



Appendix B

Sample Specification

Covering Contractor Responsibilities for HVAC Commissioning

NOTES TO APPENDIX 'B'

An inter-disciplinary team carries out commissioning. The Commissioning Agency is the leader of the team, and has overall responsibility for its organization, coordination and successful completion. But this responsibility cannot be achieved without all other team members carrying out their responsibilities.

The General Contractor (or Construction Manager), Mechanical Contractor and the various sub-contractors within Division 15, and the Electrical (Division 16) Contractor all have responsibilities with respect to HVAC systems commissioning. These responsibilities must be set out in the contract specifications defining their work.

The material in this appendix assumes the use of Comprehensive HVAC Commissioning as described in Chapter 5 of this Guideline. It contains a sample set of specification sections that describe the comprehensive commissioning process, and define the contractors' responsibilities with respect to commissioning.

This sample specification will also apply to construction HVAC commissioning. If a decision to include commissioning is made before the contract documents are completed, there is an opportunity to include commissioning requirements in the specifications issued for bid. If construction has started before commissioning is decided on, then the sample specification could be used as a guide to preparing the commissioning specification that contractors will use to identify their commissioning costs on a change order basis.

The sample specification sections are as follows:

- Section 01660 – Commissioning of HVAC Systems

This section is in the General Contractor's part of the specifications. It contains the detailed requirements with respect to commissioning applicable to all Divisions of the

work. As such, it includes requirements normally considered within the scope of both the mechanical and electrical contractors. However, it is in this location for two reasons. First, it allows all requirements, covering all Divisions of the work, to be stated in one place. Second, if specified responsibilities apply to more than one Division of work, or to several sub-contractors within Division 15, appropriate specification references can be placed in those Divisions pointing to the definitive requirements in Section 01660.

- Section 15995 – HVAC Systems Commissioning

References to Section 01660, with a suitable indication of scope, will be included here.

- Section 16??? – Electrical Systems Commissioning

References to Section 01660, with a suitable indication of scope, will be included here.

These sample specifications are included solely as an example. ACG assumes no responsibility for how the material in this Appendix may be utilized by users of the Guideline; the users assume full responsibility for any and all liability that may arise from any reference to, or use of, this material.

A. SPECIFICATION 01660 – COMMISSIONING OF HVAC SYSTEMS

Part 1 – GENERAL

1.1 COMMISSIONING AGENCY

The commissioning agency (CA) has been contracted directly with the owner for this project. The CA has overall responsibility for planning and coordinating the commissioning process. However commissioning involves all parties to the design and construction process, including the contractor.

1.2 CONTRACTOR RESPONSIBILITY

This Section of the specifications defines the contractor's responsibilities with respect to the commissioning process. Each contractor and sub-contractor shall review this Section, and shall include in their bids for carrying out the work described, as it applies to each Division and Section of these specifications, individually and collectively.

1.3 DESCRIPTION OF WORK

The purpose of the commissioning process is to provide the owner/operator of the facility with assurance that the mechanical systems have been installed according to the contract documents, and operate within the performance guidelines set out in the design intent documents (D.I.D.) and these specifications. The CA will provide the owner with an unbiased, objective view of the system's installation, operation, and performance. The commissioning process does not take away or reduce the responsibility of the installing contractors to provide a finished product, installed and fully functional in accordance with the contract documents.

Commissioning is intended to enhance the quality of system start-up and aid in the orderly completion and transfer of systems for beneficial use by the owner. The CA will be the leader of the commissioning team, planning and coordinating all commissioning activities in conjunction with the design professionals, construction manager, subcontractors, manufacturers and equipment suppliers.

The General Contractor, Mechanical Contractor, all Division 15 sub-contractors, and the Electrical Contractor shall be responsible for cooperating, and coordinating their work, with the CA. They shall also be responsible for carrying out all the physical activities required for installation of components and systems, and operating them during the commissioning process as required in this Section.

1.4 RELATED DOCUMENTS

Drawings and general provisions of the contract, including general and supplementary conditions, general mechanical provisions and applicable Divisions 15 and 16 Specification sections, apply to work of this section.

1.5 REFERENCES

ACG Commissioning Guideline

Part 2 – PRODUCTS

2.1 HVAC SYSTEMS TO BE COMMISSIONED

HVAC systems installed under this contract are to be inspected, tested, signed off as complete and operational, and operated for commissioning agency verification as described in Part 3 of this Section. This includes, but is not necessarily limited to the work listed for each system. The foregoing includes all the following:

[Insert a list of components, equipment, and systems applicable to the project. The following list should be edited and extended as appropriate, or users may provide their own lists. In 2.2, a Systems Verification checklist, obtained from the commissioning plan, should be provided for all components and equipment included here in order to more clearly define the contractor's responsibilities with respect to pre-start and start-up of components and equipment. This sample specification includes sample Systems Verification checklists for some, but not all, of the components and equipment listed. It is the user's responsibility to create and include such checklists for ALL components and systems to be commissioned.]

[In 2.3, a Functional Performance Test checklist, obtained from the commissioning plan, should be provided for all systems included here in order to more clearly define the contractor's responsibilities with respect to carrying out performance checks for confirming correct system functionality, and operating the system as directed by the CA for formal functional performance tests. This sample specification includes sample Functional Performance checklists for some, but not all, of the systems listed. It is the user's responsibility to create and include such checklists for ALL systems to be commissioned.]

1. Hot water, glycol solution, chilled water, and condenser water piping systems – work includes installation inspections and checks; pressure tests and documentation; expansion tanks; confirmation of flow balancing completion; seismic restraints installation certification. Refer to Functional Performance Test checklist #X in 2.3.
2. Duct and air-handling systems – work includes installation inspections and checks; confirmation of flow balancing completion; leak testing as applicable; seismic restraints installation certification. Refer to Functional Performance Test checklists #X through #Y in 2.3.
3. Chiller(s) – work includes installation inspections and checks (including seismic restraints installation certification); checkout and startup by manufacturer's representative; documented performance measurements including capacity, evaporator and condenser flows, motor amperage, controls operation, and sound levels. Refer to Systems Verification checklist #X in 2.2.
4. Cooling Tower(s) – work includes installation inspection and checks (including seismic restraints installation certification); checkout and startup by manufacturer's representative in conjunction with chiller; documented performance measurements including sound, capacity, motor amperage, pan heater operation, makeup water, overflow, and capacity controls. Refer to System Verification checklist #X in 2.2.

5. Closed-circuit heat rejector(s) or evaporative condenser(s) – [***list similar to that for cooling tower.***] Refer to System Verification checklist [***not included in this sample***]
6. Refrigeration Compressor/Condensing Unit(s) – Work includes installation inspection and checks (including seismic restraints installation certification); checkout and startup by manufacturer's representative as specified; documented performance measurements including capacity, evaporator and condenser pressures, motor current draw, and controls operation. Refer to System Verification checklist [***not included in this sample***]
7. Boiler(s) – Work includes installation inspections and checks (including seismic restraints installation certification); boil out and chemical treatment; checkout and startup by manufacturer's representative; documented performance measurements including combustion efficiency, capacity test, burner and controls operation. Refer to System Verification checklist #X in 2.2.
8. Pumps – Work includes documented checks on alignment, rotation, motor current draw, flows and pressures. Refer to System Verification checklist #X in 2.2
9. Supply, Return, Relief and Exhaust Fans – Work includes checks on installation (including seismic restraints, dampers and other accessories), rotation, sound levels, motor current draw, and airflows and pressures. Refer to System Verification checklists #X through #Y in 2.2.
10. Air Handling Units (both packaged and built-up) – Work includes installation inspections and checks (including seismic restraints installation certification); checkout and startup by manufacturer's representative as specified; documented capacity tests, for heating, cooling, air flow and static pressures; operation of all controls; sound level. Refer to System Verification checklists #X through #Y in 2.2
11. Air Terminal Devices – Work includes installation inspections and checks; for VAV units, flow adjustments and calibration coordinated with controls and air balancing; controls operation including flow modulation, reheat, controls responses. Refer to System Verification checklist #X in 2.2.
12. Fan-coil Units – Work includes installation inspections and checks; performance and controls checks. Refer to System Verification checklist [***not included in this sample***]
13. Water-source Heat Pumps – Work includes installation inspections and checks; documented seismic installation certification; performance and controls checks. Refer to System Verification checklist #X in 2.2.
14. Controls Air Compressor – Work includes installation inspections and checks; documented seismic installation certification; operational checks. Refer to System Verification checklist #X in 2.2.
15. Direct digital controls system – Work includes inspections and checks of installation and operation of all devices; complete operation of all controls sequences, in coordination with commissioning of all controlled systems. Refer to the Functional Performance Test checklists included in 2.3 for all controlled systems.

The contractor shall be responsible for carrying out all work required for commissioning these systems that is defined as a contractor responsibility in Part 3 of this Section.

2.2 SYSTEM VERIFICATION CHECKLISTS

This specification contains the system verification checklists as listed below:

- SVC#1. Boiler
- SVC#2. Chiller
- SVC#3. Cooling tower
- SVC#4. Pumps
- SVC#5. Supply fan
- SVC#6. Return fan
- SVC#7. Exhaust fan
- SVC#8. Coils
- SVC#9. Air-handling unit, liquid heat/cool
- SVC#10. Rooftop packaged air-handling unit, gas heat/DX cool
- SVC#11. VAV terminal units
- SVC#12. Fan-powered VAV terminal units
- SVC#13. Unitary water-source heat pump
- SVC#14. Controls air compressor

[The foregoing is a sample set of system verification checklists for illustration only. Checklists will have to be deleted and added to cover all components and equipment being commissioned on the specific project. In addition, individual checklists will require revisions to suit the specific requirements of a particular project.]

[As with this sample specification, the format for a project specification should be to have each checklist on a separate page (or pages), with a clear identification matching with the “table of contents” listing the checklists included.]

[SPACE FOR SVC#1
BOILER]

[SPACE FOR SVC#2
CHILLER]

Etc. – each additional SVC on its own page.

2.3 FUNCTIONAL PERFORMANCE TEST CHECKLISTS

This specification contains functional performance test checklists as listed below:

- FPT#1. Hot water boiler and hydronic distribution system
- FPT#2. Chilled water system, including heat rejection and hydronic distribution
- FPT#3. VAV system, liquid heat/cool air-handling unit
- FPT#4. Constant volume system, packaged rooftop gas heat/DX cool air-handling unit
- FPT#5. Waterloop heat pump system
- FPT#6. Air make-up and exhaust system

[The foregoing is a sample set of functional performance test checklists for illustration only. Checklists will have to be deleted and added to cover all systems being commissioned on the specific project. In addition, individual checklists will require revisions to suit the specific requirements of a particular project.]

[As with this sample specification, the format for a project specification should be to have each checklist on a separate page (or pages), with a clear identification matching the “table of contents” listing the checklists included.]

[SPACE FOR FPT#1
HOT WATER BOILER and HYDRONIC DISTRIBUTION SYSTEM]

[SPACE FOR FPT#2
CHILLED WATER SYSTEM, INCL. HEAT REJECTION and HYDRONIC DISTRIBUTION]

Etc. - each additional FPT on its own page.

2.4 MEMBERS OF THE COMMISSIONING TEAM

[Insert a list of commissioning team members applicable to the project. The following list is typical, but should be edited or extended as appropriate to the specific project.]

The commissioning team will consist of representatives of the following:

1. owner
2. end user [***if applicable***]
3. architect
4. mechanical design engineer
5. electrical design engineer
6. commissioning agency (CA)
7. general contractor [***or construction manager***]
8. mechanical (Div. 15) contractor (M)
9. electrical (Div. 16) contractor (E)
10. controls contractor (ATC)
11. sheet metal contractor
12. testing, adjusting, and balancing agency (TAB)
13. owner's O&M staff

During the commissioning process, participation of team members will generally be required as noted in the following table (with abbreviations as noted in brackets in the preceding list of team members). The mechanical contractor, indicated by "M", includes all mechanical sub-contractors or suppliers whose participation is required for commissioning a particular system or piece of equipment.

EQUIPMENT/SYSTEM DESCRIPTION	TEAM MEMBERS				
	CA	M	TAB	ATC	E
Boiler	X	X	X	X	X
Chiller	X	X	X	X	X
Cooling tower	X	X	X	X	X
Closed-circuit heat rejector	X	X	X	X	X
Pumps	X	X	X	X	X
Supply fan	X	X	X	X	X
Return fan	X	X	X	X	X
Exhaust fan	X	X	X	X	X
Refrigerant compressor/condensing unit	X	X		X	X
Air-handling unit	X	X	X	X	X
Coil (hot water or chilled water)	X	X	X	X	
VAV terminal unit	X	X	X	X	
Fan-coil unit	X	X	X	X	X
Water-source heat pump	X	X	X	X	X

Part 3 – EXECUTION

3.1 COMMISSIONING RESPONSIBILITIES – NON-CONTRACTOR TEAM MEMBERS

3.1.1 Introduction

As noted in 2.2, a multi-disciplinary team carries out commissioning. The commissioning responsibilities of some non-contractor team members during the construction and acceptance phases of the project are provided here for information, and to provide some context for the overall process.

3.1.2 Commissioning Agency Responsibilities

The commissioning agency will:

- plan, organize and implement the commissioning process as specified herein,
- prepare the commissioning plan, and ensure its distribution for review and comment,
- revise the commissioning plan as required during construction,
- chair commissioning meetings, and prepare and distribute minutes to all commissioning team members, whether or not they attended the meeting,
- in conjunction with the General Contractor, coordinate commissioning activities among all contractors, sub-trades and suppliers,
- monitor system verification checks, and ensure the results are documented as the checks are done,
- monitor controls point-to-point checks done by the controls contractor, and ensure the results documented as the checks are done,
- observe all start-ups and initial system operations tests and checks,

- direct the contractors to operate equipment and systems as required to ensure that all required functional performance tests are carried out for verification purposes,
- witness all functional performance tests and document the results,
- prepare and submit a Commissioning Report which documents all checks and tests done throughout the Commissioning process, and the results obtained from each, and
- ensure all required O&M manuals, instructions and demonstrations are provided to the Owner's designated operating staff.

3.1.3 Mechanical Engineer Responsibilities

The Mechanical Engineer will review the Commissioning Plan, and will participate, as appropriate, in on-site commissioning meetings.

During the acceptance phase of the commissioning process, the Mechanical Engineer may be on site to review commissioning documentation, to witness functional performance tests, and to analyze the installation and its performance.

3.1.4 Owner's Responsibilities

The Owner will ensure the availability of operating staff for all scheduled instruction and demonstration sessions. This staff will possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions.

The Owner will also ensure the appropriate involvement of the Electrical Engineer, Architect, and any other consultants as required, in the commissioning process.

3.2 COMMISSIONING RESPONSIBILITIES – GENERAL CONTRACTOR [or construction manager]

The General Contractor has responsibility to ensure the overall completion of the Work. In this regard, he shall:

1. participate as required in the HVAC commissioning process,
2. ensure the Mechanical Contractor performs all assigned HVAC commissioning responsibilities as specified in 3.3,
3. ensure the testing, adjusting and balancing agency performs HVAC commissioning responsibilities as listed in 3.4,
4. ensure the Electrical Contractor performs all assigned HVAC commissioning responsibilities as specified in 3.6,
5. ensure the cooperation and participation in the HVAC commissioning process of all other sub-contractors as applicable.

The General Contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decisions on behalf of the general contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall facilitate communications among all contractors and suppliers and other commissioning team members, and shall foster the necessary cooperative action. One specific responsibility

shall be to attend commissioning meetings, and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.

In the event that any scheduled equipment or system start-ups or functional performance tests are terminated because the CA or the mechanical engineer discover deficient or incomplete work, or due to the non-attendance of required contractor or supplier personnel, the contractor or sub-contractor responsible for the termination shall also be responsible for paying reasonable costs of time and travel expenses of any or all of the following representatives who were physically present for the purpose of witnessing the start-up or the FPT: the CA, the mechanical engineer, the electrical engineer, and the owner. The owner may provide a statement to the General Contractor identifying the specific activity that was terminated, the scheduled date, and a list of those in attendance, along with their reasonable time and travel expense costs.

[NOTE – The reference to the TAB agency in item 3 assumes that TAB is a sub-contract directly to the general contractor. For other arrangements, refer to the note at 3.4.]

3.3 COMMISSIONING RESPONSIBILITIES – DIVISION 15 (MECHANICAL) CONTRACTOR

The mechanical contractor, and all the sub-contractors and suppliers within Division 15, shall cooperate with the commissioning agency (CA), and other commissioning team members, to facilitate the successful completion of the commissioning process.

The contractor shall assign a representative to the commissioning team, and submit the person's name to the commissioning agency, within one (1) month of the award of the contract. The representative shall have the authority to make decisions on behalf of the mechanical contractor as they relate to the organization and scheduling of HVAC commissioning. The representative shall ensure communications between Division 15 contractors and suppliers and all other commissioning team members, and shall foster the necessary cooperative action. One specific responsibility shall be to attend commissioning meetings, and ensure action items arising from them are attended to as required to allow the commissioning process to proceed on schedule.

The Mechanical Contractor, and all mechanical sub-contractors and suppliers, shall cooperate with the Commissioning Agency in carrying out the HVAC commissioning process. In this context, the Mechanical Contractor shall:

1. Each contractor and sub-contractor in this division shall include in their quotes the cost of participating in the commissioning process as specified herein.
2. Ensure the automatic temperature controls (ATC) contractor performs HVAC commissioning responsibilities as listed in 3.5.
3. Provide instruction and demonstrations for the Owner's designated operating staff, in conjunction with the commissioning agency and mechanical engineer, and with the participation of qualified technicians from major equipment suppliers and the controls contractor.
4. Include requirements for submittal data, O&M data, and training information in each purchase order or sub-contract written.
5. Ensure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, and water treatment as applicable.
6. Ensure participation of major equipment manufacturing in appropriate start-up, testing and training activities.

7. Attend HVAC commissioning meetings scheduled by the CA.
8. Notify the CA a minimum of two weeks in advance of scheduled equipment and system start-ups, so that the CA may witness system verifications, and equipment and system start-ups.
9. Provide sufficient personnel to assist the CA as required during system verification and functional performance testing.
10. Prior to start-up, inspect, check and confirm the correct and complete installation of all equipment and systems for which system verification checklists are included in the commissioning plan. Document the results of all inspections and checks on the checklists and sign them. If deficient or incomplete work is discovered, ensure corrective action is taken and re-check until the results are satisfactory and the system is ready for safe start-up.
11. Notify the CA a minimum of two weeks in advance, of the time for start of the TAB work. Attend the initial TAB meeting for review of the TAB procedures.
12. Provide equipment and systems start-up resources as specified and required. If during an attempted equipment or system start-up, deficient or incomplete work is discovered that would preclude safe operation, the start-up shall be aborted until corrective action has been taken. Ensure such action is taken and verified before re-scheduling a new start-up. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.2 in this Section.
13. Carry out performance checks to ensure that all equipment and systems fully functional and ready for the CA to witness formal functional performance tests (FPTs).
14. Operate equipment and systems for FPTs in accordance with the commissioning plan and as directed by the commissioning agency. If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FPTs will be stopped by the CA. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.2 in this Section. Ensure that all corrections necessary for full and complete system operation as specified are completed; then with the ATC contractor and other applicable sub-contractors, carry out functional performance checks to confirm correct operation before applying to the CA to reschedule the FPTs for the system in question.
15. Prepare preliminary schedule for mechanical system orientation and inspections. O & M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up TAB, and task completion for use by the CA. Update schedule as appropriate throughout the construction period.
16. Attend initial O&M staff training session.
17. Conduct mechanical system orientation and inspection at the equipment placement completion stage.
18. Update drawings to as-built condition and review with the CA.
19. Gather O & M data on all equipment, and assemble in binders as required by the commissioning specification. Submit to CA prior to the completion of construction.
20. Participate in, and schedule vendors and contractors to participate in the O&M staff training sessions as set up by the CA.
21. Provide written notification to the general contractor [**or construction manager**] and CA that the following work has been completed in accordance with the contract documents and the equipment, systems and sub-systems are operating as required.
 - HVAC equipment including all fans, air handling units, dehumidification units, ductwork, dampers, terminals and all Division 15 equipment.
 - Refrigeration equipment, pumping systems and heat rejection equipment.
 - Fire stopping in the fire rated construction, including fire and smoke damper installation, caulking, gasketing and sealing of smoke barriers.

- Seismic restraints installed to specification; a certification from the seismic restraint engineer meets this requirement.
 - Dedicated smoke control systems including stairway pressurization and atrium systems.
 - Non-dedicated systems using the air-handling units for smoke control.
 - Fire detection and smoke detection devices furnished under other divisions of this specification as they affect the operation of the smoke control systems.
 - That the building control system is functioning to control mechanical equipment and smoke control systems as specified.
22. Provide a complete set of as-built drawings and O & M manuals to the CA.

3.4 COMMISSIONING RESPONSIBILITIES – TAB AGENCY

[If the TAB agency is contracted directly by the owner, this material would be included in 3.1 above and the reference to TAB in 3.2 would be deleted. If the TAB agency is a sub-contractor within Division 15, the reference to TAB in 3.2 would be relocated to 3.3 as a mechanical contractor responsibility.]

With respect to HVAC commissioning, the TAB agency shall:

1. Include costs for HVAC commissioning requirements in the quoted price.
2. Attend commissioning meetings scheduled by the CA prior to, and during, on-site TAB work being done.
3. Submit proposed TAB procedures to the CA and mechanical engineer for review and acceptance.
4. Attend the TAB planning meeting scheduled by the CA. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the HVAC system.
5. At the completion of the TAB work, submit the final TAB report to the general contractor [***or construction manager***], with copies to the Owner, CA and mechanical engineer. [***If the TAB work is contracted directly by the owner, submittal will be to the owner, CA and mechanical engineer; if contracted directly by the mechanical contractor, submittal will be to the mechanical contractor, with general contractor, CA, and mechanical engineer notified.***]
6. Participate in verification of the TAB report by the CA for verification or diagnostic purposes. This will consist of repeating a sample (normally 10% to 20%) of the measurements contained in the TAB report as directed by the CA.
7. Participate in O & M personnel training sessions as scheduled by the CA.

3.5 COMMISSIONING RESPONSIBILITIES – CONTROLS CONTRACTOR

With respect to HVAC commissioning, the controls contractor shall:

1. Include cost for commissioning requirements in the quoted price.
2. Review design for controllability with respect to equipment selected for the project;
 - Review and confirm in writing that a proper hardware specification exists to permit functional performance testing as required by specification and sequence of operation.
 - Review and confirm in writing that proper safeties and interlocks are included in design.

- Ensure the proper sizing of control valves and actuators, based on design pressure drops. Ensure that control valve authority will result in capacity control as specified. Include valve sizing and authority information in submittal to mechanical engineer.
 - Ensure the proper sizing of control dampers. Ensure damper authority to control air flows as specified. Review and confirm in writing proper damper positioning for mixing to prevent stratification. Ensure correct actuator vs. damper movement for smooth operation. Include damper sizing, control authority and actuator selection data in submittal to mechanical engineer.
 - Ensure the proper selection of sensor ranges, and include data with submittal to mechanical engineer.
 - Clarify all questions concerning sequences of operation with the mechanical engineer.
3. Attend commissioning meetings scheduled by the CA.
 4. Provide the following submittals to the CA for review;
 - Hardware and software submittals.
 - Control panel construction shop drawings.
 - Diagrams showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access, all superimposed on diagrams of the physical equipment.
 - Narrative description of all control sequences for each piece of equipment controlled.
 - Logic diagrams showing the logic flow of all control sequences.
 - 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.
 - A complete control language program listing including all software routines employed in operating the control system. Also provide a program write-up, organized in the same manner as the control software. This narrative shall describe the logic flow of the software and the functions of each routine and sub-routine. It should also explain individual math or logic operations that are not clear from reading the software listing.
 - Hardware operation and maintenance manuals.
 - Application software and project applications code manuals.
 5. Inspect, check, and confirm the proper installation and performance of controls/BAS hardware and software provided by others.
 6. Integrate installation and programming scheduling with construction and commissioning schedules.
 7. Inspect, check and confirm the correct installation and operation of input and output field points and devices through documented and signed off point-to-point checkouts.
 8. Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system, in accordance with the O&M staff training program in the commissioning plan.
 9. In conjunction with the mechanical contractor, demonstrate system performance to the CA including all modes of system operation (e.g. occupied, unoccupied, emergency) during the functional performance tests (FPTs). If improper functionality, incomplete work, or other deficiencies affecting system performance are discovered, the FPTs will be stopped by the CA. Those responsible for deficient or incomplete work will be responsible for costs in accordance with 3.2 in this Section.
 10. Provide control system technician to assist during system verification and functional performance testing.

11. Provide support and coordination with TAB contractor on all interfaces between controls and TAB scopes of work. Provide, at no additional cost to the TAB and commissioning agencies, all devices, such as portable operator's terminals and all software for the TAB agency to use in completing TAB procedures.

3.6 COMMISSIONING RESPONSIBILITIES – ELECTRICAL (DIVISION 16) **CONTRACTOR**

With respect to HVAC commissioning, the electrical contractor shall:

1. Include cost for HVAC commissioning requirements in the quoted price.
2. Review design with respect to providing power to the HVAC equipment;
 - Verify that proper hardware specifications exist for functional performance and sequence of operation required by specification.
 - Verify that proper safeties and interlocks are included in the design of electrical connections for HVAC equipment.
3. Attend commissioning meetings scheduled by the CA.
4. Schedule work so that required electrical installations are completed, and systems verification checks and functional performance tests can be carried out on schedule.
5. Inspect, check and confirm in writing the proper installation and performance of all electrical services provided.
6. Provide electrical system technicians to assist during system verification and functional performance testing as required by the CA.

B. SPECIFICATION 15995 – COMMISSIONING OF HVAC SYSTEMS

1.1 COMMISSIONING AGENCY

The commissioning agency (CA) has been contracted directly with the owner for this project. The CA has overall responsibility for planning and coordinating the commissioning process. However commissioning involves all parties to the design and construction process, including the mechanical (Division 15) contractor, and all specialty sub-contractors within Division 15, such as sheet metal, piping, refrigeration, water treatment, and controls, plus major equipment suppliers as required.

1.2 CONTRACTOR RESPONSIBILITY

The mechanical (Division 15) contractor's responsibilities are defined in Section 01660 of the specifications. These responsibilities apply to all specialty sub-contractors and major equipment suppliers within Division 15. Each contractor and supplier shall review Section 01660, and their bids shall include for carrying out the work described, as it applies to each Section within the Division 15 specifications, individually and collectively.

C. SPECIFICATION 16995 – COMMISSIONING OF HVAC SYSTEMS

1.1 COMMISSIONING AGENCY

The commissioning agency (CA) has been contracted directly with the owner for this project. The CA has overall responsibility for planning and coordinating the HVAC commissioning process. However commissioning involves all parties to the design and construction process, including the electrical (Division 16) contractor, as many HVAC system components require electrical power and controls in order to operate as specified.

1.2 CONTRACTOR RESPONSIBILITY

The electrical (Division 16) contractor's responsibilities are defined in Section 01660 of the specifications. Each contractor and supplier within Division 16 shall review Section 01660, and their bids shall include for carrying out the work described, as it applies to each Section within the Division 16 specifications, individually and collectively.