Owner Orientation / User Training

A. The CA will assist contractors prepare, coordinate and review O&M manuals, working closely with each contractor to achieve specificity and completeness.

- B. The CA will review as-built drawings, working closely with each contractor to achieve specificity and completeness.
- C. Owner training will be coordinated with the assistance of the CA. The installing contractor or manufacturer's representative will provide the training, witnessed by the CA. This training should include both classroom training and hands-on operational training. The owner may choose to videotape this training for future use. The CA will visit the site during the Turnover and Training period to assure that any on-going HVAC and/or electrical related problems are being addressed and corrected in a timely and efficient manner.
- D. The CA will assist the owner/user with warranty issues.
- E. The CA will assist in the coordination of off-season testing, calibrating, and servicing as specified in the contract documents.
- F. Training of Owner's Operators
 - 1. The owners shall be given comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of equipment.
 - 2. The Commissioning Agent, in cooperation with the Engineer of Record and Contractor, will be responsible for scheduling the training which shall start with classroom sessions followed by hands on training on each piece of equipment. Hands on training shall include start-up, operation in all modes possible, shut-down and any emergency procedures.
 - 3. Training shall be conducted in a minimum of three sectors. The first, or systems orientation portion, shall be scheduled prior to the equipment placement Maintenance orientation and inspection. This training session will include a review of all systems using the simplified system schematics including chilled water systems, condenser water or heat rejection systems, heating systems, fuel oil supply systems, supply air systems and exhaust system.
 - 4. The second, or equipment portion, shall be scheduled as soon as possible after distribution completion and start-up of equipment.
 - 5. The third portion, or the TAB and commissioning portion, shall be conducted after completion of this work.
 - 6. Classroom sessions shall include the use of overhead projections, slides, video and audio taped material as might be appropriate.
 - 7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual.
 - 8. The Engineer of Record will attend all training sessions and conduct the first session on the overall system design concept and the design concept portion of
 - 9. The manufacturer's representative shall provide the instructions on each major piece of equipment. These sessions shall use the printed installation, operation and maintenance instruction material included in the O&M manuals and shall include a review of the written O&M installations emphasize safe and proper operating requirements and preventative maintenance. Training will be included for all major pieces of equipment including pumps, chillers, boilers, hot water heaters, heat rejection equipment, air conditioning units, air handling units, fans, air terminals, controls and water treatment systems. Qualified service engineers employed by the manufacturers or their qualified sales representatives shall do equipment training. The operation and function of the equipment in the system shall be discussed.

10. Each classroom training session shall be followed by an inspection, explanation and demonstration of the equipment. The start-up and shut-down modes of operation shall be demonstrated.
11. The Contractor shall attend all sessions and shall add to each session any special information relating to the details of installation of the equipment as it might impact the operation and maintenance.
12. The Control Trade Representative shall attend all sessions and be prepared to conduct the controls portion of the training as it relates to each equipment section.
13. The Control Trade Representative shall conduct the training session on the controls system hardware and software.
14. The piping, insulation and sheet metal Trade Representatives shall conduct sessions on their respective trades with emphasis on any peculiarities of the systems, pressure limitations and maintenance requirements.
15. The TAB Trade Representative shall conduct a training session reviewing the procedures and methods used in the TAB process, shall review the TAB data and shall demonstrate use of test equipment which may have been turned over to the owner and shall point out the locations of all pitot traverse locations for the owner's future use.
16. The Commissioning Agent shall conduct a final session summarizing the commissioning program.

G. Operation and Maintenance (O&M) Manuals

1. Initial preparation shall be made by the Mechanical Trade Representative.
2. Quantity: provide four (4) hard copies of the manual and One (1) electronic copy in PDF format on a CD.
3. Format: 3" thick, 8-1/2" x 11 loose leaf binders. Provide as many as required. Binders shall not be overloaded.
4. Content:
 - a. Cover sheet.
 - b. Table of contents (as follows):
 - c. Description of systems.
 - d. The description of systems will be provided by the Engineer of Record for insertion at the time of review and before turn-over to the Commissioning Agent. This description of systems shall be a comprehensive overview of the entire system. Simplified professionally drawn system diagrams shall be provided on 8-1/2" x 11" or 11" x 17" sheets. These shall include chilled water system, condenser water system, heating hot water system, supply air systems and exhaust systems. These shall show major pieces of equipment such as pumps, chillers, control valves, expansion tanks, coils, service valves, etc. These will be the basis for the starting of the owners instruction program.
 - e. Design parameters.
 - f. The design parameters will be provided by the Engineer of Record. It will be a detailed listing of the design criteria on a room-by-room and system-by-system basis used as a basis for the design. This will be inserted by the Engineer of Record at the time of review and before turnover to the Commissioning Agent.
 - g. Contract Mechanical and Electrical Specifications.
 - h. Wiring and control diagrams, with data to explain detailed operation and control of each component.
 - i. Control sequences describing start-up, all modes of operation, and shutdown.
 - j. Installation instructions.
 - k. Operating Instructions.

- l. Preventative Maintenance Instructions.
 - m. Maintenance and overhaul instructions.
 - n. Lubricating schedule including type, grade, temperature, and frequency range.
 - o. Corrected shop drawings and submittal data.
 - p. Product information identifying all performance curves, rating data, features, and options on all installed equipment
 - q. Copies of approved certifications and laboratory test reports.
 - r. Copies of warranties.
 - s. Test procedures.
 - t. Parts list, including source of supply and recommended spare parts.
 - u. Name, address, and 24-hour telephone number of each subcontractor who installed equipment and systems and local representative for each type of equipment for each system.
 - v. Other pertinent data applicable to the operation and maintenance of particular systems or equipment and/or other data specified in technical sections of the specification.
 - w. Uninterruptible power supplies, including a list of equipment and design kW load on each.
 - x. Emergency power generation, including a list of equipment and design kW load on each.
 - y. The documentation during the construction phase shall be updated to match the equipment supplied on the project.
 - z. Procedures for starting, operation, and shutdown for every system, including all required emergency instructions and safety precautions.
5. Detailed Preparation Requirements:
- a. The cover sheet shall list: project name, location, names of the project manager, architect, structural engineer, mechanical engineer and electrical engineer, name of the firms, address and telephone number.
 - b. Each major heading in the table of contents shall have a large distinctive, clearly marked, non-erasable, plastic encased tab.
 - c. Each section shall have the following sub-tabs. Sub-tabs shall be similar to the main tabs but of a different color.
 - 1) Specifications:
The specification shall be copied and inserted complete with all addenda.
 - 2) Submittal and Product Data:
This section shall include all approved submittal data. If submittal was not required for approval, descriptive product data shall be included.
 - 3) Installation Instructions:
If the product, such as pipe, etc., does not have any written installation instructions, include a statement "Manufacturer's Written Installation Instructions not Available - Product Installed in Accordance with Specifications and Good Practice".
 - 4) Operation and Maintenance Instructions:
These shall be the written manufacturer's data edited to omit reference to products or data not applicable to this installation.
 - 5) Parts List:
These shall be edited to omit reference to items, which do not apply to this installation.

- 6) Equipment Supplier:
This section shall include the name, address and telephone number of the manufacturer's agent and/or service agency supplying or installing and starting up of the equipment.
 - 7) Field Installation Verification forms, checklists, and Commissioning Checklist:
This will be filled out by the Contractor with the specified data and submitted data and inserted into the manual for submission to the Engineer of Record. A copy shall be given to the test, adjust and balance (TAB) Trade Representative so that (TAB) data can be added. Upon completion of this entry, the form shall be forwarded with the certification of system completion and commissioning request.
 - 8) System Description:
This section shall include that portion of the overall description included in the beginning of the manual as it applies to each sub-section. In sections such as pumps, the pump designations and their use shall be listed as shown in the equipment schedule.
 - 9) Controls Description:
This will be included in each section covering controlled equipment. It will include the description from the approved temperature control submission, complete with schematic diagram showing piping arrangement and control location on 8-1/2" x 11" or 11" x 17" sheet. This data shall be provided by the Control Trade Representative in a form suitable for insertion into the O&M Manuals by the Mechanical Trade Representative and for review by the Engineer of Record.
 - 10) Condensed Operating Instructions:
This section shall include condensed instructions for start-up, shut-down, emergency operation, safety precautions, unusual features and troubleshooting suggestions. Where control is clearly covered in controls description, it is not to be duplicated here.
 - 11) Preventative Maintenance Instructions:
This section shall include condensed typewritten excerpts from the manufacturers written instructions on weekly, monthly, quarterly, annually, etc. This summary shall be prepared by the mechanical Trade Representative with help from the equipment supplier. It will be reviewed by the Engineer of Record prior to turning over to the Commissioning Agent. It shall be prepared for all items listed under "Condensed Operating Instructions" above.
- d. Testing, Adjusting and Balancing shall contain the following sections:
- 1) Specifications.
 - 2) Submittal.
 - 3) TAB Data.
This shall be the final TAB data. It will have to be added after the owner has received his training and the O&M manuals.
- e. Commissioning of Mechanical Systems shall be prepared by the Commissioning Agent and shall contain the following sections:
- 1) Specifications.
 - 2) Commissioning Plan.
 - 3) Final Report of the Commissioning Agent.
Submittal Requirement:

- f. The O&M manuals shall be submitted at the equipment placement completion stage, which shall be defined as that time in the project when the major pieces of equipment have been set in place ready for connection to piping and duct systems.

11. Warranty Review

- A. The CA will participate in an 11th month walk-through to observe the operation of the building systems. This will include a review meeting with the owner's personnel, a discussion of warranty issues, energy usage, maintenance practices, usage changes, and chronic problems, as well as other issues affecting the owner and the operation of the HVAC systems.

RESPONSIBILITIES OF INSTALLING CONTRACTORS

1. General Contractor – General Construction Trade Representative (GC)
2. Mechanical Contractor – Mechanical Trade Representative (MC)
3. Testing, Adjusting and Balancing Contractor (TAB)
4. Controls Contractor - Control System Trade Representative (CC)
5. Electrical Contractor - Electrical Trade Representative (EC)

1. General Contractor - General Construction Trade Representative (GC)

- A. Include commissioning requirements in the mechanical, electrical, and controls contracts, as well as other subcontracts, to assure full cooperation of all parties in the HVAC commissioning process.
- B. Assure acceptable representation, with the means and authority to prepare and coordinate execution of the mechanical commissioning program as described in the contract documents.
- C. Assure that the CA shall receive a copy of all construction documents, addenda, change orders and appropriate approved submittals and shop drawings for review and use in development of the commissioning plan.
- D. Coordinate inclusion of commissioning activities in the construction schedule.
- E. Issue a statement that TAB work has been completed, and that the final TAB report has been submitted for review.
- F. Issue a statement that control systems have been completely installed and calibrated.
- G. Facilitate resolution of deficiencies identified by observation or performance testing.

2. Mechanical Contractor - Mechanical Trade Representative (MC)

- A. Each contractor in this division shall include in their quote the cost of participating in the commissioning process.
- B. Include requirements for submittal data (including partial load data), O&M data, and training in each purchase order or sub-contract.

- C. Assure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, water treatment and TAB in commissioning activities.
- D. Assure participation of major equipment manufacturers in appropriate startup, training, and testing activities.
- E. Attend commissioning meetings scheduled by the CA.
- F. Assist the CA in system verification and performance testing.
- G. Prepare preliminary schedule for HVAC system inspections, O & M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, system verification, performance testing, and system completion for use by the CA. Update schedule as appropriate throughout the construction period.
- H. Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC equipment.
- I. Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- J. Notify the CA a minimum of two weeks in advance of scheduled system start-up.
- K. Update drawings to as-built condition and review with the CA throughout the construction process.
- L. Schedule vendor and subcontractor provided training sessions as required by project specifications.
- M. Provide written notification to the GC and CA that the following work has been completed in accordance with the project specifications, and that the equipment, systems and sub-systems are operating in accordance with design intent.
 - 1) HVAC equipment including fans, air handling units, dehumidification units, ductwork, dampers, terminal devices, etc.
 - 2) Fire detection and smoke detection devices furnished under other divisions as they affect the operation of the HVAC systems.
 - 3) That BAS is functioning in accordance with design intent.
- N. Participate in the Functional Performance Tests as required to achieve design intent.
- O. Participate in the off-season mode testing as required to achieve design intent.
- P. Participate in O&M Training as required by project specifications.
- Q. Provide a complete set of as-built drawings and O & M manuals for review. The CA shall review the as-built drawings and O&M manuals concurrently with the design team.

3. Testing, Adjusting and Balancing Contractor (TABC)

- A. Include cost for commissioning requirements in the contract price.
- B. Attend commissioning meetings scheduled by the CA.
- C. Submit the TAB procedures and preliminary TAB report to the CA for review at least two weeks prior to beginning TAB work.
- D. Notify the CA a minimum of two weeks in advance of scheduled TAB work.
- E. Assist the CA in system verification and performance testing.
- F. Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- G. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the CA for verification or diagnostic purposes.
- H. Participate in the Functional Performance Tests as required to achieve design intent.
- I. Provide sound and vibration where required to assist in diagnosis of areas exhibiting unacceptable levels of noise or vibration.
- J. Participate in the off-season mode testing as required to achieve design intent.
- K. Participate in O&M Training as required by project specifications.

4. Controls Contractor - Control System Trade Representative (CC)

- A. Include cost for commissioning requirements in the contract price.
- B. Review control sequence and component selection for conformance with design intent.
 - 1) Verify that specified safeties and interlocks have been selected.
 - 2) Verify proper selection of control valves and actuators based on design parameters.
 - 3) Verify proper selection of control dampers and actuators based on design parameters.
 - 4) Verify that sensor selection conforms to design intent.
- C. Attend commissioning meetings scheduled by the CA.
- D. Provide the following submittals to the CA:
 - 1) Hardware and software submittals.
 - 2) Control panel construction shop drawings.
 - 3) Narrative description of control sequences for each HVAC system and subsystem.
 - 4) Schematics showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access.

- 5) A list of all control points, including analog inputs, analog outputs, digital inputs and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
 - 6) A complete listing of all software routines employed in operating the control system. Also provide a program narrative that describes the logic flow of the software and the functions of each routine and sub-routine. The narrative should also explain individual math or logic operations that are not clear from reading the software listing.
 - 7) Hardware operation and maintenance manuals.
 - 8) Application software and project applications code manuals.
 - 9) Panel and equipment insert documents.
- E. Verify that specified interfaces provided by others are compatible with BAS hardware and software.
 - F. Coordinate installation and programming of BAS with construction and commissioning schedules.
 - G. Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC equipment.
 - H. Provide control system technician to assist during equipment startup.
 - I. Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
 - J. Participate in the Functional Performance Tests as required by the project specifications.
 - K. Provide a control system technician to assist during verification and performance testing.
 - L. Provide system modifications to achieve system operation as defined by the design intent.
 - M. Provide support and coordination for TAB contractor. Provide all devices, such as portable operator terminals and all software for the TAB to use in completing TAB procedures.
 - N. Participate in the Functional Performance Tests as required to achieve design intent.
 - O. Participate in the off-season mode testing as required to achieve design intent.
 - P. Participate in O&M Training as required by project specifications. Include training on hardware operations and programming.
 - Q. Ensure cooperation and participation of specialty sub-Trade Representatives such as Ductwork, Piping, Chemical Treatment, Refrigeration, and other applicable specialties.
 - R. Coordinate this commissioning program with the Electrical Trade Representative.

- S. Attend initial pre-commissioning coordination meeting scheduled by the Commissioning Agent. Prepare necessary preliminary schedule for Maintenance orientation and inspections, O & M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, test, adjust and balance start and job completion for use by the Commissioning Agent. Update schedule as appropriate throughout the construction period.
- T. Attend initial training session and conduct Maintenance orientation and inspection at the equipment placement completion stage. Update drawings to the record condition, to date, and review with the Commissioning Agent prior to the Maintenance orientation and inspection meeting.
- U. Obtain O & M data on all equipment and assemble in binders using tabs as required. Submit to Engineer of Record for approval prior to the Distribution completion stage.
- V. Conduct the second Maintenance orientation and inspection at the Distribution completion stage. Update drawings to the record condition, to date, and review with the Commissioning Agent prior to the inspection.
- W. Notify the Commissioning Agent of the time for the duct and piping system pressure tests and piping system flushing.
- X. Notify the Commissioning Agent of the time for start of the TAB work. Attend the initial TAB meeting for the review of the TAB procedures.
- Y. Participate in and schedule vendors and other Trade Representatives to participate in the training sessions set up by the Commissioning Agent.
- Z. Conduct a Maintenance orientation and inspection with hands on training. Update drawings to the record condition to date and review with the Commissioning Agent prior to the orientation.
- AA. Attend all regularly scheduled commissioning coordination meetings.
- BB. Provide written certification and completed Field Installation Verification forms and checklists documenting that the following work has been completed in accordance with the plans and specifications and that they are functioning as designed. Where the Work has been sub-contracted, the sub-Trade Representative shall be responsible for the initial certification with the Mechanical Trade Representative recertifying that he has inspected the Work and that it has been completed and functioning as designed. This certification must be submitted to the Commissioning Agent prior to the final verification.
 - 1) All mechanical systems and equipment including geothermal units, fans, ductwork, dampers, and air devices.
 - 2) Geothermal system piping.
 - 3) Pumps.
 - 4) Fire stopping in the fire rated construction including fire and smoke damper installation, caulking, gasketing and sealing of smoke barriers.
 - 5) Control System

- CC. Demonstrate the performance of each piece of equipment to the Commissioning Agent. Schedule the TAB, Control, and other sub-Trade Representatives as may apply to demonstrate the performance of the equipment and systems.
- DD. Provide set of record mark-ups to the Engineer of Record for inclusion into record documents.

5. Electrical Contractor - Electrical Trade Representative (EC)

- A. Include cost for commissioning requirements in the contract price.
- B. Review design for provision of power to the HVAC equipment.
 - 1) Verify proper hardware specifications exist for performance as defined by the DID.
 - 2) Verify proper safeties and interlocks are included in the design of electrical connections for HVAC equipment.
- C. Attend commissioning meetings scheduled by the CA.
- D. Verify proper installation and performance of all electrical services provided.
- E. Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC and electrical equipment.
- F. Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- G. Provide an electrical system technician to assist during verification performance testing.
- H. Participate in the Functional Performance Tests as required to achieve design intent.
- I. Participate in the off-season mode testing as required to achieve design intent.
- J. Participate in O&M Training as required by project specifications.
- K. Ensure cooperation and participation of specialty sub-Trade Representatives.
- L. Ensure participation of major equipment manufacturers and their representatives.
- M. Coordinate this commissioning program with the Mechanical Trade Representative.
- N. Attend initial pre-commissioning coordination meeting scheduled by the Commissioning Agent. Prepare necessary preliminary schedule for Maintenance orientation and inspections, O & M manual submission, training sessions, test, and job completion for use by the Commissioning Agent. Update schedule as appropriate throughout the construction period.

- O. Attend initial training session and conduct Maintenance orientation and inspection at the equipment placement completion stage. Update drawings to the record condition, to date, and review with the Commissioning Agent prior to the Maintenance orientation and inspection meeting.
- P. Obtain O & M data on all equipment and assemble in binders using tabs as required. Submit to Engineer of Record for approval prior to the Distribution completion stage.
- Q. Conduct the second Maintenance orientation and inspection at the Distribution completion stage. Update drawings to the record condition, to date, and review with the Commissioning Agent prior to the inspection.
- R. Participate in and schedule vendors and other Trade Representatives to participate in the training sessions set up by the Commissioning Agent.
- S. Conduct a Maintenance orientation and inspection with hands on training. Update drawings to the record condition to date and review with the Commissioning Agent prior to the orientation.
- T. Attend all regularly scheduled commissioning coordination meetings.
- U. Provide written certification and completed Field Installation Verification forms and checklists documenting that the following work has been completed in accordance with the plans and specifications and that they are functioning as designed. Where the Work has been sub-contracted, the sub-Trade Representative shall be responsible for the initial certification with the Electrical Trade Representative recertifying that he has inspected the Work and that it has been completed and functioning as designed. This certification must be submitted to the Commissioning Agent prior to the final verification.
 - 1) Correct labeling of all circuits with connected equipment.
 - 2) Automatic operation of emergency generator, bus transfer and UPS equipment.
 - 3) Lighting system controls operations, including occupancy sensors, automatic time controls or Energy Management control, override timers, manual dimming controls, exterior lighting controls, multi-level switching, as applicable to the Work.
- V. Demonstrate the performance of each piece of equipment to the Commissioning Agent. Schedule sub-Trade Representatives as may apply to demonstrate the performance of the equipment and systems.
- W. Provide set of record mark-ups to the Engineer of Record for inclusion into record documents.

END OF SECTION