



ASHRAE Guideline 1.3-2018R

**Public Review Draft**

# Revision of Guideline 1.3-2018, Application of the Commissioning Process to Building Operation and Maintenance Training

First Public Review (**July 2024**)  
(Complete Draft for Full Review)

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## FOREWORD

**(This foreword is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)**

*Guideline 1.3 provides guidance on implementing the training aspects of the Commissioning Process (Cx) as outlined in ASHRAE Guideline 0, The Commissioning Process for New Buildings and New Systems, and Guideline 0.2, The Commissioning Process for Existing Systems and Assemblies. Such training is directed toward the facility's operations and maintenance (O&M) personnel. These personnel may be employed in-house or may work under a service contract. The objective of this training is to allow the Owner to fully benefit from the Cx by having well-informed staff to assist with ongoing building operations.*

*Occupancy and Operations is defined as a key phase of the project acquisition process under Guideline 0 and Guideline 0.2. During this phase, the project Owner begins to use the facility with the support of the Cx Team. At the end of this phase, the Owner assumes full responsibility for correctly and effectively operating and maintaining the project's systems and assemblies. O&M personnel who understand the project objectives, Basis of Design (BoD), the nature of the incorporated systems and assemblies, and expectations for their appropriate use will be better positioned to assist in achieving the Owner's Project Requirements (OPR) and Current Facility Requirements (CFR) well into the service life of the project. Access to, and understanding of, benchmarks for systems' performance will also assist in ongoing operations.*

*The primary focus of this guideline is O&M personnel. Building users, however, might also be targeted for training under the Cx when their actions (or inactions) can affect expected building performance outcomes. Examples of such situations include manipulation of interior shading devices for daylighting control, the use of operable windows for ventilation, or user control of thermostats.*

*The training requirements described in this guideline span the four project phases defined in Guideline 0 and Guideline 0.2. These include Predesign, Design, Construction, and Occupancy and Operations. Training under the Cx may occur during the Construction Phase as well as the Occupancy and Operations Phase. Such training must be anticipated during Predesign (when the OPR is established) and solidified during the Design Phase when the project specifications are completed. The need for the design team to deal with training as part of the Cx must be conveyed before design contracts are signed (i.e., during predesign). As with the Cx itself, the activities associated with training will span from project start to finish. Ideally, training would extend beyond the end of the Occupancy and Operations Phase (defined as roughly one year into building use) via implementation of an Ongoing Commissioning Process (OCx) program.*

*This guideline is part of a larger collection of Cx documents prepared by ASHRAE and other professional organizations. Driven by the process that is detailed in Guideline 0 and Guideline 0.2, several technical support guidelines provide specifics related to implementation of Cx for various systems and assemblies. Several process support guidelines (such as this) provide more detail on various aspects of the process itself.*

*As with Guideline 0, the training requirements in this guideline are structured around a conventional program-design-bid-build project acquisition process. In general, the requirements should also apply to other types of acquisition approaches (such as design-build) with minor adjustments for project information flows and terminologies. Like Guideline 0, this guideline focuses on new construction and major renovations (where the four project phases will be fully evident). In general, however, these training requirements can be reasonably applied to existing building Cx situations (similar to Guideline 0.2) with some shift in process and terminology.*

*Although developed primarily in support of ASHRAE Guideline 0, this document provides useful and applicable support for the training aspects of ASHRAE Standard 202, The Commissioning Process for New Buildings and New Systems, and ASHRAE Guideline 0.2, The Commissioning Process for Existing Building Systems and Assemblies.*

## 1. PURPOSE

The purpose of this guideline is to provide methodologies and formats for developing training plans, conducting training programs, and documenting training results for the operation and maintenance of building systems and assemblies during the Cx.

## 2. SCOPE

- 2.1 The procedures, methods, and documentation requirements in this guideline cover the development of training plans, assembly and preparation of training materials, and the conducting of training programs for the facility's operation and maintenance (O&M) personnel.
- 2.2 The guideline addresses:
  - a. development of training requirements and plans,
  - b. verification of personnel training needs and results,
  - c. training formats and examples of training records,
  - d. sources and development of training materials,
  - e. methods of conducting training,
  - f. evaluation of training programs, and
  - g. recording of training.

### 3. UTILIZATION

The application of this guideline depends on the Owner's Project Requirements (OPR) and how a given project will be designed, constructed, and operated. This guideline is supplemental to, and should be used in conjunction with, the Cx detailed in other ASHRAE commissioning documents, such as ASHRAE Guideline 0, *The Commissioning Process Requirements for New Buildings*<sup>1</sup>, ANSI/ASHRAE/IES Standard 202, *The Commissioning Process Requirements for New Buildings*<sup>2</sup>, ANSI/ASHRAE Standard 230, *The Commissioning Process for Existing Buildings and Systems*<sup>3</sup>, or ASHRAE Guideline 0.2, *The Commissioning Process for Existing Systems and Assemblies*<sup>4</sup>. This is not intended to be a stand-alone document.

### 4. DEFINITIONS

Definitions for general Commissioning Process (Cx) terms can be found in ASHRAE Guideline 0<sup>1</sup>, ANSI/ASHRAE/IES Standard 202<sup>2</sup>, ANSI/ASHRAE Standard 230<sup>3</sup>, and ASHRAE Guideline 0.2<sup>4</sup>. Additional building operation and maintenance training related terms are defined as follows.

**needs assessment:** an organized procedure for determining Cx training needs for facility operations and maintenance (O&M) personnel and/or occupants/users; a written report that details such findings.

### 5. INTENT OF CX TRAINING

The intent of the training requirements and associated activities that are part of the Cx is to ensure (to the extent possible) that a facility's O&M staff (or service contract staff) understand key Owner's Project Requirements (OPR) and Current Facility Requirements (CFR), how these requirements are supported by selected facility systems and assemblies, and how staff may contribute to achievement of these requirements over the life of the project. The same intent applies to the training of building occupants/users when they are important to the achievement of the OPR or CFR.

It is not the intent of Cx-focused training to provide staff with basic or entry-level skills. The intent is to train otherwise qualified personnel on critical aspects of the specific systems and assemblies incorporated in a project that will, over a reasonable time period, deliver the level of performance desired by the Owner. Generally, this means maintaining the performance characteristics of systems and assemblies that were present upon building turnover, as verified and documented through the Cx.

As with the underlying Cx, planning for training should begin in the Predesign Phase of a project, be incorporated into contracts and specifications before and during the Design Phase, and be implemented during the Construction Phase as well as the Occupancy and Operations Phase, all while being verified and documented by the Cx Team. See Informative Appendix A for an overview of training during the Cx. Informative Appendix B summarizes training documentation and verification efforts.

The training aspects of a project will be documented in a formal report called a training plan. The training plan may be a stand-alone document or a section of the larger-scope Cx Plan. The training plan is a living document that evolves during the succeeding phases of a project, starting with a broad formulation of Owner objectives and

commitment and becoming a detailed road map to all training-related activities.

In general terms, the training components of the Cx will, under the auspices of the training plan, provide:

- a. a definition of the knowledge, skills, and performance expected of those being trained;
- b. an understanding of who is to be trained and the nature of their training needs;
- c. a budget under which the desired training may be accomplished;
- d. a schedule that maps the relationship of training activities to the larger project schedule;
- e. specifications for trainers, training materials, and training methods appropriate to the OPR;
- f. useful documentation of training efforts;
- g. ongoing verification of training efforts, documents, and activities.

## 6. PREDESIGN PHASE

The development of training in support of the Cx should begin during the Predesign Phase to ensure timely integration with other critical elements of the Cx. The design team should be fully aware of its responsibilities to incorporate training into the project contract documents prior to signing a contract for professional services.

The outcome of Predesign Phase consideration of training is an initial training plan. The training plan will be updated and adjusted during each successive project phase. At the end of the Predesign Phase, the training plan should provide adequate detail to allow the design team to incorporate Cx training into its fee proposal and project schedule and to adequately address training in the preparation of the construction documents.

### 6.1 Training Requirements

- a. Incorporate general expectations for training into the OPR document.
- b. Define roles and responsibilities for the training planning efforts.
- c. Perform a needs assessment, as outlined in Informative Appendix D, sufficient to address the aspects of training discussed in Section 5 and consistent with the OPR.
- d. Broadly identify the intended audiences for training, the training objectives associated with each audience, and the scope and depth of training desired for each audience group.
- e. Identify preferred formats for training delivery and documentation.
- f. Establish an initial training budget and schedule. See Informative Appendix G for budget suggestions.
- g. Incorporate the information described in Sections 6.1a through 6.1f into a written training plan (see Informative Appendix F).
- h. Verify that the training plan is in accordance with the OPR.
- i. Communicate the training plan to the design team.

### 6.2 Implementation Guidance

- a. Ensure that a sense of the intended scope and depth of O&M training for systems and assemblies is included in the OPR as a means of providing a benchmark for the success of the training plan and its implementation. See Informative Appendix E for further information.
- b. The Owner and Commissioning Provider (CxP) should jointly establish who will be responsible for developing the training plan, including completing the activities that are described in 6.2c through 6.2f.
- c. Extract from the OPR (prior to its finalization) the systems and assemblies that will likely require training.
- d. Conduct a needs assessment. The needs assessment should consider the available sources of operating personnel and services (for example, in-house or outsourced labor) and the level of responsibility assigned to these personnel, certification requirements (if applicable), and the Owner's expectations for performance and use of the facility. Informative Appendix D provides suggestions for this activity.
- e. Create an initial list of parties who will require training in order to ensure achievement of the OPR. This list should be aligned with the list of particular systems and the general level of the training they will require. The needs assessment results will inform this task.
- f. Develop a milestone schedule and budget that considers (commensurate with a Predesign Phase understanding of likely solutions):
  1. Sequence of training-related activities

2. Who will be trained
  3. In general, how the training should occur (possible venues and delivery methods)
  4. Equipment and systems on which personnel will be trained
  5. Training and operations objectives for key systems and assemblies
  6. Potential means of verifying training effectiveness
  7. Desired retention of training records
  8. Development of modules that can be used to train new or replacement personnel.
- g. Review the adequacy of the Predesign Phase training plan in assisting the Owner in achieving the OPR for the project. If revision of the draft training plan is necessary because of this OPR coordination review, such revisions should be completed prior to embarking on the Design Phase. See Informative Appendix F for a sample training plan.
- h. Convey the Predesign Phase training plan to potential project design teams so that they are aware of expectations for design team participation in Cx training, potentially as a trainer and certainly as the party responsible for incorporating training requirements into the construction documents. Training responsibilities may fall on the Owner, the CxP, the design team, the contractors, major equipment providers, and/or specialized training professionals, depending upon the needs of the project and the OPR.

### **6.3 Documentation**

- a. Training expectations included in the OPR
- b. Needs Assessment Report
- c. Training plan (As noted above, this document will be updated in successive phases of the Cx and may be a stand-alone document or a clearly defined section of the Cx Plan).

### **6.4 Verification**

- a. Verify that training is addressed in the OPR.
- b. Verify that the needs assessment aligns with the OPR.
- c. Verify that the training plan is consistent with the OPR.
- d. Obtain Owner's acceptance of the training plan.

## **7. DESIGN PHASE**

O&M personnel should be provided with the project-specific knowledge necessary to run the facility in a manner that will allow achievement of the OPR. O&M personnel and building occupants should understand how their actions may impact achievement of the OPR.

Addressing training during the Design Phase will result in an updated and expanded training plan, the inclusion of training requirements in the project specifications, development of statements describing training requirements to be completed by entities other than the contractor (such as the design team), and development of success metrics for training activities (perhaps in the form of training checklists). The Design Phase training plan will build on the Predesign Phase training plan, will be updated during the Construction Phase, and will be further updated during the Occupancy and Operations Phase. At the end of the Design Phase, the training plan should provide detail adequate to allow the design team to incorporate training into the construction documents so that bidding contractors can accurately estimate the cost and schedule impacts of required training. In addition, noncontractor training entities will understand how their component of training fits into the overall training scheme and schedule.

### **7.1 Training Requirements**

- a. Refine and finalize the definition of roles and responsibilities for the training implementation efforts.
- b. Update the Predesign Phase needs assessment report to reflect information on specific systems, equipment, and assemblies that is developed during the Design Phase.
- c. Establish detailed training requirements that address the findings of the updated needs assessment and meet the OPR.
- d. Develop verification protocols and procedures that will be used to confirm the success of training efforts. Training checklists may be developed to assist with verification.

- e. Place requirements for training that will be conducted by the contractor (and/or trade contractors) into the contract documents (specifications). These specifications should provide the following:
  1. Clear definitions of training audiences
  2. Training objectives for each audience
  3. Recommendations for training venue (if appropriate)
  4. Verification procedures that will apply to training efforts (see Informative Appendix J)
  5. Requirements for archiving of training activities (as appropriate to the project OPR)
  6. Explicit requirements for retraining in cases where verification indicates training results do not comply with the OPR
- f. Place training requirements into Division 1 (general conditions) and other divisions of the specifications (in accordance with the systems being commissioned on a given project).
- g. Develop formal statements describing any training that is to be provided by parties not bound by the contract documents. These statements may describe training to be conducted by the design team, subject matter experts, Owner's staff, and/or the Cx Provider (CxP), depending on the project context. Incorporate these requirements into the training plan and convey them to the appropriate parties in detail sufficient to allow procurement of the necessary services.
- h. Coordinate any parallel training efforts (not related to the Cx) with the schedule for Cx training.
- i. Include requirements in the specifications that address the inclusion of training materials (including desired formats) in the Systems Manual.
- j. Update the training plan so that it fully addresses project-specific training needs relative to the OPR.
- k. Coordinate the training activities schedule with the larger Cx Plan.
- l. Obtain Owner's acceptance of Design Phase training activities.

## 7.2 Implementation Guidance

- 7.2.1 An understanding of the training efforts that can help with accomplishment of the OPR can be developed using the needs assessment guidance in Informative Appendix D. In addition, ASHRAE Guideline 0<sup>1</sup> describes a nominal group technique workshop approach that may also prove valuable.
- 7.2.2 Design Phase training requirements should be established after systems, equipment, and assemblies for the project have been decided but before finalization of the construction documents to ensure that project-specific specifications for training are clearly conveyed in the construction documents. A sample specification for Cx training is provided in Informative Appendix I.
- 7.2.3 The understanding of project-specific systems, equipment, and assemblies developed during the Design Phase will inform the process of determining training roles and responsibilities. Various parties on the project acquisition team, such as the contractor/trade contractor, members of the design team, the CxP, the Owner's project manager, and/or equipment/assembly providers, may reasonably be involved in delivering training.
- 7.2.4 During the latter part of the Design Phase, project solutions will be adequately developed so that training requirements can be customized to clearly address the following:
  - a. Specific systems, subsystems, equipment, and assemblies on the project for which training will be provided; this information will result from an understanding of the OPR.
  - b. Existing (or anticipated) capabilities and knowledge of the O&M personnel (and occupants) as compared to the capabilities and knowledge necessary to meet the Owner's expectations for project performance as expressed in the OPR.
  - c. A reasonably firm projection of the number and type of training sessions for each audience group. The overall training program should be organized as a series of instructional modules (often corresponding to training sessions) that cover a manageable portion of the training materials and that are presented in a logical sequence with time for digestion and reflection (plus verification). Informative Appendix J outlines training types. Informative Appendix L provides tips for successful training.
  - d. Learning objectives and associated teaching outlines that clearly describe and address the specific skills and knowledge that participants in each session are expected to master. Informative Appendix M



provides examples of training agendas.

- 7.2.5** An initial training session should be presented to the O&M personnel (and occupants, as appropriate) as a means of providing an overview of the OPR; a session to deliver an overview of the Basis of Design (BoD) is also recommended. These two early training elements can provide background and context for the project, including performance expectations, why key systems/assemblies were selected by the design team, operational and use assumptions critical to project success, and known system/assembly limitations.
- 7.2.6** Most training should be scheduled for completion during the Construction Phase and prior to substantial completion of the project. Synergies between training activities and start-up and Cx testing activities should be identified and exploited; for example, equipment start-up and systems test procedures may provide an opportunity for real-world training.
- 7.2.7** Training during the Occupancy and Operations Phase may be required for certain systems and assemblies because of deferred testing, seasonal functions, and/or the availability of occupants/users.
- 7.2.8** Use of the Systems Manual should be integral to the training of O&M personnel. A successful training program will provide an overview of the Systems Manual and include modules that deal with O&M. Modules might address the following:
  - a. Location, format, and scope of project record documents
  - b. System, equipment, and assembly identification systems
  - c. Warranties (normal and extended) and maintenance service agreements
  - d. Emergency instructions and procedures; key information needed to operate the facility during various emergencies, including step-by-step instructions for each type of emergency
  - e. Instructions and procedures for normal operation, including step-by-step instructions for day-to-day operations
  - f. Information on adjustment procedures required for the persistence of benchmarked operational parameters
  - g. Troubleshooting procedures and instructions for diagnosing operating problems
  - h. Procedures for routine testing and inspections, including routine maintenance procedures
  - i. Repair procedures (component disassembly, removal, replacement, and reassembly) as appropriate
- 7.2.9** Training should address upkeep of the Systems Manual as changes are made to systems, equipment, and assemblies; the importance of including maintenance documentation and logs in such updates should be noted during training.
- 7.2.10** Training on integrated systems operations should be included where such operations are important to achieve the OPR (as is often the case).
- 7.2.11** The specifications that deal with training should, as a minimum,
  - a. define the time requirements (length and sequencing) for all training sessions/modules—or include an allowance for bidding purposes;
  - b. define the expected experience and knowledge for the instructor of each session/module (relating directly to the subject matter of the training session; see Informative Appendix H);
  - c. address whether repeating training session to accommodate multiple shifts is necessary;
  - d. describe requirements for archiving (in the training plan and/or Systems Manual) training artifacts (such as handouts, slide sets, videos, attendance sheets, verification materials, etc.); see Informative Appendix L.3;
  - e. define requirements for the electronic recording of training sessions/modules (including expected quality, format, and naming conventions); see Informative Appendix L.2.
- 7.2.12** Training materials should include or use the following:
  - a. Training plan (including schedules, syllabi, and session agendas; see Informative Appendix M)
  - b. Systems Manual

- c. Manufacturers' training manuals and materials
- d. Electronic media or video recordings from manufacturers or vendors

### **7.3 Documentation**

- a. Updated needs assessment report
- b. Updated training plan
- c. Updated OPR (if necessitated by development of more detailed training plans)
- d. Training specifications (incorporated into the construction documents)
- e. Verification metrics (perhaps via training checklists).

### **7.4 Verification**

- a. Verify that any changes made to the OPR to reflect Design Phase thinking about training are appropriately incorporated.
- b. Verify that needs assessment results align with the OPR.
- c. Verify that the training plan is consistent with the OPR.
- d. Verify that Cx specifications conform to the OPR. (This may be accomplished using sampling in accordance with ASHRAE Guideline 0<sup>1</sup> and the project OPR.)
- e. Obtain Owner acceptance of the training plan.

## **8. CONSTRUCTION PHASE**

Much (but not necessarily all) of the training that occurs as part of the Cx will occur during the Construction Phase of a project. This can only be successfully accomplished if planning for this training is completed during the Predesign and Design Phases.

The outcome of Construction Phase training efforts is a well-prepared staff that can operate the commissioned building systems and equipment (and maintain assemblies) in a manner that will accomplish the OPR. Training that can only be conducted in the occupied project will take place during the Occupancy and Operations Phase. Construction Phase training will follow a training plan that provides detail on success metrics adequate to allow the Cx Team to verify the appropriateness of conducted training and recommend acceptance to the Owner. Training documentation will be updated during the Construction Phase then verified and accepted. The training plan will be expanded to address the upcoming Occupancy and Operations phase.

### **8.1 Training Requirements**

- a. The Cx team will designate (or engage) a party responsible for training coordination.
- b. Training requirements associated with equipment and assemblies, and that are included in the project specifications, will be addressed in submittals.
- c. Training requirements that are the contractor's responsibility per the specifications but that are not directly associated with equipment/assemblies will be addressed in training-specific submittals.
- d. Training requirements that are not the responsibility of the contractor will be addressed via delivery proposals as defined in the respective professional services contracts.
- e. The Owner will arrange for submittal of training proposals for any areas of training for which they are responsible.
- f. Training submittals and proposals will be verified against the OPR. Elements found to be unacceptable will be revised in accordance with the conditions set forth in the project specifications and/or professional services contracts. Such deviations will be noted in the project issues and resolution log. Sampling may be used for these verifications in accordance with the project Cx Plan.
- g. Verify acceptability of proposed instructors in accordance with the requirements of the training plan.
- h. Schedule training sessions and modules in accordance with the training plan and approved submittals and proposals.
- i. Confirm that Systems Manual materials to be used in training activities are available prior to the onset of the respective training sessions/modules.
- j. Confirm the availability of training spaces, instructors, and resources. This will include the availability of



any facility systems, equipment, and assemblies being used as the basis for hands-on training or demonstration.

- k. Conduct training that is to be completed during the Construction Phase (as scheduled per the training plan).
- l. Complete recording and archiving of training materials as required by the training plan and project specifications.
- m. Document attendee participation in training sessions as per the requirements of the training plan.
- n. Verify that training delivery has been successful according to the metrics of the training plan. Identify deviations in the issues and resolutions log. Conduct retraining identified as necessary by this verification process. Verify that retraining is successful.
- o. Verify that training records and artifacts are properly incorporated into the training plan, Cx Plan, Systems Manual, and/or Cx Reports in accordance with project requirements.
- p. Obtain Owner approval of Construction Phase training activities.

## 8.2 Implementation Guidance

- a. Training to be conducted by the contractor, trade contractors, and product manufacturers/suppliers will be governed by the project specifications (both general and specific) developed during the Design Phase. Solid training specifications are crucial to successful training. Likewise, review of submittals detailing how training will be delivered can be critical to ensuring a successful and coordinated training experience.
- b. Training to be conducted by entities not bound by the construction documents (such as the design team or CxP) will be governed by provisions of professional services contracts developed prior to the Design Phase. Inserting training requirements into these contracts may be a challenge but is critical to a diverse presentation of materials for most projects. Plans for such training elements (akin to submittals) will allow for coordination of all aspects of training and smooth the delivery of these particular sessions/modules.
- c. The success of training activities (as is the case for all Cx Activities) should be verified against the OPR. The development of training checklists can facilitate such verification. See Informative Appendix J for sample training checklists.
- d. The project specifications will provide minimum success benchmarks for training efforts; these may include methods and responsibilities for the delivery of training records, such as video recordings, materials, signoffs, etc. These benchmarks (informed by the project OPR) will provide the basis for verification of training conducted during the Construction Phase and describe remedial actions (such as retraining) that will be triggered by failure to comply with verification standards. Informative Appendix K provides examples of training verification approaches. Verification may involve sampling as prescribed and permitted by the Cx Plan. Sampling strategies for training are presented in ASHRAE Guideline 0<sup>1</sup>.
- e. The documentation of Construction Phase training activities and outcomes in a final training plan, Systems Manual, and/or Final Cx Report will be as described in the training plan and/or Cx Plan. Roles and responsibilities related to documentation will be contained in the project specifications and professional services contracts. Appropriate documentation of training in support of the OPR will be verified as part of the Cx.
- f. Recommendations for recording and archiving of training sessions are provided in Informative Appendix L.
- g. Owner acceptance of Construction Phase training efforts will be facilitated by a request and summary report from the CxP.

## 8.3 Documentation

- a. Updates to the OPR that may be necessitated by Construction Phase training decisions.
- b. An updated training plan.
- c. An updated Systems Manual that includes Construction Phase training artifacts (as per project-specific documentation requirements). Such artifacts may involve various media, such as recordings, slide presentations, CDs, etc.
- d. An issues and resolutions log that tracks training plan deviations.
- e. Training Checklists.
- f. A training summary in the Cx Report.

#### **8.4 Verification**

- a. Verify the success of training conducted during the Construction Phase.
- b. Verify that any need for retraining identified by verification efforts have been successfully met.
- c. Verify the adequacy of the updated training plan to meet the OPR.
- d. Verify reasonable clearance of training-related concerns from the issues and resolution log.
- e. Verify that the OPR has been updated to reflect changes in training expectations (as may be required by project circumstances).
- f. Obtain Owner acceptance of Construction Phase training results.

### **9. OCCUPANCY AND OPERATIONS PHASE**

During the Occupancy and Operations Phase, all training associated with the original Cx, including occupant training and deferred training (as may be required by project circumstances), will be completed; this excludes Ongoing Cx (OCx) efforts. At the end of the Occupancy and Operations Phase, all requirements of the training plan will be successfully completed (including documentation, verification, and acceptance by the Owner). If OCx is requested by or proposed to the Owner, a draft training plan for the period of the OCx contract will be prepared (normally this is handled independently of the original Cx contract).

#### **9.1 Training Requirements**

- a. Complete all aspects of training as described in the training plan; at a minimum, this will include training on the operation and maintenance of commissioned systems, equipment, and assemblies, and on the use and updating of the Systems Manual.
- b. Verify the success of training activities using the metrics and procedures described in the training plan. Enter identified training deviations in the issues and resolution log.
- c. Complete any retraining necessitated by verification findings.
- d. Document training activities and results as per the training plan.
- e. Obtain Owner acceptance of Occupancy and Operations Phase Cx training activities and results.

#### **9.2 Implementation Guidance**

- a. Training to be conducted by the contractor, trade contractors, and product manufacturers/suppliers will be governed by the project specifications (both general and specific) developed during the Design Phase. Clear training specifications are crucial to successful training.
- b. Training to be conducted by entities not bound by the construction documents, such as the Design Team or CxP, will be governed by provisions of professional services contracts developed prior to the Design Phase. Such contractual agreements should address both Construction Phase and Occupancy and Operations Phase training requirements.
- c. The success of training activities should be verified against the OPR. Training checklists can facilitate such verification.
- d. The project specifications will provide success benchmarks for training efforts. These benchmarks are the basis for verification of training conducted during the Occupancy and Operations Phase. Remedial actions (such as retraining) that are triggered by failure to comply with verification standards are also provided by the project specifications. Verification may involve sampling as prescribed and permitted by the Cx Plan.
- e. The documentation of Occupancy and Operations Phase training activities and outcomes in a final training plan, Systems Manual, and/or Final Cx Report will be as described in the training plan and/or Cx Plan. Roles and responsibilities related to this documentation will be described in the project specifications and professional services contracts. Appropriate documentation of training will be verified as part of the Cx.
- f. Owner acceptance of Occupancy and Operations Phase training efforts will be facilitated by a summary report from the CxP.

#### **9.3 Documentation**

- a. Updates to the OPR or CFR that may be necessitated by changes in thinking about training that occur during the Occupancy and Operations Phase.

- b. An updated and final training plan.
- c. A training section in the final Cx Plan (as per project-specific documentation requirements).
- d. An updated Systems Manual that includes Occupancy and Operations Phase training artifacts (as per project-specific documentation requirements).
- e. An issues and resolution log that tracks training plan deviations.

#### **9.4 Verification**

- a. Verify the success of training conducted during this project phase.
- b. Verify that retraining needs identified by verification have been successfully met.
- c. Verify the adequacy of the final training plan.
- d. Verify reasonable clearance of training-related concerns from the issues and resolution log.
- e. Verify that the OPR has been updated to reflect changes in training expectations (as may be required by project circumstances).
- f. Obtain Owner acceptance of Occupancy and Operations Phase training results.

### **10. ONGOING COMMISSIONING PROCESS**

The objective of Ongoing Cx (OCx) is to extend the benefits of the Cx into the life of a project beyond the end of the original Cx contract (which commonly terminates roughly one year after first occupancy). OCx will facilitate persistence of project performance (and may target continuous improvement in project performance as technologies and materials evolve) by expanding on defined building performance metrics developed during the original Cx. Conducting on OCx requires the development of an OCx Plan, which will include an element titled “Training Plan”. This training plan will describe an anticipated schedule and budget for Cx-based training that will ensure that the performance of commissioned systems does not degrade over time. Retraining; training on new systems, equipment, or assemblies; and training on new procedures may constitute the primary focus of OCx training, which will be documented, verified, and accepted. Training under OCx may or may not involve construction specifications (depending upon the nature of project changes over time); thus, a clear statement of training expectations is important for all involved with procuring, delivering, and verifying such training.

### **11. EXISTING BUILDINGS—OTHER THAN ONGOING COMMISSIONING**

Continuation of the Cx into the life of a building without a substantial break in the process is termed “Ongoing Cx (OCx)” and is described in Section 10. If a building (or system) that was previously commissioned undergoes a substantive gap in Cx service or if the Cx is applied to a building that was never previously commissioned, the process is termed “Existing Building Cx (EBCx)” and is outlined in ANSI/ASHRAE Standard 230<sup>3</sup> and ASHRAE Guideline 0.2<sup>4</sup>.

The outcome of training in an existing building context is a well-prepared staff that can operate the commissioned building systems in a manner that will accomplish the Owner’s expectations for building performance. Other than the specific references to contracts, specifications, and the Construction Team, the flow of information for existing buildings may follow the same approach outlined in this guideline for new construction. This will involve process steps that are conceptually similar to those required by new building Cx, namely the development of Owner’s Project Requirements (referred to as Current Facility Requirements [CFR] in the context of an existing building), development of an understanding of the training necessary to meet such requirements (including a needs assessment), preparation of a training program with clear success metrics, validation of successful training, documentation of training results and materials, and acceptance by the Owner of major training outcomes.

### **12. REFERENCES**

1. ASHRAE. 2019. ASHRAE Guideline 0, *The Commissioning Process for New Buildings and New Systems*. Peachtree Corners, GA: ASHRAE.
2. ASHRAE. 2024. ANSI/ASHRAE/IES Standard 202, *The Commissioning Process for New Buildings and New Systems*. Peachtree Corners, GA: ASHRAE.


3. ASHRAE. 2022. ANSI/ASHRAE Standard 230, *The Commissioning Process for Existing Buildings and Systems*. Peachtree Corners, GA: ASHRAE.
4. ASHRAE. 2015. ASHRAE Guideline 0.2, *The Commissioning Process for Existing Systems and Assemblies*. Peachtree Corners, GA: ASHRAE.

**(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)**

## INFORMATIVE APPENDIX A—TRAINING FLOWCHART

Informative Appendix A provides a graphical representation of key training efforts within the structure of the Cx described in ASHRAE Guideline 0.1<sup>1</sup> and ASHRAE Guideline 0.2<sup>4</sup>. This flowchart does not depict the entirety of training as a part of the Cx.

Project Acquisition Phase	Training Focus	Summary Description
PRE-DESIGN	Needs assessment	Conduct preliminary needs assessment for training.
	Owner’s Project Requirements (OPR)	Address sense of training expectations in the OPR.
	Cx Plan	Include training elements in the Cx Plan.
DESIGN	Needs assessment	Conduct a more fully informed needs assessment.
	OPR	Update training expectations/requirements in the OPR.
	Expand training in Cx Plan	Fully address training activities in the Cx Plan.
	Basis of Design (BoD)	Consider training implications when developing the BoD.
	Checklists/test protocols	Include training elements in checklists/test protocols.
	Systems Manual	Consider training aspects in Systems Manual development.
CONSTRUCTION	Specifications	Include training requirements in project specifications.
	OPR and Cx Plan	Update (as necessary) training aspects of OPR and Cx Plan.
	Checklists/test protocols	Place training in checklists and test protocols (as appropriate).
	Training	Conduct training as per the Cx/training plan.
	Verification	Verify success of training in supporting the OPR.
	Issues and resolution log	Track training deviations and resolutions (as necessary)
Systems Manual	Incorporate training materials into Systems Manual per OPR.	

Project Acquisition Phase	Training Focus	Summary Description
	OPR and Cx Plan	Update (as necessary) training aspects of OPR and Cx Plan.
	Training	Conduct training as per the Cx/training plan
	Verification	Verify success of training in supporting the OPR.
	Issues and resolution log	Track training deviations and resolutions (as necessary).
	Systems Manual	Incorporate training materials into Systems Manual per OPR.
	Final Cx Report	Summarize training efforts for Owner.



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## INFORMATIVE APPENDIX B—TRAINING DOCUMENTATION AND VERIFICATION MATRIX

Informative Appendix B provides a summary of key documentation and verification activities related to Cx training under ASHRAE Guideline 0<sup>1</sup> and ASHRAE Guideline 0.2<sup>4</sup>.

Project Phase	Documentation Related to Training	Verification Related to Training
<b>Pre-design</b>	<b>Needs Assessment:</b> Conducted to broadly ascertain training context.	Confirm that a preliminary training needs assessment has informed the OPR.
	<b>Owner’s Project Requirements (OPR):</b> Training needs are addressed in the OPR.	Confirm that training is appropriately dealt with in the OPR.
	<b>Cx Plan:</b> training scope, schedule, budget, and responsibilities are addressed in the Cx Plan	Confirm that training expectations as expressed in the OPR are reflected in the Cx or training plan.
	<b>Training Plan:</b> When warranted by project scale or complexity, training may be addressed in a stand-alone document (training plan) that addresses scope, schedule, budget, and responsibilities.	
	<b>Cx Reports:</b> Include training efforts in reports.	Confirm that process reports include appropriate information on training efforts and activities.
<b>Design</b>	<b>Needs Assessment:</b> Refine preliminary assessment report to better address increased knowledge of project direction.	Confirm that a refined training needs assessment has been conducted.
	<b>OPR:</b> Update training needs in the OPR as necessary.	Confirm that training is appropriately dealt with in the OPR.
	<b>Cx or Training Plan:</b> Update training scope, schedule, budget, and responsibilities in the plan to provide more detail on Construction Phase.	Confirm that training expectations as expressed in the OPR are reflected in the Cx or training plan.
	<b>Basis of Design (BoD):</b> Update training scope, schedule, budget, and responsibilities in the plan to provide more detail on Construction Phase.	Confirm that training expectations as expressed in the OPR are reflected in the Cx or training plan.
	<b>Checklists and Test Protocols:</b> Consider training when developing these verification tools; testing may provide on-site training opportunities.	Consider whether Cx testing activities have been included in training planning (as appropriate to project and OPR).
	<b>Systems Manual:</b> This document will both be used in training and be the subject of training.	Confirm that training elements are included in the Systems Manual and that training on use of the Systems Manual is part of the Cx Plan (as appropriate to the OPR).
	<b>Specifications:</b> Any training to be conducted by the contractor (and/or trade contractors) should be clearly called out in the project specifications.	Confirm that specifications address training in a manner consistent with the OPR; typically done by a sampling-based review.

<b>Project Phase</b>	<b>Documentation Related to Training</b>	<b>Verification Related to Training</b>
	<b>Issues and Resolution Log:</b> Use the issues and resolution log to document and resolve any training deviations encountered during the Design Phase.	Confirm that any identified training issues are resolved in a timely manner.
	<b>Cx Reports:</b> Include training efforts in reports.	Confirm that process reports include appropriate information on training efforts and activities.
<b>Construction</b>	<b>Owner’s Project Requirements (OPR):</b> Update relative to training as necessary.	Confirm that training needs addressed in the OPR reflect current project direction.
	<b>Cx or Training Plan:</b> Update training scope, schedule, budget, and responsibilities in the plan to provide more detail on Occupancy and Operations Phase; conduct Construction Phase training if any.	Confirm that training expectations in the current OPR are reflected in the Cx or training plan.
	<b>Checklists and Test Protocols:</b> Implement any training activities associated with these verification tools.	Confirm that training activities associated with checklists and test protocols have been appropriately conducted.
	<b>Systems Manual:</b> Incorporate training materials and use for training per Cx Plan.	Confirm that training records are included in the Systems Manual and that training on use of the Systems Manual has been conducted to support OPR.
	<b>Issues Log:</b> Use the issues and resolution log to document and resolve any training deviations encountered during the Construction Phase.	Confirm that any identified training issues are resolved in a timely manner.
	<b>Cx Reports:</b> Include training efforts in reports.	Confirm that process reports include appropriate information on training efforts and activities.
<b>Occupancy and Operations</b>	<b>OPR:</b> Update relative to training as necessary.	Confirm that training needs addressed in the OPR reflect current project direction.
	<b>Cx or Training Plan:</b> Update relative to training as necessary.	Confirm that current OPR training expectations are reflected in the Cx or training plan.
	<b>Checklists and Test Protocols:</b> Implement any training activities associated with these verification tools.	Confirm that training activities associated with checklists and test protocols have been conducted to support OPR.
	<b>Systems Manual:</b> Incorporate training materials and use for training per Cx Plan.	Confirm that training records are included in the Systems Manual and that training on use of the Systems Manual has been conducted to support OPR.
	<b>Issues Log:</b> Use the issues and resolution log to document and resolve any training deviations encountered during the Occupancy and Operations Phase.	Confirm that any identified training issues are resolved in a timely manner.
	<b>Cx Final Report:</b> Include training efforts in report.	Confirm that process report includes appropriate information on training efforts and activities.

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## **INFORMATIVE APPENDIX C—GENERAL TRAINING RESOURCES**

This appendix provides several resources that may provide useful guidance for the training that is conducted as part of the Cx.

### **General Industry Training**

<https://www.trainingindustry.com>

### **Training Magazine**

<https://trainingmag.com>

### **Training Best Practices and Organizational Success**

<http://www.trainingindustry.com/content-development/articles/training-best-practices-and-organizational-success.aspx>

### **Best Practices in Training Adults**

[https://outreach.wikimedia.org/wiki/Best\\_practices\\_in\\_training\\_adults](https://outreach.wikimedia.org/wiki/Best_practices_in_training_adults)

### **Three Types of Training Needs Assessments (and when to use them)**

<http://www.apsiconsult.com/3-types-training-needs-assessments>

### **Needs Assessment**

[https://en.wikipedia.org/wiki/Needs\\_assessment](https://en.wikipedia.org/wiki/Needs_assessment)

### **HVAC System Inspection and Maintenance Standard**

ANSI/ASHRAE/ACCA Standard 180, *Standard Practice for Inspection and Maintenance of Commercial-Building HVAC Systems*

### **Operations and Maintenance Guideline**

ASHRAE Guideline 32, *Management for Sustainable, High-Performance Operations & Maintenance*

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## **INFORMATIVE APPENDIX D—NEEDS ASSESSMENT STRUCTURE**

This appendix provides a suggested approach to structuring a needs assessment for the training that is associated with the Cx.

### **NEEDS ASSESSMENT FOR Cx TRAINING**

On most commissioned projects, a fair amount of time and money will be devoted to training in response to the requirements of ASHRAE Guideline 0<sup>1</sup> (and/or ANSI/ASHRAE/IES Standard 202<sup>2</sup>). Without a solid needs assessment, this investment in training resources may be misdirected. Equally undesirable, the opportunity for training afforded by the Cx may be incompletely implemented, thereby reducing project performance (including persistence).

A needs assessment for the training elements of the Cx is conducted as an organized analysis to determine who needs to be trained on what as a means of increasing the likelihood of success in achieving the OPR for a given project. At a minimum, training needs should be assessed during the Predesign Phase and the Design Phase. Training that responds to the findings of the needs assessment process is normally delivered during the Construction Phase and the Occupancy and Operations Phase.

The benefits of a training-focused needs assessment typically include the following:

- a. A better understanding of the role of training in delivering the OPR
- b. Improved likelihood that training design will respond to project needs
- c. Development of a clear focus for training activities
- d. Identification of gaps between desired O&M staff and user knowledge/capabilities and actual knowledge/capabilities
- e. Improved ability to match training to trainees
- f. Development of a basis for verification of training activities
- g. Better structure for the project training plan

A Cx-based needs assessment will generally consider three distinct realms of analysis:

- a. Project level, where the big-picture of project context and outcomes is considered relative to the ability of training to improve these outcomes.
- b. Systems and assemblies level, where unique, unusual, and/or particularly demanding requirements for knowledgeable O&M staff and/or users are connected to successful outcomes.
- c. Individual level, where the knowledge and skills required to operate, maintain, and use project elements should be conveyed to those with day-to-day responsibility or involvement with the systems.

The training needs for a project may be ascertained via any number of methods. Selection of appropriate methods will be project-specific. Potential methods include the following:

- a. **Observations.** In existing facilities that are similar to a proposed project, the performance of O&M personnel and/or users can be seen and informally matched to expectations for new project operations; the same is true for building performance (relative to energy, comfort conditions, unscheduled downtime, user complaints, etc.).
- b. **Interviews.** Where personnel or users (of an existing facility or similar project) are available, they can be interviewed to determine what training they would find useful or critical for success in the proposed project context; interviews allow for a free flow of ideas (which can be a positive or a negative)
- c. **Questionnaires.** As with interviews, but with a preestablished scope and flow, questionnaires can be used where interviews might be difficult (as with distant facilities where access is restricted, or where the number of people involved makes one-on-one interviews too time consuming)
- d. **Review of Job Descriptions.** Job descriptions for current or similar personnel can be compared to expectations for the new project. This may identify gaps between current and proposed performance capabilities.
- e. **Testing.** Nonthreatening testing of personnel may identify differences between current knowledge and desired

knowledge.

- f. **Review of Best Practices.** Research into best training practices can shed light on identifying training needs.
- g. **Development of the OPR Document.** An understanding of Owner expectations for a project can be very informative relative to the necessary capabilities of project staff and users.

This appendix suggests two means of organizing information about training needs: narratives and matrices.

**Predesign Narrative.** Briefly describe how this project differs in terms of performance expectations and likely systems and assemblies from a typical project with which O&M staff and occupants/users would be familiar. Note any specialized operational considerations (such as LEED certification, utility incentives, occupant controllability, etc.).

**Predesign Needs Matrix.** See Table D-1 for an example.

**Design Phase Narrative.** Briefly describe any systems, equipment, or assemblies that warrant particular attention during training activities due to their uniqueness, operational fragility, mission criticality, reliability track record, etc.

**Design Phase Needs Matrix:** See Table D-2 for an example.

**TABLE D-1 Predesign Phase Training Expectations Matrix**

<b>O&amp;M is expected to be handled primarily by &gt;&gt;</b>	<b>Inhouse staff</b>	<b>Contract staff</b>	<b>Combination of these</b>
<b>Nonstaff who are expected to be involved in building operations &gt;&gt;</b>	<b>Residents</b>	<b>Occupants</b>	<b>Visitors</b>

<b>System Or Assembly</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>
	Big-Picture Context	Performance Expectations	Unusual Features	Normal Operations Awareness	Emergency Operations Awareness	Systems Integration Awareness	Other
Project Aspirations							
Project Performance Goals							
Enclosures							
HVAC							
Electrical							
Fire Protection							
Plumbing							
Other							



**TABLE D-2 Design Phase Training Expectations Matrix**

<b>O&amp;M is expected to be handled primarily by &gt;&gt;</b>	<b>Inhouse staff</b>	<b>Contract staff</b>	<b>Combination of these</b>
<b>Nonstaff who are expected to be involved in building operations &gt;&gt;</b>	<b>Residents</b>	<b>Occupants</b>	<b>Visitors</b>

<b>System Or Assembly</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>	<b>Who Should Be Trained</b>
	Big-Picture Context	Performance Expectations	Unusual Features	Normal Operations	Emergency Operations	Systems Integration Considerations	Other
Project Aspirations							
Enclosures							
Roof							
Walls							
Fenestration							
HVAC							
Chillers							
Boilers							
AHUs							
Pumps							
VAV Boxes							
Controls							
Other Systems							

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## **INFORMATIVE APPENDIX E—TRAINING IN THE OWNER’S PROJECT REQUIREMENTS (OPR)**

Informative Appendix E provides an example of the type of information regarding training that should generally be included in the OPR.

The purpose of the OPR is to generally define outcomes that an Owner will consider successful for his/her project. Selecting specific means of accomplishing these desirable outcomes is the job of the design team. In the case of Cx training, it is likely that the CxP will also play a role in selecting appropriate training elements.

### **Training as Part of the Cx**

The objective of Cx training for this project is to ensure the safe operation and maintenance of laboratory equipment and systems on a day-to-day basis; to ensure operational compliance with all applicable regulations; and to, over time, maintain the listed systems in an operating condition close to that experienced at substantial completion.

Onsite training for the operators/maintainers and users/occupants should include a description and overview of systems, not just of the components and equipment that comprise each system. Training held in conjunction with Cx should include general orientation and reviews of the written O&M instructions, relevant health and safety issues or concerns, operation in all possible modes, preventive maintenance, and common troubleshooting problems and solutions.

Building systems on which the operations/maintenance entity should be trained include the following:

- a. HVAC systems
- b. Building automation systems (BAS)/controls
- c. Electrical systems
- d. Lighting controls
- e. Security systems
- f. Fume hoods and biosafety cabinets
- g. Cleanroom operations and systems

Building systems that the occupants/users should be trained on include the following:

- a. Lighting controls
- b. Cleanroom operations and systems

Most training should be completed prior to substantial completion, and all sessions should be videotaped and converted to DVD format (compatible with Owner’s computer systems) for the Owner’s ongoing use.

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## **INFORMATIVE APPENDIX F—TRAINING PLAN**

Informative Appendix F provides a sample training plan, developed for an actual project, as an example of the scope and content of this document.

The training plan evolves over the life of the Cx. As each subsequent phase of project acquisition nears, the training plan will be updated to clearly address the upcoming phase as well as provide a somewhat more detailed outline of training anticipated in later project phases.

### **F1. TRAINING PLAN**

**F1.1 General.** This is a preliminary training plan that will be developed in greater detail as design progresses and as contract documents are developed. The Cx Plan schedule will indicate in detail how training will be sequenced, including the duration of each training session.

**F1.2 Development of the Training Plan.** The final training plan should be complete either (select one)

- a. no more than three months after award of Contract or
- b. before the construction contract work is 50% complete.

**F1.3 Responsibilities.** The designer will be responsible for development of training and will monitor all training activities, including the following:

- a. Preparation of agenda and outlines
- b. Videorecording of all sessions

The contractor will be responsible for implementation of training activities, quality of instruction and training materials, and for coordination of the instructors.

**F1.4 Instructors.** Instructors and trainers will include the designer, contractor, factory-trained and certified equipment suppliers and manufacturers, factory-trained and certified maintenance specialist personnel, and the service contractors holding service contracts for the following:

- a. Energy management control system (EMCS), including fume hood and similar controls
- b. Fire alarm systems and emergency systems
- c. Security systems
- d. Lighting control systems
- e. Elevators
- f. Other service contracts that may be implemented during this project

**F1.5 Trainees.** Trainees will include the property manager, building operators, maintenance staff, security staff, technical specialists as necessary, and facility occupants as necessary.

The following is a list of O&M personnel, property management staff, and others requiring requisite training. The CxP will coordinate their attendance at agreed-upon times.

- a. Facility property manager
- b. Operating staff (building operators)
- c. Maintenance staff (TBD)
- d. Building maintenance staff
- e. Service contractors (e.g., cleaning)
- f. Security staff

**F1.6 Prerequisite skills and qualifications.** To be identified.

**F1.7 Scheduling of Training.** Training sessions relating to the design philosophy are to be given by the designer and should be presented no more than three months after award of the construction contract. This will permit

all involved in the construction and future operation of this facility to become familiar with all aspects of the design philosophy. If the O&M personnel have not been identified or are not available at this time, these sessions will be repeated during the contractor-led training sessions. All training will be completed prior to issuance of the interim certificate.

**F1.8 Details of Training.** Training will meet all identified qualification requirements of installed equipment and systems. Training will include the following:

- a. All aspects of operation under all normal, emergency, and what-if modes, over the full range of operating potentials
- b. Detailed maintenance; troubleshooting; regular, preventive, and emergency maintenance

Training will consist of the following elements to be completed with demonstration of completeness before date of acceptance:

- a. Random on-site familiarization and observations during construction
- b. Installation, layout of equipment, systems, and components
- c. Start-up and testing of the work
- d. Access to approved shop drawings and equipment O&M data
- e. Hands-on instruction relating to start-up, shut-down, and emergency procedures
- f. Features of controls, monitoring, servicing, maintenance
- g. Performance verification and commissioning
- h. Reasons for and results related to associated systems of adjustment of set points of control, limit, and safety devices
- i. Interaction among systems during integrated operation
- j. Troubleshooting diagnostics
- k. Formal classroom sessions relating to functional and operational requirements, system philosophy, limitations of each system, and operation and use of Systems Manual

Other elements will include system operating sequences; step-by-step directions for operation of valves, dampers, and switches; adjustment of control settings; and other specialized training relating to installed systems. Duration will be as specified in the Cx specifications. On-site observations will include still-photo records, particularly of concealed elements, as deemed necessary by the O&M personnel.

Training sessions on design philosophy organized around the Systems Manual will include the following:

- a. Overview of how each system is intended to operate
- b. Description of design parameters and operating requirements
- c. Description of operating strategies
- d. Information to assist in troubleshooting system operating problems

**F1.9 Training materials.** Training materials will be in a form permitting future training to be provided in the same degree of detail and will include at least the following:

- a. As-built contract documents
- b. Systems Manual
- c. Testing, adjusting, and balancing reports
- d. Searchable PDFs of all training presentations
- e. Manufacturers' training videos (after prior screening for suitability)
- f. Equipment models

The number of hours for these training sessions will be identified by equipment, systems, etc.

**F1.10 Videorecording.** Hands-on and classroom sessions will be recorded for future reference and retraining; sessions being recorded will be held only after all systems have been fully commissioned. Production will be of professional quality and organized into several short modules to permit incorporation of changes. Recording

format will be specified in advance.

**F1.11 Standard of training:** Training will be in sufficient detail and of sufficient duration to ensure the following:

- a. Safe, reliable, cost-effective, energy-efficient operation of all systems in normal and emergency modes and under all conditions
- b. Effective ongoing inspection and measurement of system performance
- c. Proper preventive maintenance diagnosis and troubleshooting
- d. Ability to update documentation
- e. Ability to operate equipment and systems under emergency conditions until appropriate qualified assistance arrives

**F1.12 Limitations.** Long-term, ongoing training will not be included. However, the training courses and training materials will be archived to permit further ongoing training as well as training of new personnel.

**F1.13 Demonstrations.** Training will include demonstrations by the trained personnel of their depth of understanding and confidence operating all installed systems and equipment.

**F1.14 Manufacturers' Training Materials.** These may be used as a training tool only after the engineer's review and written approval (to occur at least three months prior to static completion).

All training benchmarks will be included in the construction and completion schedules.

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## **INFORMATIVE APPENDIX G—BUDGETING FOR TRAINING**

Informative Appendix G provides recommendations for elements to consider when developing a budget for training that is conducted as part of the Cx.

### **Elements to Consider During the Budget Development Process**

#### **Professional Services**

- Training planning
- Trainers
- Video recording
- Archiving
- Travel expenses

#### **Owner Staff Time**

- Pretesting
- Project objectives (Owner’s Project Requirements) training
- Operations and maintenance training
- Vendor-provided training
- Specialized training
- Post testing
- Archiving
- Travel expenses

#### **Occupant Staff Time**

- Systems functions
- User/occupant adjustable systems elements

#### **Space**

- Preparation space
- Training rooms
- Storage for materials

#### **Equipment Rental**

- Video/digital recording
- Specialty equipment
- Safety equipment (durable)
- Software

#### **Materials**

- Binders
- Reproduction
- Digital media storage
- Safety equipment (consumable)
- Other consumables



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## **INFORMATIVE APPENDIX H—TRAINING INSTRUCTOR QUALIFICATIONS**

Informative Appendix H provides guidance on basic principles to consider when selecting a training instructor. The essential questions are as follows:

- a. Is the person knowledgeable in the specific technical area for which training is required?
- b. Can the person communicate his/her knowledge successfully to the intended audience?

### **Training Instructor Qualifications**

The training instructor is a very important part of the overall training process. Ideally, training instructors are familiar with the specific project and experienced with the application of the system, subsystem, or component in question. It is also very important that technical instructors can communicate their overall message effectively to the audience.

Some examples of instructor roles and appropriate qualifications are as follows:

- a. **Mechanical Systems Information.** The lead mechanical engineer for the project should be well versed in the Basis of Design (BoD) and any modifications made during the installation, start up, and verification of the specific equipment, system, or project. Ideal training qualifications for this person would include technical expertise and experience in engineering similar systems or equipment and previous experience in training an operations team.
- b. **Electrical Systems Information.** The lead electrical engineer for the project should be well versed in the BoD and any modifications made during the installation, start up, and verification of the specific equipment, system, or project. Ideal training qualifications for this person would include technical expertise and experience in engineering similar systems or equipment and previous experience in training an operations team.
- c. **Control Systems Information.** The lead controls programmer should be well versed in all aspects of the systems management programming for the specific application or project. This would include an understanding of the interfaces, navigation, trending, alarming, and the sequence of operation as actually programmed in the systems. Ideal qualifications for this person would include technical expertise with the automation platform and previous experience in training an operations team.
- d. **Systems Overview Information.** The lead CxP should be well versed in the operation and performance of the commissioned systems specific to the application or project. Ideal training qualifications for this person would include technical expertise and experience in Cx of similar systems or equipment and previous experience in training an operations team.
- e. **Specific Applications Information.** The vendor/contractor start-up technicians should be well versed in the specific application of the equipment to the systems and subsystems of the specific project. Ideal training qualifications for this person would include technical expertise and experience in the start-up and operation of similar systems or equipment and previous experience in training an operations team.

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## **INFORMATIVE APPENDIX I—GENERAL TRAINING SPECIFICATIONS**

Informative Appendix I provides a sample specification that addresses the training aspects of the Cx for a fairly large project.

### **SECTION 017900 DEMONSTRATION AND TRAINING**

#### **PART 1 - GENERAL**

##### **1.1 SUMMARY**

- A. Related Documents
  - 1. Drawings and general provisions of the Subcontract apply to this section.
  - 2. Review these documents for coordination with additional requirements and information that apply to work under this section.
- B. Section Includes
  - 1. The University's facility staff (and occupants and service trade contractors as needed) shall receive orientation and training on features, systems, and equipment in this facility requisite with the complexity and criticality of the system and the University's needs.

##### **1.2 EQUIPMENT-SPECIFIC REQUIREMENTS**

- A. Additional training requirements may be found in specific equipment sections.

#### **PART 2 - PRODUCTS**

##### **2.1 VIDEO RECORDING**

- A. The trade contractors shall video record selected trainings, including audio, according to the following schedule:
  - 1. HVAC and controls: 10 hours
  - 2. Plumbing: 2 hours
  - 3. Electrical: 4 hours
  - 4. Special: 2 hours
- B. Which portions of which training sessions are video recorded shall be at the discretion of the CxP and the University.
- C. An introduction shall be made at the beginning of each recording identifying what equipment is being illustrated, where it is located, and who the trainer is.
- D. Recording shall be accomplished with a tripod when possible and performed in an expert manner so that the issues being discussed are clearly illustrated and instructions are clearly audible. A high-quality camera shall be used and additional light provided if ambient light is insufficient.
- E. Media shall be clearly labeled with the equipment, date, trainer, and segment duration.
- F. Recording shall be in video tape format.
  - 1. For larger equipment, not more than one training session shall be put on a single tape. Not more than three pieces of equipment shall be on any single tape, even if the tape is not filled. Small camera-sized tapes are acceptable as the final submittal if a standard VHS adapter tape is provided.
- G. Provide an alternate price for digital recording.
  - 1. The digital recording shall be bookmarked at each training with an index/table of contents provided and recorded on the CD. The bookmarks will clearly indicate which equipment is being presented, and the format will allow search and go-to functions for rapidly locating training segments.
- H. An original and one copy of the recordings shall be submitted to the University.

## **PART 3 - EXECUTION**

### **3.1 GENERAL RESPONSIBILITIES**

- A. The trade contractor shall be responsible for training coordination and scheduling and ultimately for ensuring that training is completed on all equipment per the Specifications.
- B. The CxP will be responsible for coordinating and approving the content and adequacy of the training of University personnel for commissioned equipment.
  1. The CxP will develop an overall training plan after meeting with the University and appropriate facility staff to determine needs and areas of emphasis for this project.
  2. The CxP will develop criteria for determining that the training was satisfactorily completed, including attending some of the training, etc. The CxP recommends approval of the training to the University Project Manager.
  3. At one of the training sessions, the CxP will present a brief presentation discussing the use of the Systems Manual and the blank functional test forms for recommissioning equipment.
- C. Training, as needed and at the discretion of the University and Cx Provider, shall consist of the installing technician, installing trade contractor, and the appropriate trade or manufacturer's representative on each major piece of equipment. Practical building operating expertise and in-depth knowledge of all modes of operation for the specific piece of equipment, as installed in this project, are required. More than one party will be required to execute the training on primary equipment.
- D. The controls trade contractor, as requested, shall attend and present at sessions in addition to the controls training to discuss the interaction of the controls system as it relates to the equipment being discussed.
- E. The mechanical and electrical design engineer and architect or the Cx Provider may attend the first training session for each of the main or special systems and assemblies and present the overall system design. This presentation will include a review of all systems using the simplified system schematics (one-line drawings).
- F. Unless otherwise required or approved, the training shall be conducted during regular business hours during a regular work week.

### **3.2 TRAINING AGENDAS**

- A. For each piece of equipment or system, a written training agenda will be provided by the Cx Provider for use by the trade contractor. The generic agenda has been provided for typical equipment at the end of this section. A similar but more in-depth agenda will be provided for the controls system prior to training. The agenda shall cover the following elements:
  1. Equipment (included in training)
  2. Intended audience
  3. Location of training
  4. Objectives
  5. Subjects covered (description, duration of discussion, special methods, etc.)
  6. Duration of training on each subject
  7. Instructor for each subject
  8. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)
  9. Instructor and qualifications

### **3.3 TRAINING PROCESS AND CONTENT**

- A. The Training Process
  1. The training process shall normally begin with classroom type sessions followed by hands-on training for each piece of equipment that shall illustrate the various modes of operation, including start up, shutdown, fire/smoke alarm, power failure, etc.
  2. During any demonstration, should the system fail to perform in accordance with the requirements of the operation and maintenance (O&M) manuals or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
  3. The training process shall follow the outline in the table of contents of the O&M manual and illustrate

whenever possible the use of the O&M manuals for reference.

B. Training Shall Include the Following

1. Use of the printed installation, operation, and maintenance instruction material included in the O&M manuals.
2. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed, and spare-parts inventory suggestions. The training shall include start up, operation in all modes possible, shutdown, seasonal changeover as applicable, and any emergency procedures.
3. The mechanical trade contractor shall fully explain and demonstrate the operation, function, and overrides of any local packaged controls not controlled by the central control system.
4. Discussion of relevant health and safety issues and concerns.
5. Discussion of warranties and guarantees.
6. Common troubleshooting and maintenance issues, problems, and solutions.
7. Explanatory information included in the O&M manuals and the location of all related plans and manuals in the facility.
8. Discussion of any peculiarities of equipment installation or operation.
9. The format and training agenda in ASHRAE Guideline 1.1 is recommended, as applicable.
10. Hands-on training shall include start up, operation in all modes possible (including manual), shutdown, and any emergency procedures and preventative maintenance for all pieces of equipment.
11. Training shall occur after functional testing and piping and equipment labeling are complete unless approved otherwise by the University Project Manager.

3.4 DURATION OF TRAINING

A. The trade contractor shall provide training on each piece of equipment according to the following schedule. The trade contractor shall provide training and orientation for other equipment installed on the project not listed here.

B. Training Schedule	Hours
<i>Mechanical Support Systems</i>	
Chilled water system (chiller, cooling tower, piping, pumps)	3
Treated water system (pumps, heat exchanger)	3
Heating water system (boiler, piping, pumps)	2
Air-handling units	2
Water-cooled AC units	1
Restroom exhaust system	0.5
Miscellaneous exhaust fans	0.5
<i>Lab and Cleanroom Mechanical</i>	
Lab air handlers	1
Cleanroom air handler	1
Fan filter units (cleanroom)	1
Process exhaust system	1
Fume hoods	1
Air terminal boxes	1
Snorkel exhaust devices	1
Biosafety cabinets	1
Miscellaneous exhausted safety cabinets	1
Split AC unit (cold rooms)	1
<i>Lab and Cleanroom Process</i>	
DI/hot DI water system	1

Acid/Base waste neutralization and bulk neutralization chemicals	0
Solvent waste collection	0
Metals waste collection	0
Bulk gases storage and delivery (Argon, etc.)	1
High-purity specialty gas storage and delivery	0.5
Process vacuum	1
Oil-free compressed dry air (CDA) and process CDA (with air dryer)	1
Biowaste sterilization	0
Biomedia preparation	0
Bioglassware cleaning	0
<i>Plumbing</i>	
Domestic water system	2
Domestic water-heating system (with accessories)	2
Sump pumps	1
Fire protection	2
Emergency eyewashes and safety showers	1
<i>Electrical</i>	
Wiring devices (switches and outlets)	0.5
Lighting controls	2
Variable-frequency drives	4
Transformers	1
Motor control centers	4
Switchgear	1
Ground fault and secondary grounding	1
Emergency power generator system and ATS	2
Fire alarm	4
<i>Special Systems</i>	
Elevators	2

### 3.5 SPECIAL RESPONSIBILITIES

- A. HVAC Controls: The trade contractor shall have the following special training responsibilities relative to the HVAC control systems:
1. For the primary HVAC equipment, the controls trade contractor shall provide a short discussion of the control of the equipment during the mechanical or electrical training conducted by others.
  2. The standard operating manual for the system and any special training manuals shall be provided for and retained by each trainee. In addition, the system technical manual shall be demonstrated during training. Manuals shall include detailed description of the subject matter for each session. The manuals shall cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Manuals will be approved by the Cx Provider.
  3. The trainings will be tailored to the needs and skill-level of the trainees and be oriented to the specific system installed in this project.
  4. The trainers shall be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainers shall be used. The University shall approve the instructor prior to scheduling the training.
  5. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system shall be repaired or adjusted as necessary and the demonstration repeated.
  6. There shall be three training sessions:

- a. Training I—Control System: The number of trainees for Training I shall be eight, and training shall be conducted in two separate sessions of four hours each. This training may be held on-site. Upon completion, each trainee, using appropriate documentation, should be able to perform elementary operations and describe the general hardware architecture and functionality of the system. The Controls trade contractor shall provide three laptops, plus the permanent workstation with network connections and the controls operating system installed and functioning for this building, in the training room for use by the trainees.
  - b. Training II—Building Systems: The second session shall be conducted upon completion of the system commissioning. The number of trainees for Training II shall be 20, and training shall be conducted on site in two separate sessions of 12 hours each. The Controls trade contractor shall provide three laptops, plus the permanent workstation with network connections and the controls operating system installed and functioning for this building, in the training room for use by the trainees. The session shall include instruction on the following:
    - (1) A review of the as-built drawings and O&M manuals; a walkthrough of the facility to identify control panels and device locations.
    - (2) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls, and any interface with security and communication systems.
    - (3) Security levels; alarms; system start up, shutdown, power outage and restart routines; changing set points and alarms and other typical changed parameters; overrides; freeze protection; manual operation of equipment; optional control strategies; energy savings strategies and set points that, if changed, will adversely affect energy consumption; energy accounting; procedures for obtaining vendor assistance, etc.
    - (4) All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically, and printing trends. Trainees will actually set up trends in the presence of the trainer.
    - (5) Every screen shall be completely discussed, allowing time for questions.
    - (6) Use of keypad or plug-in laptop computer at the zone level.
    - (7) Use of remote access to the system via phone lines or networks.
    - (8) Setting up and changing an air terminal unit controller.
    - (9) Graphics generation.
    - (10) Point database entry and modifications.
    - (11) Understanding FMCS field panel operating programming (when applicable).
  - c. Training III—Deferred On-Site: The third training will be conducted on-site six months after occupancy and consist of eight hours of training in one session. The session will be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the systems.
- B. Testing, Adjusting, and Balancing (TAB): The Subcontractor shall have the following special training responsibilities relative to the TAB work:
1. The TAB technician shall meet with facility staff after completion of TAB and instruct them on the following:
    - a. Go over the final TAB report, explaining the layout and meanings of each data type.
    - b. Discuss any outstanding deficient items in control, ducting, or design that may affect the proper delivery of air or water.
    - c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans, and pumps that are close to or are not meeting their design capacity.
    - d. Discuss any temporary settings and steps to finalize them for any University-furnished, University-installed equipment.
    - e. Other salient information that may be useful for facility operations relative to TAB.



**END OF SECTION 017900**

**Source:**

LBNL. 2008. Sample Specification: Section 017900—Demonstration and Training. Lawrence Berkeley National Laboratory, Berkeley, CA. <https://commons.lbl.gov/download/attachments/75501677/01900.doc>

**(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)**

## **INFORMATIVE APPENDIX J—TRAINING CHECKLISTS**

Informative Appendix J provides sample checklists that may be of assistance in planning, conducting, and assessing Cx training.

### **J1. GENERAL TRAINING CHECKLIST**

#### **Predesign Phase**

- a. Training needs assessment
- b. Define types of people being trained
- c. Define types of systems and assemblies to train on
- d. Ensure inclusion in the OPR
- e. Establish training budget/milestone schedule
- f. Determine roles and responsibilities for training plan development
- g. Draft initial training plan

#### **Design Phase**

- a. Further development of training plan
- b. Development of course agendas for each system or assembly
- c. Ensure project specifications include training requirements for vendors/contractors
- d. Engage vendors/contractors as required for development of training materials

#### **Construction Phase**

- a. Finalize training presentations and student materials
- b. Finalize training schedule and verify vendor support as required
- c. Confirm availability of equipment for training sessions
- d. Coordinate recording requirements and delivery of training material
- e. Conduct class attendee course evaluations

#### **Occupancy and Operations Phase**

- a. Confirm training of occupants and of deferred training

**Table J-1 Training Types Checklist**

Topic	Training Type							
	None	Literature	Video	Vendor	Factory	On-Site Manufacturer	Academic Classroom	On-Site Academic
Individual Equipment								
Routine Maintenance								
Simple Repairs								
Major Repairs								
Overhaul								
Systems								
Standard operations								
Emergency operations								
Failure modes								
Future expansion								
Facility								
System interrelations								
OPR training								
Emergency Procedures								
Failure modes								

**Table J-2 Logistics Checklist**

<b>Contributor</b>	<b>Activity</b>	<b>Complete (Y/N)</b>	<b>Additional Topic Information</b>
<b>Client Training Coordinator</b>	<b>Pretraining</b>		
	Confirm training dates		Scheduling required to capture shift workers who will be attending training.
	Submit class roster for all days of training.		Class rosters needed for printing and developing of student handouts and manuals.
	Reach agreement on class agenda, start and stop times, lunch time.		Communicate start times with class attendees one week before training date.
	Reserve access to the training room during setup day and all days of training (7:00AM–5:00PM).		Room needs to be reserved for the entire day for each day of training and should not be interrupted by meetings or video conferences.
	Coordinate access to site equipment to support field walkthroughs.		Ensure no security issues.
	Support coordination of lunch service as needed.		Use of caterer or other service; space for all class participants to each lunch.
	Coordinate on-site IT tech support as required for A/V equipment in training room and live link-up to BMS and PMS.		Typically will need two projectors, Internet access, linkup with BMS system or PMS, as applicable; provide contact phone number for local IT person.
	<b>Day of Training</b>		
	Be on-site at least one hour before scheduled training start time.		Leave enough prep time to deal with any last-minute issues the morning of training.
	Verify that equipment access is available for field walkthroughs.		Confirm with site training coordinator and operations team.
	Provide on-going training logistical support as needed.		Review class schedule, break times, lunch break.
<b>Training Coordinator</b>	<b>Pretraining</b>		
	Finalize class rosters with client.		Scheduling required to capture shift workers
	Upload rosters for each training day on network; share with applicable parties.		Allows easy access to rosters by the client team.
	Confirm training dates with client.		
	Confirm training schedule one week before training is scheduled to begin.		
	Inform instructor team of training dates with enough notice to schedule travel.		
	Have entire team meet at site the day before actual training for classroom and field walkthrough setup.		
	Finalize training presentations with development group.		All should agree the presentation is ready for print.
Perform final technical content review.		Proofread document for spelling and format.	

**Table J-2 Logistics Checklist**

<b>Contributor</b>	<b>Activity</b>	<b>Complete (Y/N)</b>	<b>Additional Topic Information</b>
<b>Training Coordinator</b>	Send final presentations to client for pretraining review.		Coordinate with site training coordinator; may not be required depending on topic.
	Coordinate with administrative group to have presentations printed and shipped to site.		If placing print request with central stores, provide one week for printing and shipping; material to be shipped no later than two days before start of training; confirm delivery with person receiving the books.
	Coordinate with client on lunch service for each day of training.		
	Ship any needed training supplies to site.		May be able to take by car if more convenient; radio headsets for field walkthroughs; extension cords; power strips to charge radios; stapler and three-hole punch; course evaluation and sign-in sheets; collapsible training podium; pens, notepads, laser pointer, remote control for computer; training aids are not available at the site.
	Coordinate camera equipment/shipping with videographer.		See training video guidelines.
	<b>Set-Up Day</b>		
	Check in with client and obtain access to training room.		Confirm that room is reserved all day for each day of training.
	Set up tables as desired in training room.		Horseshoe table pattern has worked well for past training sessions.
	Test dual screen projectors; test all video equipment with computers used during training.		
	Perform test run of all presentations that will be used for training.		Save presentations to desktop so that server access is not needed.
	Set up radio headsets and chargers; charge all radios for training next day.		Use table at back of room for radio storage and charging station; have extra headsets available.
	Check all student manuals for damage caused by shipping.		If manuals are shipped in binders, pages may become loose during shipping.
	Pass out manuals, one for each expected class attendee.		Manuals may be reused during training; instruct each class participant to take notes on separate paper or notepad.
	Set up video capturing equipment.		Camera, tripod, microphones, and lighting; refer to video capturing guidelines document.

**Table J-2 Logistics Checklist**

<b>Contributor</b>	<b>Activity</b>	<b>Complete (Y/N)</b>	<b>Additional Topic Information</b>	
<b>Training Coordinator</b>	Set up field walkthrough.		Verify with site that equipment access is available; tape off access to areas as applicable; perform dry run of field walk-through; remove any trash or debris that will interfere with walk-through and video capturing.	
	Make pens and notepads available for class attendees.		Have a box of pens and several notepads available for those who need them.	
	Confirm that lunch service is scheduled.		Verify day before training with caterer; also recommend verifying again the morning of the first day of training.	
	Stage the training aids that will be used in the classroom during presentation.		Any parts, equipment, etc. that will be used as visual aids.	
	<b>Day of Training</b>			
	Be on-site at least one hour before the scheduled training start time.		Leave enough prep time to deal with any last-minute issues the morning of training.	
	Confirm that equipment access is available for field walkthroughs.		Confirm with site training coordinator and operations team that access is established.	
	Prepare course agenda for review with class (course introduction presentation).		Understand class schedule, break times, lunch break.	
	Set up computers for presentation, and perform final test run of all AV equipment.		Have standby computer available for training; do not rely on battery power for presentation computer.	
	Have instructor team assembled to meet and greet the class attendees 15 minutes before start of training.		Try to meet and get to know each attendee before the training session starts.	
	Have class sign-in sheet and course evaluation forms ready.		Make sure everyone has signed attendance sheet before training is completed each day.	
	Check all radio headsets to ensure they are charged and ready.		Have a few extra sets available; headsets have a high rate of failure or communication issues.	
	Record questions from the class that may be used for future training.		Consider an online shared document host for the Q&A.	
	Have each class attendee complete the course evaluation form.		Use standard evaluation sheet to allow for long-term trending.	
Collect student manuals.		Applicable if hard copies are distributed instead of electronic files.		
Hold internal training team meeting to critique training session.		Review course effectiveness with entire training team.		
Prepare classroom for next day's training.		Clean classroom, set up student handbooks, prepare any visual aids that will be used.		
<b>Post Training</b>				

**Table J-2 Logistics Checklist**

<b>Contributor</b>	<b>Activity</b>	<b>Complete (Y/N)</b>	<b>Additional Topic Information</b>
<b>Training Coordinator</b>	Coordinate with applicable knowledge groups to provide answers for online questions.		All questions should be answered and posted within one week of completion of training.
	Coordinate to have all questions uploaded to online Q&A page.		
	Have final versions of all presentations used during training uploaded to client's server.		Final versions uploaded to client's secure network server in PDF format.
	Package and ship any items that need to be returned (or other location).		Coordinate shipping with site administrative group as needed.
	Properly dispose of all printed training materials.		Printed training manuals should be shredded if they contain any confidential information.
	Compile class attendee course evaluation comments for review by training team.		Scan all evaluation sheets; results should be formatted and shared with instructors and development team.
	Develop lessons-learned item list for review by training team.		List should be formatted and shared with instructors and development team.
	Compile final list of course attendees and share with client.		

**Table J-3 Verification Checklist**

<b>Project Phase</b>	<b>Element to Be Verified for Training Component</b>	<b>Date Completed</b>	<b>Comments</b>
<b>Predesign</b>	Needs Assessment Report		
	Owner's Project Requirements (OPR)		
	Cx/Training Plan		
	Cx Reports		
<b>Design</b>	Needs Assessment Report		
	OPR		
	Cx/Training Plan		
	Systems Manual (development)		
	Contract Documents (specifications)		
	Issues and Resolution Log		
	Cx Reports		
<b>Construction</b>	OPR		
	Cx/Training Plan		
	Training of Targeted Audiences		
	Systems Manual		
	Issues and Resolution Log		
	Cx Report		
<b>Occupancy and Operations</b>	OPR		
	Cx/Training Plan		
	Training of Targeted Audiences		
	Systems Manual		
	Issues and Resolution Log		
	Cx Final Report		



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## **INFORMATIVE APPENDIX K—TRAINING EFFECTIVENESS QUESTIONNAIRE**

Informative Appendix K provides examples of a general evaluation instrument and a topic-specific quiz used to verify the effectiveness of Cx training.

### **K1. SAMPLE TRAINING EVALUATION TOOL—GENERAL RATING OF TRAINING SESSION**

#### **Training Evaluation**

**Session:** \_\_\_\_\_

**Date:** \_\_\_\_\_ **Location:** \_\_\_\_\_

**Purpose:** This form is used to evaluate each training session.

Based upon this evaluation, later sessions can be improved.

Every attendee will fill out one copy of this form.

**Evaluation scale: 1 = very well and 5 = not at all; mark questions that are not applicable with N/A.**

1. How well were the objectives of this training session met?

| 1 | 2 | 3 | 4 | 5 | N/A |

2. Do you know where the components/systems are located?

| 1 | 2 | 3 | 4 | 5 | N/A |

3. Do you know what area the components/systems are serving?

| 1 | 2 | 3 | 4 | 5 | N/A |

4. Do you understand the various types and purpose of these components/systems?

| 1 | 2 | 3 | 4 | 5 | N/A |

5. Do you understand/know how to systematically troubleshoot common problems with these components/systems?

| 1 | 2 | 3 | 4 | 5 | N/A |

6. Do you know how the components/systems operate under all normal modes?

| 1 | 2 | 3 | 4 | 5 | N/A |

7. How well do you understand the importance of meeting the design intent for the systems covered?

| 1 | 2 | 3 | 4 | 5 | N/A |

8. Are you able to efficiently find the relevant information in the Systems Manual to operate and maintain the systems/components you were trained for in this session?

| 1 | 2 | 3 | 4 | 5 | N/A |

9. Do you know how to perform the needed maintenance on the equipment and/or do you know to get the information you need?

| 1 | 2 | 3 | 4 | 5 | N/A |

10. Do you know how to get updated technical service information for the components/systems?

| 1 | 2 | 3 | 4 | 5 | N/A |

Explain why any questions got very low or very high ratings from you:

What topics would you like to have covered that were absent from this training session:

Other comments concerning anything about this training session (e.g., information prior to training, content):

## **K2. SAMPLE TRAINING EVALUATION TOOL—INTERIOR ELECTRICAL SYSTEMS QUIZ**

**Name:** \_\_\_\_\_

1. How many TVSS unit(s) are located on the bus duct?
  - a. One TVSS Unit
  - b. Two TVSS Units
  - c. Three TVSS Units
  - d. Four TVSS Units
2. How can you increase the load capacity of the UPS?
  - a. Upgrade the firmware
  - b. Shut down a portion of the network equipment
  - c. Add more batteries
  - d. The UPS is not capable of increasing its load capacity
3. What are the ratings on TVSS units located on the bus duct?
  - a. 240 kA and 80 kA
  - b. 125 A
  - c. 100 A
  - d. 240 kA, 160 kA, and 80 kA
4. Soft loading is a type of?
  - a. Open transition power transfer
  - b. Closed transition power transfer
  - c. CRAC unit ATS power transfer
  - d. None of the above
5. TVSS units should be replaced?
  - a. When protection is degraded and a spare unit is available
  - b. After ten years when a spare unit is available
  - c. After twenty years
  - d. After twenty-five years

**(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)**

## **INFORMATIVE APPENDIX L—TRAINING BEST PRACTICES**

Informative Appendix L provides general suggestions and specific recommendations that can improve the effectiveness of training efforts. Three areas are addressed: general best practices, recording of training, and archiving of training.

### **L1. Tips for Successful Training**

Reserve two to three months to arrange the schedule and engage participants for training sessions. Do not underestimate the time it will take to set this up. Start early; there is no need to wait for submittals to be completed.

Begin by sending a framework to the Owner with the expected number of sessions and major topics.

Create the list using the specifications, common sense, and a realization that time spent in a training session is time the Owner should pay service staff without immediate return on investment. Attempt to strike a balance between time commitment and the value of training.

Ensure that factory-trained instructors are listed explicitly; these can be difficult to reserve and may become scheduling bottlenecks.

- a. Group major topics of interest together per training session to ensure that the same group of trainees can attend the entire session.
  1. Example: Don't force the Owner to send HVAC technicians for two hours, and then switch to electrical staff, etc.
  2. Example: Training for maintenance technicians occurs on four separate days, one day for mechanical systems, one day for electrical and plumbing systems, one day for introduction to the control system (general user interface functions, not necessarily related to project building), one day for control system specifics of the project building, run through sequences of operations, alarms, trending, typical operating points, and emergency response. Training for tenants (typically for a lab, hotel, hospital, or naturally ventilated building with tenant interactions) may be separate, with different focus, and last for one day.
- b. Ask the Owner to confirm who will attend. Ensure they understand it is their choice whom to select but that the selected staff should be committed. Schedule conflicts may not be avoidable, for example in small organizations with a single building engineer, but should be avoided where possible. Discuss this in person. Ensure that you understand what things the Owner explicitly wants training on even if this is not specified (VFD interfaces for example). Difficulties to consider include the following:
  1. Is there a building-specific maintenance crew or third-party hired service agency? If so, who from the building is responsible for continuity of maintenance? Who will ensure that newly hired service techs from the outside organization learn the minimum they need to know about the project building?
  2. Who are the tenants? Are they known at the time of initial training? If they are unknown, who is responsible for transmitting information to them? Will they rotate, for example like students in a dorm, or will they move from a different location, for example corporate HQ tenants? Ensure that the person responsible for transferring training information at initial or regular steps is part of the conversation.

For facilities with rotating staff or tenants, ensure that training materials, collected in the initial sessions with contractors, are reusable for subsequent sessions; ensure they are required to be video recorded and preserved on-line for future use.

Ask the Owner for typical dates when training cannot occur (e.g., chief engineer is always out every other Friday; never book a training session then).

Once the Owner has responded with a list of staff who should attend the various sessions, ask the general contractor to call specialized personnel for the following:

- a. Factory training (meaning training that occurs at a factory).
- b. Factory-trained instructors (often on a schedule visiting different locations in the country and booked months in advance).
- c. Once instructors and/or facilities are confirmed, transmit the schedule back to the Owner for reconfirmation of

intended dates.

- d. Allow time for discussion if there are disagreements about the scope of training (number of hours, systems covered).

Officially accept the training plan, enter it into the Systems Manual, and ensure that all attendees receive a copy well before the actual sessions are scheduled. Set up reminders to push unconfirmed dates or personnel back to the top of the agenda to avoid scheduling problems. Use online scheduling tools to assist in the complex effort of scheduling multiple people from different organizations across multiple days of training.

Ensure that design engineers are part of the training sessions. Often they are either far removed mentally from the project, having been minimally engaged to that point; they are physically (geographically) removed from the project, or they are almost completely invoiced and unlikely to join the meeting. Schedule a virtual meeting for them to give a 15 to 20 minute introduction explaining the basics of the design intent of commissioned systems in order to avoid misunderstandings that carry serious repercussions later. Capture this introduction on video.

Ensure that the Owner and general contractor agree as to who provides the training space and equipment (projectors, conference phones, restrooms, lunches, video cameras). Note that regular phones on small \$25 tripods have been successfully used to take training videos. Press “Stop” and then immediately restart videos at short intervals (every 15 minutes or so) to make for shorter videos (if editing software or expertise is unavailable, see below); these files will be easier to download/post/transfer.

Ensure that training sessions actually take place by continuing to remind stakeholders and obtaining active confirmations at regular, increasingly shorter intervals.

Ensure that sign-in sheets are created and that the CxP receives a copy for the Systems Manual. The Owner needs to know who attended and who may have to be retrained because they missed a session through a last minute cancellation that was not communicated.

Ensure that the CxP has a budget to attend sessions and cover topics that may be skipped or partially covered by instructors. Attendees are typically too overwhelmed with the amount of information presented to ask critical questions or demand complete coverage of topics.

Ensure that budgets are allocated for someone to compress video and host it somewhere online for download or streaming.

- a. Create a table of contents (can be text based, in a simple \*.txt file) that highlights major topics covered so that people can find the relevant section in a video.
- b. Compress the video so that it can be streamed and so that the user can easily navigate to a certain location; divide the videos into smaller segments for even better streaming.
- c. Example from a public PG&E training session webcast presenting a free trend analysis tool (not related to a commissioning project, but a good example of what can be distributed):
  1. <https://app.box.com/UT3-Training-PGE> (video stream)
  2. <https://app.box.com/UT3-Training-Contents> (download)
- d. Without this packaging effort, no one can ever use a video short of sitting through an entire session from start to end, which is not very effective or successful.

Ensure the CxP has means to judge whether adequate training was given on relevant topics. By far the best way to do this is to have the CxP attend important training sessions. Where this is not possible, the CxP should review video training recordings. Ensure that the CxP receives these recordings in a timely manner.

## **L2. Recording of Training**

### **L2.1 General Tips**

- a. Organize necessary equipment
  1. Main video camera
  2. Back-up video camera
  3. Tripod/stand
  4. Batteries

5. Tapes/DVDs/flash memory
6. Wireless microphones (presenter and audience as required)
- b. Ensure camera settings are correct.
  1. Date and time
  2. Wide/standard angle setting
- c. Be familiar with the equipment that will be used for the session.
- d. Overview of general video terms and techniques.
  1. Steady hand
  2. Walk slowly to the objective, if necessary, rather than zooming in
  3. Pan, zoom, close-up, wide angle, tilt, dolly (used sparingly)
    - i. It's best to maintain a wide angle to get an overview of the training, only zooming when absolutely necessary.
    - ii. Try to avoid any panning or zooming and, if required, do so slowly and steadily.
  4. Establishing shot (overview shot).
  5. Keeping perspectives and use of screen (2/3 rule).
  6. Use a tripod for stationary shots.
  7. If outdoors, film with the sun behind your back or off to either side; shooting in the direction of the sun makes the video dark and hard to see.
  8. When you start filming, let the recording run for about five seconds before you speak, pan, or zoom. This allows the camera to get up to speed and makes it easier for the editor to edit. Finish the same way, with five seconds of silence and a still camera.

## **L2.2 Classroom Session Recording Tips**

- a. Overview
  1. During classroom training, the preference is to capture both the presenter and the presentation.
  2. It is not necessary or useful to provide footage of the trainees or other observers.
  3. Plan for such training sessions ahead of time by noting the approximate size of the group, number of instructors, and location.
- b. Testing
  1. The videographer should test record sound and picture the day prior to the sessions and then view the video on a laptop to gauge the quality.
  2. All areas that will be filmed in the field should be surveyed and test captured.
  3. Optimal angles should be sought by trying multiple options.
- c. Best practices
  1. Before filming, take a moment to talk with the instructors to establish their presentation setup and their positions in the room.
  2. Consider using screen-capture software to record the presentation (and potentially the audio) on the presenter's computer.
  3. Use an A/C adapter power source whenever possible.
  4. Use a tripod whenever possible, and limit the instructor's movements to stay within the camera viewing area to minimize panning.
  5. Have adequate back-up batteries and mini DVDs/memory cards to last through the duration of the training class.
  6. Have the instructor clip the wireless microphone on their shirt close to their mouth; ensure the microphone is on and a signal is established before recording.
  7. Place the camera in a position where trainees do not interfere with the shot but where it is able to capture both the instructor and the presentation.
  8. Recording should continue uninterrupted except during breaks in the training session.

### **L2.3 Field Walkthrough Session Tips**

- a. Pre-production
  1. Storyboard the process at hand.
  2. Organize sequence of events.
  3. Create checklist of required shots.
  4. Discuss tips and tricks with someone knowledge of the process, or review MOPs (when recording operational events).
  5. Develop a narrative to include with the storyboard.
  6. Determine approximate timeframes.
  7. Identify slow and fast processes.
- b. Production
  1. Organize team members in strategic locations by equipment
    - i. Close-up shots
    - ii. General overview
  2. During a walking tour, ask the trainer to speak loudly with the wireless microphone attached closely to the instructor's mouth. Wind and machinery are louder on tape than in real life, and they make the trainer's voice hard to hear. Playback volume can always be lowered, but the voice volume cannot be increased without raising the volume of the background noise
  3. If it is a walking training tour, be aware of your surroundings for the sake of safety.

### **L3. Archiving of Training**

Training of a building Owner's O&M personnel is essential to fully benefit from the Cx by having well-informed staff to assist with ongoing building operations. In addition to developing the O&M personnel's understanding of the installed HVAC&R equipment and controlling systems, they will need to access and understand the building systems' Basis of Design (BOD) and maintenance procedures that are required to sustain system performance over the life of the building.

Due to the large volume of reference material accumulated during the building's Design, Construction, and Occupancy and Operations Phases, a well-planned and organized procedure for data collection and archiving should be developed. This is best handled by electronic data archiving programs and services that specialize in management of physical media and digital data.

Data to be archived will include, but not be limited to, the following documents:

- a. Executive Summary
- b. Planning, design, calculations, assumptions, drawings, and specifications
- c. Building, systems, and assemblies information
- d. Project administration documents generated during the building's construction
- e. Final documents generated at completion of construction, including the Systems Manual
- f. Printed, audio, and video generated during O&M training sessions
- g. All documents generated during the building's Cx
- h. Documents associated with operation and maintenance of the building systems during occupancy

It is essential that all documentation be preserved as a resource for present and future operation and maintenance of the building systems. A large portion of this material will be specific to the building and over time become irreplaceable. Therefore, this data should be archived in a safe location that allows for immediate retrieval, periodic update, and long-term safe storage. It is important that archived data be backed up to a second or even third secure storage location to ensure that it will not be lost in an unavoidable event.

The process of documentation and archiving is described in ASHRAE Guideline 1.4, *Preparing System Manuals for Facilities* in Section 9 through 11.

**(This appendix is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)**

## **INFORMATIVE APPENDIX M—TRAINING AGENDA**

Informative Appendix M provides several examples of Cx training agendas.

### **M1. EXAMPLE OF A SYSTEMS-FOCUSED OUTLINE TRAINING AGENDA**

#### **SESSION A—Electrical and Fire Protection Systems**

Lectures/Demonstrations

- A1 Emergency power supply system
- A2 Fire alarm system
- A3 Lighting control
- A4 Switchboards
- A5 Medium-voltage pad-mounted switchgear
- A6 O&M procedures for clean agent fire suppression systems, including emergency procedures, abort functions, and safety requirements

#### **Session B—Mechanical and Plumbing Systems**

Lectures/Demonstrations

- B1 Variable-speed drives
- B2 Chillers
- B3 General familiarization and operating procedures for plumbing equipment
- B4 Water treatment systems

#### **Session C—Control System**

Lectures/Demonstrations

- C1 Laboratory control systems
- C2 Automatic temperature controls
- C3 Direct digital controls (DDC) system operations (for up to six operators)
- C4 DDC system emphasis on advanced features of system, energy conservation strategies, and reporting capabilities and how to implement them (for up to two supervisors)

### **M2. EXAMPLE OF A CONTENT-FOCUSED OUTLINE TRAINING AGENDA**

- a. Overview and description of the purposes of the system
- b. System troubleshooting: description of diagnostic step-by-step procedures for determining the source of problems on the system level; review technical service manual in detail
- c. Component maintenance: instruction of required procedures for weekly, monthly, and annual preventive checks and timely repairs to preserve system integrity
- d. Component troubleshooting: description of diagnostic procedures for determining the source of problems on the component level
- e. Review of control drawings and schematics (have copies for attendees)
- f. Start-up, loading, normal operation, unloading, shutdown, unoccupied operation, seasonal changeover, etc., as applicable
- g. Integral controls (packaged): programming, troubleshooting, alarms, manual operation
- h. Building automation system (BAS) controls: programming, troubleshooting, alarms, manual operation, interface with integral controls
- i. Interactions with other systems, operation during power outage and fire

- j. Relevant health and safety issues and concerns and special safety features
- k. Energy-conserving operation and strategies
- l. Any special issues to maintain warranty
- m. Common troubleshooting issues and methods, control system warnings, and error messages, including using the control system for diagnostics
- n. Special requirements of tenants for this equipment's function
- o. Service, maintenance, and preventive maintenance (sources, spare parts inventory, special tools, etc.)

### **M3. EXAMPLE TRAINING AGENDA FOR A REASONABLY COMPLEX INSTITUTIONAL PROJECT**

#### **Training Agenda and Sign-Off Form**

PROJECT: \_\_\_\_\_

Date: \_\_\_\_\_

Equipment/System: \_\_\_\_\_

Hours Required: \_\_\_\_\_

Specification Section: \_\_\_\_\_

1. Audience and General Scope: [Owner and/or CxP fill out this section.]

Intended audience type (enter number of staff):

- \_\_\_\_\_ Facility manager
- \_\_\_\_\_ Facility engineer
- \_\_\_\_\_ Facility technician
- \_\_\_\_\_ Project manager
- \_\_\_\_\_ Tenant
- \_\_\_\_\_ Other: \_\_\_\_\_

General objectives and scope of training (check only one):

- \_\_\_ A. Provide only an overview of the purpose and operation of this equipment, including required interactions of trainees with the equipment.
- \_\_\_ B. Provide an overview plus technical information of the purpose, operation, and maintenance at an intermediate level, expecting that serious malfunctions will be addressed by factory reps.
- \_\_\_ C. Provide an overview plus technical information (purpose, operation, troubleshooting, and maintenance) at a very detailed level, expecting that almost all operation, service, and repair will be provided by the trainees.

2. Instructors [Trainer fills out this section: \_\_\_ prior to training and submits to CxP or \_\_\_ after training.]

ID	Trainer	Company	Position
(1)	_____	_____	_____
(2)	_____	_____	_____
(3)	_____	_____	_____

3. Agenda (check one option below):

- \_\_\_ A. The responsible trade contractors' trainers fill out this section prior to conducting training and submit it to the CxP for approval.
- \_\_\_ B. The Owner and the CxP fill out this section prior to training and submit it to the trade contractor for their use.
- \_\_\_ C. This section is left blank until the training is completed; the trainer fills it in as a record of what was covered in the training.



Training Date: \_\_\_\_\_

**Agenda of General Subjects Covered—Duration, Instructor, Completion**

OVERVIEW

Minutes:            ID No:            Completed:

Reason for system selection, layout and general purpose, unique features, general interactions with other systems, and special O&M issues.

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CONTROLS

Minutes:            ID No:            Completed:

Integral controls (packaged): programming, troubleshooting, alarms.

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Review of control drawings (have copies for attendees)

\_\_A \_\_B

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BAS controls: programming, troubleshooting, alarms, manual operation, interface with integral controls

\_\_A \_\_B

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A: This training to be done during equipment training.

B: This training to be done during central BAS training.

OPERATION

Minutes:            ID No:            Completed:

Describe and demonstrate start-up, loading, normal operation, unloading, shutdown, unoccupied operation, seasonal changeover, manual operation, etc., as applicable.

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Interactions with other systems, operation during power outage and fire.

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Relevant health and safety issues concerns and special safety features.

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Energy conserving operation and strategies (if applicable).

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**TROUBLESHOOTING**

Minutes:            ID No:            Completed:

Common troubleshooting issues and methods, control system warnings and error messages, including using the control system for diagnostics.

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**MAINTENANCE**

Minutes:            ID No:            Completed:

Service, maintenance, and preventative maintenance (sources, spare parts inventory, special tools, etc.).

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For associated piping and ducting, describe layout, location of isolation valves, zone dampers for handling leaks and repairs, etc.

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Any special issues to maintain warranty

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Special requirements of tenants for this equipment's function

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**Q/A PERIOD**

Minutes:            ID No:            Completed:

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**OTHER COVERED**

Minutes:            ID No:            Completed:

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TOTAL DURATION OF TRAINING IN HOURS: \_\_\_\_\_

VIDEO TAPING

Training shall be video recorded with audio, with copies provided to the University:

- Digitally
- Taped
- by trade contractor
- by others

Training methods that will be included (clarify as needed; trainer checks all that apply):

- Use of the O&M manuals, illustrating where the verbal training information is found in writing
- Each attendee will be provided with the control drawing schematic and sequence of operations and a copy of this agenda
- Site demonstration of equipment operation
- Written handouts
- Manufacturer training manuals
- Classroom lecture
- Video presentation

#### 4. Record of Training

Dates of Training: \_\_\_\_\_

Hours Spent: \_\_\_\_\_

Trainers: \_\_\_\_\_

Attendees:

Printed Name \_\_\_\_\_ Signature \_\_\_\_\_

Printed Name \_\_\_\_\_ Signature \_\_\_\_\_