# COMMISSIONING GUIDELINES

Commissioning is the process of verifying and documenting that the facility and all its systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the owner’s project requirements (ASHRAE definition).

## Systems Start-up and Commissioning

Specify the performance testing procedures that will be used for start-up and commissioning of the installed equipment and total system. Define procedures for developing and implementing a commissioning plan and specify any requirements for the Entity and/or third-party review and approvals, pre-functional inspections, use of manufacturers’ start-up procedures, and for executing functional performance tests. Include operating parameters for the installed equipment such as temperature setbacks, equipment run times, load controlling specifications and other conditions for the equipment.

Provide a general commissioning schedule, including any seasonal testing, and outline commissioning tracking and reporting requirements, including periodic and final commissioning reports, and any other required submittals such as a systems manual. Prescribe any requirements for warranty walk-through or other commissioning follow-up procedures.

Include specific provisions on how the Entity’s project requirements or design intent for each measure or system will be defined. Define any requirements for certification that the tests followed the specified procedures and met or exceeded the expected results.

Define the qualifications and affiliation of the commissioning agent, and provide an overview of the roles and responsibilities of the commissioning agent, the qualified energy service provider (ESP) and the Entity in the commissioning process.

Provide for the Entity to be notified of and present during all commissioning procedures. Include a provision for the documentation of the Entity’s attendance at the various tests and the Entity’s approval that the tests followed the specified procedures and met or exceed the expected results.

Because of the design-build nature of the energy performance contract (EPC) project, the details of the commissioning activities are developed along with the project scope, rather than being explicitly defined at the beginning of the project. Commissioning requirements must be:

1) specified in the contract,

2) defined explicitly after design,

3) implemented during construction,

4) completed prior to final project acceptance, and

5) followed-up on after acceptance.

Specify commissioning that will be completed during the following phases:

**PHASE 1 – CONTRACT DEVELOPMENT**

Outline the project’s specific commissioning requirements including:

* Qualifications and affiliation of the Commissioning Agent (CxA);
* Roles and responsibilities of CxA, ESP and Entity, including witnessing of commissioning activities;
* Process that will be followed to document the design intent or Entity’s project requirements for each cost-saving measure or system;
* Requirements for Entity or 3rd party design reviews or submittal approvals;
* Schedule for developing and approving a commissioning plan, including expected content such as:
	+ Pre-functional inspections,
	+ Functional testing procedures,
	+ Required use of manufacturers’ start-up procedures,
* Plan for seasonal testing and conditional acceptance, if needed;
* Contents and timing of project reports, Final Commissioning Report, and Systems Manual;
* Requirements for CxA oversight of O&M training; and
* Plan for warranty walk-though or other follow-up procedures.

The key responsibilities of the CxA are:

1) Directing the commissioning team in the completion of the commissioning requirements;

2) Overseeing or performing the commissioning tests; and

3) Verifying the adequacy of the commissioning results.

Develop a written design intent for each system or cost-saving measure installed documenting the Entity’s project requirements. Specific operational parameters, design details, performance requirements (conditions in addition to energy savings), or other provisions that are established by a design intent are:

* Operational parameters, such as temperature setback capabilities or operator interface features;
* Requirements for design details or ancillary items, such as sensors, valves, access, electrical, existing equipment demolition, etc.;
* Performance requirements, such as equipment efficiencies or ton-hours of chilled water to be delivered.

**PHASE 2 – PROJECT DESIGN**

Commissioning related activities performed by the commissioning team in the design phase include:

* ESP completes project design;
* Entity and CxA review design and approve equipment submittals;
* ESP and Entity document the design intent for each cost-savings measure or system;
* CxA develops a draft commissioning plan, including the specifics of all pre-functional inspections and functional performance tests;
* CxA develops commissioning specifications for project (if needed);
* Entity and ESP review and accept commissioning documents;
* CxA issues Final Commissioning Plan and specifications.

**PHASE 3 – CONSTRUCTION**

Commissioning related activities that occur during the construction phase include:

* Construction observation by Entity’s commissioning representative and CxA;
* Periodic commissioning meetings are held with the project team;
* Commissioning progress reports are submitted by the CxA;
* Pre-functional inspections are completed and certified by the ESP prior to equipment start-up and functional testing;
* Manufacturers’ start-up procedures are completed by the ESP or manufacturer’s representative.

**PHASE 4 – PROJECT ACCEPTANCE**

In this phase the functional performance tests are executed and the procedures are documented by the CxA, explicitly including how the Entity’s project requirements or design intent prescribed for each system were met. Any items that did not pass shall be tracked and presented to the project team in a deficiency log. The ESP will rectify the items and then perform a retest in the presence of the CxA to confirm that the items have been fixed. The deficiency log is then updated by the CxA, noting the date and corrective action taken. The Entity may choose to specify consequences for multiple failed re-tests to limit the possibility of excessive use of the CxA’s time. The ESP then assembles the Final Commissioning Report or a Systems Manual including, at minimum, the following:

* Commissioning summary report;
* ESP certified pre-functional checklists;
* Completed manufacturers start-up sheets;
* Results of functional testing and verification of system performance;
* Detailed operating procedures / sequences of operations;
* Closed out deficiency log;
* Overview of training provided to O&M staff.
* Some Entities may prefer to receive a more comprehensive Systems Manual, which is required for LEED certification. A systems manual typically brings together comprehensive project documentation:
	+ Entity’s project requirements or design intent;
	+ Schematic system drawings;
	+ Approved submittals;
	+ Recommended record keeping procedures;
	+ Maintenance procedures & schedules;
	+ Test requirements for ongoing commissioning.

**PHASE 5 – POST-ACCEPTANCE PHASE**

Commissioning activities that typically extend beyond Project Acceptance include deferred functional testing and warranty verification. Some functional testing may be postponed until seasonal conditions are appropriate to evaluate the system. When some functional testing has been deferred, acceptance of the project is conditional upon the success of the scheduled tests. Most equipment installed will have a one-year warranty provided by the manufacturer. A warranty check-out with the ESP after 8 to 10 months of operation is a recommended commissioning activity. Reviewing the equipment warranties and performing a site walkthrough can identify any problems that may still be covered by a manufacturer’s or contractor’s warranty.

### Commissioning Plan

A Commissioning Plan should involve the following:

* Written as a user-friendly document that defines the flexibility requirements and migration path of the proposed system
* Provides complete documentation of how system design intent will meet the owner’s needs
* Includes design review and post-acceptance project monitoring
* Defines design objectives for the functional use of the system
* Provides an adequate set of pre-functional test checklists to verify installation compliance with design intent
* Provides an adequate description of functional performance tests (e.g. step by step procedures)
* Functional performance tests verify that the controls function as an integrated system congruent with design intent
* Functional performance tests cover equipment startup, seasonal changeovers, and shut down
* Performance tests cover system normal, alarm, and failure sequences
* Requires a master list of deficiencies and status of resolution for each item
* Sensor accuracy tests performed with standardized instruments
* Performance testing includes both hardware and software
* Provides effective operations and maintenance training for building operators
* Contains equipment data sheets and commissioning logs
* Contains equipment startup checklists
* Requires production of a systems manual with full documentation of the control logic in addition to O&M manuals
* Requires a final commissioning report and recommissioning schedule or continuous commissioning plan

### Operating Parameters of Installed Equipment

Operating parameters should for the operation of the installed equipment such as sequence of operation, temperature setbacks, equipment run times, load controlling specifications and other conditions for the operation of the equipment.

### ESP's Training Responsibilities

Describe the ESP's training program or sessions for Entity personnel including the duration and frequency of the specified training. Describe any provisions for on-going training, commitments to train newly hired personnel, and training with respect to possible future equipment or software upgrades. Also specify any fees associated with the Entity's request for training beyond what the ESP is contractually bound to provide.

Describe your firm’s proposed approach to providing technical training. Indicate the proposed number of personnel to be trained and the type and frequency of training to be provided for the duration of the Agreement. Indicate how your firm shall address any turnover of key Entity personnel as it relates to project performance.

The Training Approach is customized to meet the specific needs of the Entity. It is a systematic process for identifying and implementing operational and maintenance improvements and for ensuring continued performance over time. The work scope is developed to focus on optimizing the building’s systems and protecting the significant investment made by the Entity. This work scope will result in improved occupant comfort, maximum energy and operational savings and will be accomplished in a cost-effective manner.

As part of ensuring continued performance over time, the Entity should consider implementing an Asset Management software solution to optimize training and maintenance procedures. Turnover is a key concern for every building management team and an automated technology solution will assist in training maintenance personnel by automating preventive maintenance scheduling, work orders and inventory management. Maintenance personnel receive step-by-step procedures and the required parts to complete a planned or unplanned maintenance activity. In addition to saving money on unnecessary or repeated trips to equipment, the training helps facilities personnel that do not have experience with a specific piece of equipment.

The overall goal of a Training Approach process is to assure that the HVAC, electrical and safety systems in the building are operating in accordance with the proper design intent and to maintain comfort during the life of the building. The process will accomplish the following:

* Building HVAC, electrical and plumbing systems will operate according to the design intent that best suits the needs of the occupants and will provide a comfortable, safe and healthy environment
* Energy and operating costs will be reduced due to systems operating at maximum efficiency and through the implementation of energy efficient measures through the application of current technology
* Maintenance staff will be adequately trained to operate and maintain HVAC, electrical, plumbing and other systems in accordance with the proper design intent
* Reduction in occupant complaints reducing maintenance service calls
* Improvement in the overall building environment
* Extended service life of existing HVAC, electrical, plumbing and other systems and equipment

The key steps in the Training Approach processes are outlined as follows:

* Define and document the service requirement for each system and component. Each work scope item will include the following:
	+ Identify the actual work scope that is required
	+ Define the frequency of service procedures
	+ Identify materials required
	+ Identify any special tools or skills required
	+ Identify the approximate time required to perform the service
	+ Identify the safety concerns for the specific work scope
* Identify the specific service scope that can be performed by in-house staff. These work items will be selected based on the following factors:
	+ Availability of in-house staff.
	+ Expertise required by in-house staff
	+ Tools required to perform work
	+ Time required to perform work
* Train the in-house staff to perform specific service scope work items. The benefits of work completion by in-house staff include:
	+ The Entity will realize cost savings by self-performing work items
	+ The Entity will not be dependent on outside vendors
	+ Enhanced understanding of system/equipment operation by in-house staff
	+ Improved job satisfaction for in-house staff due to increased responsibilities
* Identify the specific service scope to be performed by external service providers. These work items will be selected based on the following factors:
	+ Requirement of specific expertise
	+ Risk management of asset life
* Recommend service providers to perform work scope items. These providers will be selected based on the following factors:
	+ Local presence.
	+ Knowledge of Entity facilities
	+ Warranty requirements
	+ Specific system/equipment expertise
	+ Cost of service

### Retro-Commissioning

Retro-commissioning is commissioning for facilities that have not been commissioned before. Good candidates for retro-commissioning are buildings with:

* Complex systems
* Consumption exceeding commercial building energy consumption benchmarks
* A history of operating problems
* Incomplete prior commissioning efforts
* Advanced DDC control systems
* High air change rates
* Dedicated facilities manager
* Permanent web-based metering
* Systems sub-meters
* Historical low-profile data
* Large, single HVAC systems
* Water-side economizers
* VAV systems
* Data collection to support condition-based maintenance
* Trend data from the building/energy management system
* Good utility baseline data
* Motivated and capable facility staff
* Extensive use of control strategies

Recommendations for Monitored Retro-Commissioning

* Review building/energy management system trend logs
* Review energy use profiles
* Set alarms for savings persistence
* Continuous monitoring and optimization
* Benchmark all buildings
* Invest in staff training
* Major opportunities to resolve air system distribution noise, laboratory operational issues, better temperature control, and controls calibration
* Improved ventilation effectiveness
* Improved chiller sequence
* Improved reset controls and VAV static controls

Examples of trend logs to collect may include:

* Supply air vs. return air
* Chiller schedule
* Chiller outdoor air lockout
* Hot water supply temperature reset
* Hot water pump outdoor air lockout
* kW demand monitoring vs. outdoor air temperature
* Chiller kW vs. outdoor air temperature
* Ton hours vs. outdoor air temperature
* kWh vs. ton hours
* Run hours of ventilation fans

Monitored retro-commissioning involves three steps:

* A performance persistence tracking system
* A performance degradation review process
* A persistence problem resolution process

Examples of points that may be archived include:

* Fan static pressure
* Schedule for the fan control signal
* Air and water temperatures
* Lobby schedules
* Chiller sequences
* Chilled water valve cycling
* Supply air temperature reset