ASHRAE Guideline 1.4P

Advisory Public Review Draft

The Systems Manual for Facilities

First Public Review (May 2013)
(Complete Draft for Full Review)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed guideline, go to the ASHRAE website at www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the guideline (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any guideline may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

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The Assistant Director of Technology for Standards and Special Projects of ASHRAE should be contacted for:

a. interpretation of the contents of this Guideline,
b. participation in the next review of the Guideline,
c. offering constructive criticism for improving the Guideline, or
d. permission to reprint portions of the Guideline.

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The Systems Manual for Facilities

NOTE

When addenda, interpretations, or errata to this guideline have been approved, they can be downloaded free of charge from the ASHRAE Web site at http://www.ashrae.org.

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

FOREWORD

Developing the Systems Manual encompasses gathering the information related to the facility, equipment, systems, and assemblies; from the planning, commissioning process, design, construction, testing, and training activities; and operations planning function and incorporating it into a usable information resource, with indexes and cross references. This resource will include final project documentation, including OPR, BOD, the final Cx Plan, Cx Progress Reports, submittals, manufacturer installation manuals, manufacturer O&M manuals, system schematics, record drawings, testing results, and training and other relevant materials. This information is edited and organized to focus upon the key systems (roofing, walls, fire alarm, chilled water, hot water, etc.), in the facility. Coordination with O&M personnel in developing standard formats and divisions (shops) is accomplished to simplify future Systems Manual revisions.

It is the intent that the Systems Manual be assembled in electronic format to facilitate access and reduce storage requirements. The electronic format will also reduce the possibility of loss for parts or all of the information. For Systems Manuals assembled in hard copy format, the larger documents such as record drawings, specifications, submittals, and O&M documents can be stored in secure locations with these locations referenced in the Systems Manual.

Also included in the Systems Manual is the development of periodic maintenance and information for insertion into a computer maintenance management system (CMMS), including equipment make and model information, checking requirements, maintenance requirements, and troubleshooting items.

If the Systems Manual is assembled during a commissioning process, the Commissioning Authority (CxA) shall be responsible for evaluating the development of the Systems Manual. At other times, the responsible person or agency will be designated by the Owner.

The entity responsible for developing the Systems Manual should include all items involved in the project and capture the system and assembly data in either an electronic or printed version. In addition, printed operations, service, maintenance, spare parts list, and repair manuals may be provided. This entity (owner, contractor, design professional, CxA, other) shall have the skills of design, construction, and operations required to develop a cohesive Systems Manual.

The required details for a full Systems Manual are enhanced in each of the Technical Guidelines. The Systems Manual will have multiple sections depending upon the Owner's designated requirements and the number of systems focused upon during the facility development, renovation, or repair process.

In summary, the Systems Manual contains information and documentation on the building design and construction, along with operational requirements, maintenance information, training and testing documentation for the use of building operations, and maintenance and optimization of the facility over its useful life.

The format and content of the Systems Manual provided in this standard can be effectively used in both new construction and for assembling one for an existing building, even if the building is not commissioned.

Systems Manual Documentation Collection Requirements

The Systems Manual process captures project requirements, design documentation, construction details, evaluation and testing results, and training programs as the information becomes available. Additionally, the recommended operating and maintenance procedures and ongoing documentation requirements are assembled and included. Changes to the manuals are expected as the building maintenance systems are developed and changes to the systems occur.

The arrangement of the Systems Manual shown in section 4 is based upon collection of documentation

during the normal construction process. It is also acceptable to arrange the documentation by system if that is the Owner's preference, This system arrangement may require substantial additional time and documentation effort to rearrange the information.

1. PURPOSE

This guideline provides procedures for producing a Systems Manual as a resource for training, operations, maintenance, and upgrading of facilities.

2. SCOPE

This guideline applies to information from planning, commissioning process, design, construction, testing, and training activities, and operations planning for new, renovated, and existing facilities, equipment, and assemblies.

3. DEFINITIONS

***Acceptance*:** A formal action, taken by a person with appropriate authority (which may or may not be contractually defined) to declare that some aspect of the project meets defined requirements, thus permitting subsequent activities to proceed.

***Basis of Design (BOD)*:** A document that records the concepts, calculations, decisions, and product selections used to meet the Owner's Project Requirements (OPR) and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.

***Checklists*:** Project and element-specific checklists that are developed and used during all phases of the commissioning process to verify that the OPR are being achieved. Checklists are used for general evaluation, testing, training, and other design and construction requirements.

***Commissioning (Cx)*:** See Commissioning Process.

***Commissioning Authority (CxA)*:** An entity identified by the Owner who leads, plans, schedules, and coordinates the commissioning team to implement the Commissioning Process.

***Commissioning Plan (Cx Plan)*:** A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process.

***Commissioning Process*:** A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that all of the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the OPR.

***Commissioning Process Activities*:** Components of the Commissioning Process.

***Commissioning Progress Report*:** A written document that details activities completed as part of the Commissioning Process and significant findings from those activities and is continuously updated during the course of a project.

***Commissioning Team*:** The individuals and agencies, who through coordinated actions, are responsible for implementing the Commissioning Process.

Commissioning Testing: The evaluation and documentation of the equipment and assemblies: delivery

and condition; installation; proper function according to the manufacturer's specifications, and project documentation to meet the criteria in the OPR.

Construction Checklist*:** A form used by the commissioning team to verify that appropriate materials and components are on-site, ready for installation, correctly installed, functional, and in compliance with the OPR. Also see ***Checklists.

***Construction Documents*:** This includes a wide range of documents, which will vary from project to project and with the Owner's needs and regulations, laws, and jurisdictional requirements. Construction documents usually include the project manual (specifications), plans (drawings), and General Terms and Conditions of the contract.

***Contract Documents*:** This includes a wide range of documents, which will vary from project to project and with the Owner's needs, regulations, laws, and jurisdictional requirements. Contract Documents frequently include price agreements, construction management process, sub-contractor agreements or requirements, requirements and procedures for submittals, changes, and other construction requirements, timeline for completion, and the Construction Documents.

***Coordination Drawings*:** Drawings showing the work of all trades to illustrate that equipment can be installed in the space allocated without compromising equipment function or access for maintenance and replacement. These drawings graphically illustrate and dimension manufacturers' recommended maintenance clearances.

Current Facility Requirements (CFR): A written document that details the current functional requirements of an existing facility and the expectations of how it should be used and operated. This includes goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information to meet the requirements of occupants, users, and owners of the facility.

Design Checklist: A form developed by the commissioning team to verify that elements of the design are in compliance with the OPR. Also see ***Checklists***.

***Design Review – PEER*:** An independent and objective technical review of the design of the project or a part thereof, conducted at specified stages of design completion by one or more qualified professionals, for the purpose of enhancing the quality of the design.

***Design Review – Constructability*:** The review of effective and timely integration of construction knowledge into the conceptual planning, design, construction, and field operation of a project to achieve project objectives efficiently and accurately—at the most cost effective levels to reduce or prevent errors, delays, and cost overruns.

***Design Review – Code or Regulatory*:** A review of a document conducted by staff or designated entity of an Authority Having Jurisdiction to determine whether the content of the document complies with regulations, codes, or other standards administered by the Jurisdiction.

***Design Review – Commissioning*:** A review of the design documents to determine compliance with the OPR, including coordination between systems and assemblies being commissioned, features and access for testing, commissioning and maintenance, and other reviews required by the OPR and commissioning plan.

***Evaluation*:** The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems and their performance are confirmed with respect to the criteria required in the OPR.

***Existing Building Commissioning Process*:** A quality-focused process for attaining the Current Facility Requirements of an existing facility and its systems and assemblies being commissioned.

The process focuses on planning, investigating, implementing, verifying, and documenting that the facility and/or its systems and assemblies are operated and maintained to meet the Current Facility Requirements, with a program to maintain the enhancements for the remaining life of the facility.

***Facility Guide*:** A basic building systems description and operating plan with general procedures and confirmed facility operating conditions, set points, schedules, and operating procedures for use by facility operations to properly operate the facility.

***Final Commissioning Report*:** A document that records the activities and results of the Commissioning Process and is developed from the final Commissioning Plan with all of its attached appendices.

***Issues and Resolution Log*:** A formal and ongoing record of problems or concerns and their resolutions that have been raised by members of the Commissioning Team during the course of the Commissioning Process.

***On-Going Commissioning Process (OCx)*:** A continuation of the Commissioning Process well into Occupancy and Operations to continually improve the operation and performance of a facility to meet current and evolving Current Facility Requirements or OPR. On-Going Commissioning Process activities occur throughout the life of the facility; some of these will be close to continuous implementation, and others will be either scheduled or un-scheduled as needed.

***Owner's Project Requirements (OPR)*:** A written document that details the requirements of a project and the expectations of how it will be used and operated. This includes project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information. (The term Project Intent or Design Intent is used by some Owners for their Commissioning Process OPR.)

Performance Test (PT): The process used to verify that a material, product, assembly, or system meets defined performance criteria. The methods and conditions under which performance is verified are described in one or more test protocols.

***Re-Commissioning*:** (See Existing Building Commissioning.) An application of the Commissioning Process requirements to a project that has been delivered using the Commissioning Process.

Retro-Commissioning: (See Existing Building Commissioning.) The Commissioning Process applied to an existing facility that was not previously commissioned.

***Systems Manual*:** A system-focused composite document that includes the design and construction documentation, facility guide and operation manual, maintenance information, training information, Commissioning Process records, and additional information of use to the Owner during occupancy and operations.

***Test Procedure*:** A written protocol that defines methods, personnel, and expectations for tests conducted on components, equipment, assemblies, systems, and interfaces among systems to verify compliance with the OPR.

***Training Plan*:** A written document that details the expectations, schedule, duration, and deliverables of Commissioning Process activities related to training of project operating and maintenance personnel, users, and occupants.

4. SYSTEMS MANUAL CONTENT, ORGANIZATION, AND UTILIZATION

4.1 Introduction

The Systems Manual contains information on the Owner's Facility and Project Requirements and

documentation of building design and construction, along with operational requirements, maintenance information, training and testing documentation for the use of building operations, maintenance, and optimization of the facility over its useful life.

The Systems Manual shall provide the information needed to understand, operate, and maintain the facility's equipment, systems, and assemblies.

The format and content of the Systems Manual provided in this guideline can be effectively used in both new construction and for assembling a Systems Manual for an existing building, even if the building is not commissioned.

4.2 Systems Manual Preparation Objectives

The objectives of the Systems Manual are to:

1. Provide the necessary information to the facility operating staff and the maintenance function to understand the design and construction of the facility and how to operate and maintain the building,
2. Assemble the facility design, construction, and testing results for building systems in one set of documents,
3. Provide a documentation source to be used in training materials, and
4. Provide documentation for building performance improvement and ongoing commissioning.

The Systems Manual is the repository of design, construction, testing, and operations information, including updates and corrections to systems and assemblies as they occur during construction and operation. For commissioned projects, the Commissioning Team shall be responsible for updating the Systems Manual during the Commissioning Process, including design construction and operation as required in the OPR, Commissioning Plan, and contract documents. For existing building projects that do not involve commissioning, the building operating and maintenance functions (staff or contractors) are responsible for developing, utilizing, and updating the Systems Manual.

4.3 Systems Manual Documentation Requirements

4.3.1 The Systems Manual process captures project requirements, design and construction documentation, evaluation and testing results, and training programs as the information becomes available. Additionally, the recommended operating and maintenance procedures and ongoing documentation requirements are assembled and included. Changes to the manuals are expected as the building maintenance systems are developed and changes to the systems occur.

4.3.2 The systems manual should contain the following sections:

I. Executive Summary

II. Facility Design and Construction

1. Owner's Project Requirements

2. Basis of Design requirement

3. Facility/Project Design and Record Documents (or directions to their location).

III. Facility, Systems, and Assemblies Information

1. Facility and Equipment Specifications

2. Approved Submittals

3. Manufacturer's Operation and Maintenance (O&M) Data

4. Warranties

5. **Contractor/Supplier Listing and Contact Information.**

IV. Facility Operations

1. **Facility Guide, including: Operating Plan; Facility and Equipment Operating Schedules; Set Points, Ranges, and Limitations; Systems Operation Control Sequences of Operation; and Emergency Procedures.**

Note: Items two through 6 should be added to the Systems Manual when required by the Owner's Facility and Project Requirements and/or Commissioning Plan

2. **Maintenance Plans, Procedures, Checklists, and Records**
3. **Maintenance Schedules**
4. **Utility Measurement and Reporting**
5. **Ongoing Commissioning Operational and Maintenance Record Keeping**
6. **Janitorial and Cleaning Plans and Procedures.**

V. Training

1. **Training Plans and Materials**
2. **Training Records**
3. **System Manual maintenance and documentation**
4. **Operator's ongoing documentation of modifications and adjustments to the facility systems and assemblies.**

VI. Commissioning Process Report

1. **Commissioning Plan(s)**
2. **Commissioning Design and Submittal Review Reports**
3. **Testing and Start up Reports, evaluation checklists, and testing checklists completed for Commissioned Systems and Assemblies**
4. **Cx Progress Reports**
5. **Issues and Resolution Logs**
6. **Item Resolution Plan for open items.**

4.3.3 Sources and Content of the Documents in the Systems Manual

I. Executive Summary

The executive summary contains an overview of the building design, construction, and operational requirements. The information is intended to provide general guidance on the intended operation, performance, and maintenance of the building in conformance to the Owner's Project Requirements and/or Current Facility Requirements.

II. Facility Design and Construction

1. **Owner's Project Requirements (OPR)/Current Facility Requirements (CFR)**
   Insert final copy of OPR/CFR developed and revised during the project and commissioning process. This provides the operations and maintenance (O&M) staff as well as future owners the information on the original intent for the design and use of the facility.

2. **Basis of Design (BOD)**
   Insert final copy of BOD document and any other design information developed during the project and commissioning process. This provides the O&M staff as well as future owners the information

on the design of the facility.

3. Construction/Project Record Documents
Insert final program and design documents, and insert or describe locations of record drawings and documents. Digitized systems manuals can also contain copies of the record documents and minimize the loss of these documents.

III. Facility, Systems, and Assemblies Information

1. Specifications
Insert final copy of facility and equipment design specifications.

2. Approved Submittals
Insert final copy of specific approved submittals by specification section sequence, including a copy of final approved and commissioned sequences of operation for equipment and systems, along with limitations to operation.

3. Manufacturer's Operation and Maintenance Data
Insert manufacturer provided installation and operation and maintenance (O&M) manuals that have been verified and localized to the installed building system or equipment by specification section sequence.

4. Warranties
Insert System and Equipment warranties arranged by specification section sequence.

5. Contractor/Supplier Listing and Contact Information
Insert a listing of all contractors and major suppliers, including address, phone, and email to facilitate repairs and replacements.

Insert the design team members listing along with contact information to facilitate information transfer on original designs and maintenance and optimization.

IV. Facility Operations

1. Facility Guide, including: Operating Plan; Building and Equipment Operating Schedules; Set Points and Ranges; Sequences of Operation, Limitations, and Emergency Procedures Actions.

Insert a copy of the completed facility operating plan with explanations of the intended use and operation of the facility.

Insert a copy of the final commissioned sequences of operation for all operating equipment.

Insert a copy of final commissioned set points of all equipment with operational adjustments. Include the set point normal intended ranges and limitations.

Insert a copy of routine maintenance requirements.

Insert a copy of emergency procedures and locations of applicable controls.

Note: Items two through 6 should be added to the Systems Manual when required by the Owner's Facility and Project Requirements and/or Commissioning Plan.

2. Maintenance Procedures, Checklists, and Records
Insert procedures, forms, and checklists for facility operation and maintenance. Include updating requirements. Describe inspections and testing required on a routine basis and standard forms required.

3. Maintenance Schedules

Include recommended maintenance schedules for systems and equipment along with update requirements.

4. Utility Measurement and Reporting

Include description of utility metering and monitoring systems.

Provide document formats and procedures for tracking utility usage and reporting this information to meet Owner's and jurisdictional requirements.

Include a copy of the facility Measurement and Verification (M&V) Plan if available.

5. Ongoing Commissioning Operational and Maintenance Record Keeping
Include ongoing commissioning and optimization procedures and documentation to monitor and improve the performance of facility systems.

6. Janitorial and Cleaning Plans and Procedures
Insert a copy of facility cleaning and janitorial plan with procedures and intended chemicals and equipment.

V. Training

1. Training Plans and Materials

Include instructions and procedures for the use of appropriate sections of the Systems Manual for training for building O&M personnel.

Insert copy of training plans used for each type of equipment along with session syllabus used.

Insert training materials used, arranged in specification sequence. Describe location or sources of available additional training.

2. Training Records
Insert records of training, schedules, sign in sheets, etc. Include copy of training documentation and training recordings on the operation of the systems and equipment, along with appropriate trouble shooting instruction.

3. Training for Ongoing System Manual Updating
Include training and documentation on the updating and continued usage of the Systems Manual.

VI. Commissioning Process Report

1. Commissioning Plan(s)
Insert the final commissioning plan and completed commissioning report with evaluation and testing forms and records for each building and system.

2. Commissioning Design and Submittal Review Reports
Insert a copy of the commissioning design and submittal review reports

3. Testing Reports

Insert completed Commissioning Process Report with documents and verification and testing forms and records for each building and system and assembly included in the Cx Process. This creates a record of all required testing contained in the commissioning sections of the project contract documents and performed during the project.

Insert manufacturers', testing agencies', and contractors' reports.

Insert installers' and commissioning authorities' completed checklists. This provides a record of installation checks and observations for future reference.

Insert installers' and commissioning authorities' completed performance checklists of assemblies, equipment, and integrated systems. This provides a record of performance checks and observations for future reference.

Insert relevant commissioned system and assemblies test reports.

4. **Cx Progress Reports**
   Insert a copy of all commissioning progress reports

5. **Issue and Resolution Logs**
   Insert a copy of all issue and resolution logs with resolution or status of each item. This provides a record of problems and issues found and resolved during the design and construction process for future reference.

6. **Item Resolution and Open Items**
   Insert a list of any open items and seasonal or additional testing required.

4.4 Usage of Systems Manual

4.4.1 The initial information contained in the Systems Manual is provided by the project and commissioning teams to provide essential information needed by the operation and maintenance staff to understand, operate, and maintain the building's systems and assemblies, optimally operate the building, and provide a system for documenting modifications.

4.4.2 The necessary sections of the Systems Manual are used in the initial and subsequent training of the O&M staffs.

4.4.3 The O&M staff use the Systems Manual to document modifications they implement and the reasoning for the modifications and improvements and as a repository of needed modifications required to meet current facility requirements that will guide future modifications, updated Basis of Design information, and changes to equipment and assemblies being replaced.

4.4.4 The Systems Manual is the repository of institutional knowledge that records needed for present operation and future modifications and history of modifications by all who contribute to the modifications that happen over the life of a building.

4.4.5 The information on the building systems may be arranged by system when that is a requirement of the project.

4.5 Systems Manual Evaluation and Acceptance Criteria

4.5.1 Production of the Systems Manual will depend upon the directives in the Owner requirements, the process of how the project is designed and built, how it is to be operated, and the organization and application of the maintenance program.

4.5.2 This guideline is supplemental to the commissioning process detailed in ASHRAE Standard 202-2013 and ASHRAE Guideline 0-2005 and should be used in conjunction with those and other applicable documents

4.5.3 Chapters 5 through 10 of this guideline provide guidance on the actions necessary to assemble, produce, utilize, and update the information in the Systems Manual at each stage of the project. The annexes provide examples of documentation and formats that can be used in developing the Systems Manual.

4.5.4 To assure compliance with the Owner's Facility and Project Requirements, there should be a compliance and approval process for each stage of the development and revision of the Systems Manual.

5. PRE-DESIGN PHASE FUNCTIONS

5.1 Introduction

During the pre-design or existing facility commissioning planning phase of a project, the Owner defines the requirements, formats, and interface requirements for the System Manual for the building during the development of the OPR or CFR. This chapter outlines the functions and activities required during this phase of the project to produce an acceptable Systems Manual.

5.2 Pre-Design or Existing Building Commissioning Planning Phase Systems Manual Preparation Objectives

The Owner should establish in the OPR or CFR and by contract that the responsible parties provide the documentation and assemble the documents in a prescribed format. The objectives of the Systems Manual include:

5.2.1 Provide a salient repository for information essential for the building operators to understand, operate, and maintain the systems and assemblies and to inform those not involved in the design and construction process about the Owner's objectives and criteria that defined building attributes required to support the various Owner-envisioned activities the building was designed to support.

5.2.2 Provide current facility/OPR to guide operation and communicate requirements for future modifications needed to support changes in Owner-envisioned activities and occupants' mission for the life of the building.

5.2.3 Provide operations and maintenance staff procedures for documenting and tracking information on updates and modifications to systems and assemblies as they occur during the Occupancy and Operations Phase and the reasoning for the modifications to the building's operation.

5.2.4 Provide documentation of additional information gathered during the project and Commissioning Process, including techniques for optimization and a systems-based organization of information.

5.3 System Manual Structure

During the pre-design or planning phase, the Owner should establish the format and expected source of documents that meets their project or company requirements

5.3.1 The format and organization of the Systems Manual is shown in Section 4.3.

5.3.2 Establishing format for documents included in the System Manual should be done during this phase so the design and construction teams can start at the beginning of the project with document collection and assembly.

5.3.3 The format and document collection systems are initially set in the OPR and/or CFR. The Systems Manual contents outlined in Section 4 can be used as the list and arrangement or modified to meet the Owner's needs for a specific project or existing documentation system.

5.3.4 Additional format and content information for the individual documents in the Systems Manual are shown in the annexes to this guideline.

5.4 Roles & Responsibilities for Systems Manual Initial Documentation

5.4.1 The roles and responsibilities for each component of the Systems Manual as well as the entity that will coordinate and assemble the initial project Systems Manual are defined during the development of the OPR or CFR under the direction of the Owner. These responsibilities should be defined in project requirements and contract requirements. The components that comprise the

Systems Manual as shown in Section 4.3 are to be included in the project Systems Manual and should be designated to be performed by specific entities.

5.4.2 Building Operator's Responsibilities
The Owner is responsible for the activities of their building operations staff. As such, periodic review of the Systems Manual is essential to the transfer of institutional knowledge to successors of existing staff necessary to efficient operation of the building. Defining these requirements at this time will allow the requirements to be included in the initial building operating requirements.

The head of the facility's operation should either personally maintain or ensure maintenance of the Systems Manual records, including but not limited to the following:

- Changes in operating schedules
- Overriding controls and the associated reasoning
- Changes to building automation system set points and the associated reasoning
- Equipment replacement that is not the same make and model
- Additions or modifications to the systems being maintained by operational staff
- Designed and constructed modifications, including changes to floor plan layout
- Documentation of repetitive equipment failures or malfunctions
- Updating construction record documents to reflect modification to the building infrastructure
- Collection and inclusion of CFR, BOD, Operation and Maintenance Manuals for new or replaced components, systems, and assemblies, and associated Commissioning Reports
- Updating of optimization strategies
- Updating of system schematics (single line diagrams)
- Modification to operational procedures for normal, abnormal, and emergency modes of operation
- Current training record for each operation and maintenance staff member.

5.5 Budgets

The Owner should include sufficient funding in construction and renovation projects to implement the Systems Manual. During facility operation, there should be sufficient funding to update and maintain the Systems Manual.

5.6 Pre-Design Phase Systems Manual Evaluation and Acceptance Criteria

5.6.1 The Systems Manual format, contents, and application should be reviewed by the CxA and building O&M staff if available at this phase. The OPR or CFR should also be reviewed at this time.

5.6.2 The Systems Manual should be reviewed and approved by the Owner with the OPR/CFR at the time of initial completion and periodically during the life of the building.

6. DESIGN PHASE FUNCTIONS

6.1 Introduction

During the design phase (if included in the project) the design team updates and expands the Systems Manual requirements and provides the contractors, operators and maintenance personnel specific instruction in the assembly and use of the Systems Manual.

6.2 Design Phase Systems Manual Preparation Objectives

The design phase objective includes the conversion of the Systems Manual requirements into contract documents. This will instruct the contractors, suppliers, and building operators, as well as the design and commissioning teams, on their responsibilities to produce the Systems Manual.

6.3 Design Phase Systems Manual Documentation Requirements for Specific Building or Project

6.3.1 During the design phase, the Owner's requirements are converted to specific project document requirements. The responsibility to produce the document deliverables is inserted in project plans and specifications.

6.3.2 The schedules to provide the individual documents and the finished Systems Manual are included in the project documents.

6.3.3 The design and commissioning teams will define system description and documentation requirements for all systems as required in OPR/CFR

6.3.4 The Systems Manual formats and updating requirements should be specifically defined in the contract documents and operation plans.

6.3.5 The Systems Manual usage in training requirements is defined and made a requirement for project completion.

6.3.6 Requirements should be defined for the collection of checklists and other Systems Manual documents, including evaluation and functional performance testing by the contractor and commissioning team.

6.3.7 The inclusion of Facility Guide and maintenance checklists for equipment and systems for building operation should be defined and required.

6.4 Design Phase Systems Manual Evaluation and Acceptance Criteria

6.4.1 The Systems Manual format and application in the project documents should be reviewed by the CxA on commissioned projects.

6.4.2 The Systems Manual requirements in the projects should be reviewed and approved by the Owner.

7. CONSTRUCTION PHASE FUNCTION

7.1 Introduction

During the construction phase, the Systems Manual requirements are updated and implemented to provide the documents and assemble them for use in training and operation and maintenance functions.

7.2 Construction Phase Systems Manual Preparation Objectives

7.2.1 The objectives of the construction phase are to implement the documentation process and provide necessary coordination.

7.2.2 The contractor is required to include performance and documentation requirements for Systems Manual document collection and Systems Manual assembly in subcontracts.

7.3 Construction Phase Systems Manual Documentation Requirements

7.3.1 Coordinate Owner's Systems Manual Requirements

The contractor and the Project and Commissioning Teams work together to produce and capture the necessary documents for the Systems Manual.

7.3.2. Update Owner's Facility Project Requirements

If proposed changes are at variance with the Owner's Facility Project Requirements and are approved by the design professionals and Owner, then the OPR/CFR (and BOD) must be revised and approved. This provides for continuous updating of the OPR/CFR (and BOD) to reflect the constructed project and facility.

7.3.3 Conduct Pre-Construction Systems Manual and Commissioning Process Meeting

Special issues relative to sequencing and early installation of equipment located in limited access areas (such as equipment to be installed in lower levels of a building) should be discussed and solutions determined.

7.3.4 Determine Procedures, Responsibilities, and Schedules for Documentation Production and Collection

Coordination drawings should be reviewed to verify that the following requirements have been met and construction information is being transferred to the operation staff:

a. Mechanical and electrical equipment spaces show structural elements, equipment, piping, ductwork, and conduit.

b. Ceiling space coordination drawings show a consistent layering for structural elements, ceiling grid, access doors and panels, fire and smoke dampers, lighting, piping, ductwork, conduit, and control elements.

c. Vertical shaft coordination drawings for piping and ductwork show structural elements, equipment, piping, ductwork, and conduit.

d. Specified clearances are shown for maintenance and operation procedures appropriate to the accepted make and model of equipment.

e. Coordination drawings demonstrate adequate space for maintenance access and installation and identify spaces reserved for maintenance and operational procedures.

7.3.5 Equipment Submittals

7.3.5.1 Equipment and component vendor submittals shall be obtained for use by the CxA and project team. This information, when confirmed and approved, shall be used in developing the

Construction Checklists and test procedures. These approved submittals are to be included in the Systems Manual.

7.3.5.2 Submittal of the sequence of control should be presented in the form of a control logic diagram or other approved format.

7.3.5.3 The training-program submittals review includes the schedule, syllabus, evaluation forms, qualifications of the trainer, any video or other material that will be used, any proposed demonstration training, and recording or documentation of the training for future use and inclusion in the Systems Manual (refer to Annex O).

7.3.6 Testing and Evaluation Documentation

7.3.5.1 The testing and evaluation procedures, documentation, and results should be recorded and the results assembled for the Commissioning Report and Systems Manual.

7.3.5.2 The project record documents should be updated and prepared for inclusion in the Systems Manual.

7.4 Construction Phase Systems Manual Evaluation and Acceptance Criteria

7.4.1 The Systems Manual project documentation should be reviewed by the CxA and building O&M Staff before the end of construction.

7.4.2 The Systems Manual should be reviewed and approved by the Owner.

8. OCCUPANCY AND OPERATION PHASE FUNCTION

8.1 Introduction

During the occupancy and operation phase, the Systems Manual is utilized to assist in the operation and maintenance of the building. The documents are updated on a periodic and as needed basis to keep the Systems Manual current.

8.2 Occupancy and Operations Phase Systems Manual Objectives

During the Occupancy and Operations phase, the Owner must maintain the mechanism or develop new mechanisms to perpetuate the content and usefulness of the Systems Manual. While these mechanisms were generally defined in the OPR and should be maintained throughout the project up to the Occupancy and Operations Phase, changes in Operational procedures, building functions, personnel or technology dictate the need for updating procedures. The objectives of the Systems Manual in the Occupancy and Operations Phase include:

8.2.1 Maintain a salient repository for information essential for the building operators to understand, operate, and maintain the systems and assemblies.

8.2.2 Ensure updating mechanisms are maintained to continuously evaluate the needs and objectives of the building's function in order to ascertain whether the building's systems and assemblies meet the building's functional requirements.

8.2.3 Ensure that operators and maintenance staff effectively utilize procedures for documenting and tracking information on updates and modifications to systems and assemblies as they occur during the Occupancy and Operations Phase and the reasoning for the modifications to the building's operation.

8.2.4 Continuously and consistently update the systems information utilizing the prescribed update process including techniques for optimization and a systems-based organization of information. This would include adding additional systems and assemblies that may be installed or modified in function throughout the life of the building.

8.3 Occupancy and Operations Phase Systems Manual Documentation Requirements

8.3.1 Continual Updating of the Systems Manual

The responsibility for maintaining the accuracy and relevancy of the Systems Manual is transferred from the contractors to the O&M personnel at the start of the Occupancy and Operations Phase. The Owner's personnel may accept this responsibility directly, place the responsibility on a property manager, or hire an outside contractor to assist with the maintenance process.

8.3.2 Maintaining and updating of the Systems Manual is required for the life of the facility and includes:

a. Inclusion of material as the result of completing the commissioning process activities in the Occupancy and Operations Phase.
b. Inclusion of updated maintenance procedures and schedules, ongoing operational record keeping, benchmarking results, and actions taken in the optimization of the facility systems.
c. Modifying information as changes are made to the systems, including updating the OPR/CFR and BOD.
d. Keeping the record documents current with changes in programming, nomenclature, equipment, systems, and assemblies.

e. Utilizing training mechanisms to ensure that new personnel are properly informed to perpetuate systems and procedures for updating the systems manual.

8.4 Occupancy and Operations Phase Systems Manual Evaluation and Acceptance Criteria

8.4.1 The Systems Manual format and content should be reviewed and approved on a periodic and scheduled basis by the responsible person on the building Owner's staff, or designated representative of the Owner. This is especially important when a contracted firm or property manager is in charge of maintaining the Systems Manual. This process is essential to ensure effectiveness of the systems manual as a tool for efficiently maintaining equipment, systems, and assemblies over the life of the building.

8.4.2 The procedures and processes for updating the Systems Manual should be reviewed by the party responsible for maintenance of the systems manual as part of a continuous improvement process and approved by the Owner on a periodic and scheduled basis.

9. EXISTING BUILDING FUNCTIONS

9.1 Introduction

For existing facility systems and projects, the plans and documentation sources often vary from new construction. The requirements for assembling a Systems Manual if it does not exist or updating an existing Systems Manual may require document gathering alternatives and alternative assembly procedures.

9.2 Existing Building Systems Manual Objectives

9.2.1 For updating of an existing Systems Manual, if the building had a Systems Manual prepared at the time of construction or renovation, those documents should be updated and maintained as described in Chapter 8 of this guideline..

9.2.2 In providing a new Systems Manual for an existing building, if no organized Systems Manual exists for a building, the documentation, to the extent that it exists or can be developed, should be gathered and assembled in the format required by the Owner. The purpose of this Systems Manual is the same as in a new building, that is, to provide design, construction, and operations information for training of the operating and maintenance staffs.

9.3Existing Building Systems Manual Documentation Requirements where no Systems Manual Presently Exists

9.3.1 Gathering Information

a. Original design, drawings, and specifications can be found in some facilities in the maintenance office or property manager's area. In some cases, the information may be in a storage area. If the original or remodel design team is known, they may be a source of design documents. Usually this information is in paper format and will need to be scanned if the Systems Manual will ultimately be in digital form.

b. Current Facility Requirements should be documented in a written plan. This is a fundamental requirement for proper building operation. These requirements should include the form and format for the Systems Manual.

c. Existing submittals for equipment and systems should be located in the maintenance office or storage area. This information will assist in the operation and maintenance of the building. Most likely, the submittals will be in paper form and will need to be scanned into digital form for an electronic format Systems Manual. The submittals should be arranged in a logical order, such as the CSI Master Spec format, and include an index system.

d. Existing equipment O&M documents and manufacturer supplied information should also be located in the maintenance office or storage area. The O&M data will most likely be in paper form and will need to be scanned into digital form for an electronic format Systems Manual. If the model and serial number of the equipment is available, usually on a nameplate, the manufacturer could be contacted and the equipment documentation requested. This information will need to be arranged in a searchable format for convenient use. This arrangement could be similar to the CSI master format or the manufacturer's O&M data merged with the submittals and specifications so that all the information on a specific piece of equipment or system is in the same location or chapter in the Systems Manual.

e. Existing and current sequences of operation are essential to the building operation. These can often be located with the facility control system information. If the facility has a computerized energy management and control system, the sequence may be included in or derived from the control system computer or documentation. If a written sequence of operation for the facility is not

available, one should be developed with information from the CFR and the operating knowledge of the building staff. This sequence of operation should be entered into the Facility Guide and operating plan in an understandable format.

f. Existing facility maintenance programs, plans procedures, and schedules should be located from building maintenance operation documentation. If there are no written plans, these should be developed and included in the Systems Manual to assist in the continuity of building operation and to assist in building improvement programs. Current facility operation and maintenance personnel and maintenance contractors are usually the best sources for this information.

g. Existing maintenance testing records separated by system should be collected and entered into a records section to provide a base of operating data for future maintenance programs and building improvement programs.

9.3.2 Format Development
The format of the Systems Manual and the collected information should be defined in the CFR. This information should be arranged to best suit the building operating requirements, be understandable to the operating staff, and be easy to locate and use.

9.3.3 Documentation Processing
The documentation should be in digital form if the Systems Manual is assembled in that media. It is recommended that the digital format be used to reduce the loss of parts of the documents and to make the information easier to find.

9.3.4 Developing Plans, Records, and Documents that do not Currently Exist
A complete facility Systems Manual would contain all the information included in the contents list in Section 4 of this guideline. However, in existing buildings that were not commissioned and/or a Systems Manual was not provided, this is seldom the case. As many of the documents that can be located should be captured and arranged in a standard format for future use. The Facility Guide information and current operating and maintenance information should be developed from current operations as a minimum for building operation.

9.3.5 Information Retention and Updating
The Systems Manual should be maintained and updated with available information. Even if the manual is not complete or ideal, it should be treated in the same manner as a document needed to properly operate the building. The documents should be reviewed on a regular and scheduled basis and updated as required to keep them current. Any changes to equipment or facility operations should be entered into the Manual at the time of the change.

9.3.6 Systems Manual Usage and Access
The Systems Manual is intended to be used by building management, O&M personnel, maintenance contractors, and design and commissioning teams for building commissioning and upgrading. The access to the Systems Manual information in a digital format is the most convenient for all users.

9.4 Existing Building Systems Manual Evaluation and Acceptance Criteria

9.4.1
The Systems Manual format and application in the project documents should be reviewed and accepted by the building O&M management and staff on a periodic basis.

9.4.2
The Systems Manual should be reviewed and approval by the owner on a periodic and scheduled basis.

10. COMPUTERIZATION AND INTERFACE WITH OTHER PROGRAMS

10.1 Introduction

Even though a Systems Manual can be assembled in a hard copy format, it is usually better to digitize the information and assemble it into a searchable format. The volume of information is much easier to handle and store in digital form. There are several formats available for the assembly of the Systems Manual, from manual paper copies, to digitized versions of the paper documents, to totally computerized systems.

10.2 Computerization and Interface Objectives include:

a. Capturing all the information in a common digital format to make access easier.
b. Reducing the loss of information that can be physically removed from a printed manual.
c. Improving the accessibility to the information.
d. Making the manual easier to maintain and update.

10.3 Computerization and Interface Documentation Requirements

10.3.1
The most important requirement for a digital Systems Manual is to provide a format that can be stored on a computer system or produced on CDs that can be accessed and read by the intended users. If the intent is to make the information available on a full time basis on mobile platforms such as tablet computers, then the system will be more complex.

10.3.2
The simplest format for a digital Systems Manual is a spread sheet or database program. An outline or index can be created on a computer or server system and the documents entered in the outline as they are collected. This method is among the simplest, but searchability can be a challenge.

10.3.3
Several more complex database systems have been developed and have varying degrees of functionality.

10.3.4
The US Army Corps of Engineers has developed a very complete system of design and construction data collection that can interface directly with some computerized maintenance programs. That system is called ‘COBie’ or Construction Operations Building Information Exchange.

10.4 Computerization and Interface Verification and Acceptance Criteria

10.4.1
The Systems Manual format and application in the project documents should be reviewed on a scheduled periodic basis and accepted by the building O&M management.

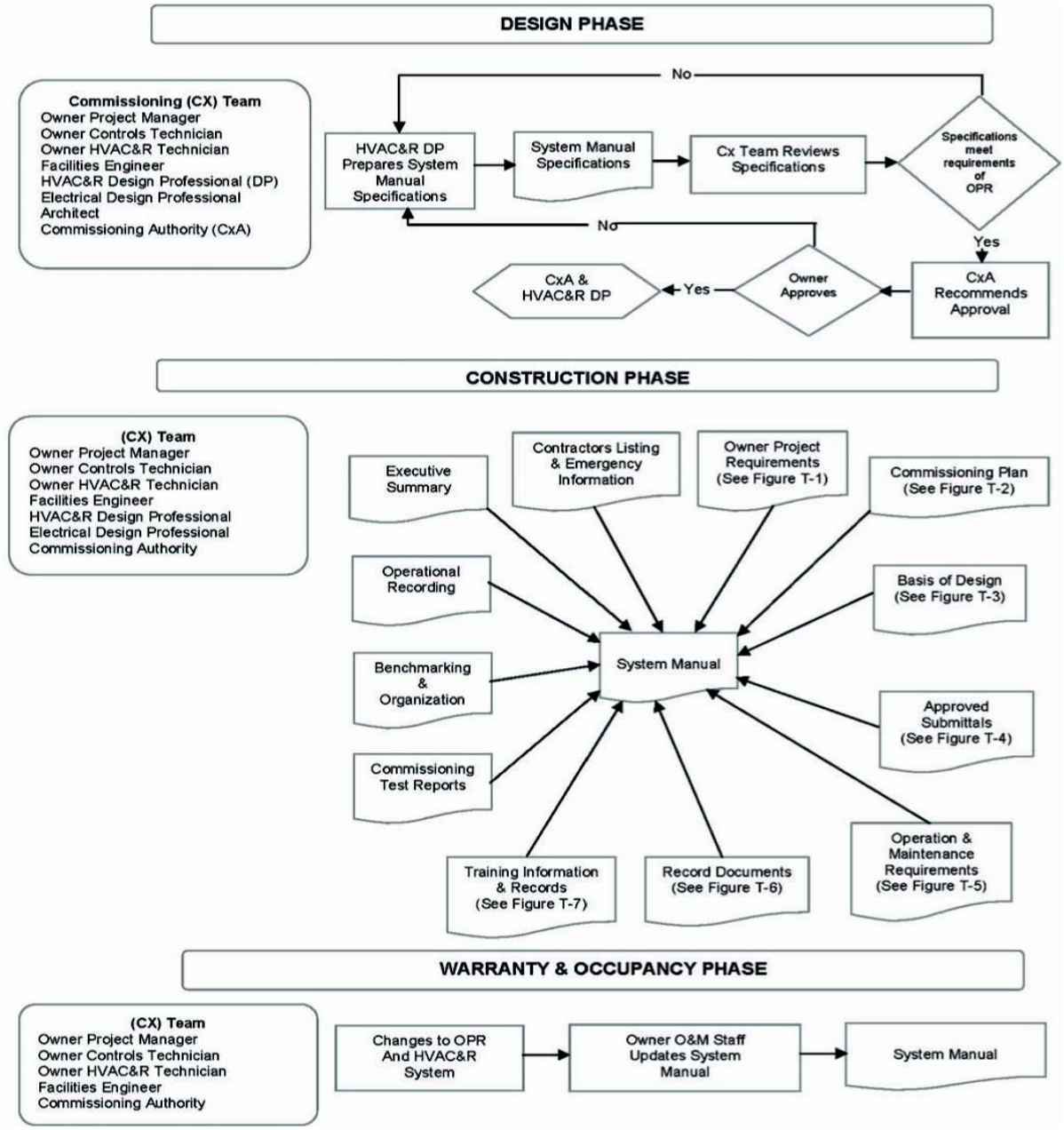
10.4.2
The Systems Manual should be reviewed and approved by the Owner on a periodic and scheduled basis.

INDEX TO ANNEXES

This annex is not a mandatory part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline. It has not been processed according to the ANSI requirements for a guideline and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.

INFORMATIVE ANNEX A

Systems Manual Documentation Matrix



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INFORMATIVE ANNEX B

Systems Manual Contract Requirements
Initiating the Process

Systems Manual assembly is a team effort, and the entire project team is part of the Process. The OPR/CFR and Cx Plans define project team's roles and responsibilities, communication protocols, assembly activities, and the schedule of those activities. Success is dependent on each team member's understanding of what is expected of them and obtaining their buy-in. That is why it is essential that the Owner clearly define, contractually, each team member's role and responsibility and their part in the Systems Manual Process and achievement of the defined objectives and criteria defined by the OPR or CFR in providing the Systems Manual.

The Owner is head of the project and shall be engaged in defining the team's goals and objectives, verifying they are clearly documented in the OPR documents, contract, and project requirements. The Systems Manual providers use these directives to implement the Process for the Owner's benefit.

The Owner shall require the update of the OPR and Systems Manual as defined objectives and criteria contained in the document are changed as the project progresses.

The Owner shall mediate and provide direction to project team for issues identified but unable to be resolved among the team as part of the issue resolution process to resolve disposition of issues identified through the Project Processes. The Owner shall approve, in writing, the resolution.

Setting Contractual Requirements

This annex provides suggested examples of how to implement the process contracting activity. It is not intended to be a comprehensive representation or a best practice example. Owners and practitioners applying the project process should carefully follow ASHRAE Standard 202 and applicable technical guidelines tailored to their specific projects.

Suggested contract language must be developed for each activity applicable to a specific project or building such as:

Systems Manual

a. Project and Commissioning Teams shall include in the specifications contractor deliverables defined in the OPR/CFR to become part of the Systems Manual assembled by the Project Team. The specifications shall define the format and information required in the submittal.

b. Designer shall provide BOD information in defined format for inclusion in Systems Manual.

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INFORMATIVE ANNEX C

Roles and Responsibilities

Summarize project specific responsibilities such as provided below in the appropriate contract documents.

Team Members
The members of the project and commissioning teams consist of the Owner or representative, CxA, design professionals, assigned members of the Construction Manager/General Contractor team, appropriate sub-contractor(s), and any other installing subcontractors or suppliers of equipment. The Owner's building or plant operator/engineer is also a member of the commissioning team.

General Management Plan
The CxA is hired by the Owner. The CxA's responsibilities, along with all contractors' responsibilities, are detailed in the specifications. The specifications will generally take precedence over the Cx Plan. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents and assembly of the Systems Manual.

General Descriptions of Roles
General descriptions of the commissioning roles are as follows:

CxA: Coordinates the process, writes tests, and oversees and documents performance tests and the assembly of the Systems Manual.

GC: Facilitates the project process, ensures that Subs perform their responsibilities, and integrates the collection of documents and assembly of the Systems Manual into the construction process and schedule

Subs: Demonstrate proper system performance and submit the documentation for the Systems Manual

DP The Design Professionals perform construction observation, approve O&M and Systems Manuals, and assist in resolving problems.

PM: Facilitates and supports the process and gives final approval of the Systems Manual

Mfr.: The equipment manufacturers and vendors provide documentation to facilitate and perform contracted startup and submit documentation for the Systems Manual.

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INFORMATIVE ANNEX D

Systems Manual Executive Summary

The executive summary contains an overview of the building design, construction, and operational requirements. The information is intended to provide general guidance on the intended operation, performance, and maintenance of the building in conformance to the OPR and/or CFR.

SYSTEMS MANUAL

EXECUTIVE SUMMARY

1. Overview of the Facility Design and Intended Use.
   Using the OPR and/or CFR as references, this section describes the facility and outlines its intended uses. The systems and assemblies included in the Systems Manual are listed and described along with their function in facility operations.

2. Facility Construction.
   This section outlines the construction process and history and describes any plans or intent for future changes or expansion.

3. *Ope*rational Requirements.
   Provide general guidance on the intended operation, performance, and maintenance of the facility in conformance to the OPR and/or CFR. Include a summary and direction to the operational plans and requirements included in the various sections of the Systems Manual.

4. Systems Manual Contents Description and Use.
   Section II: Facility Design and Construction:
   Describe the use, function, and location of the design documents, including the OPR/CFR, BOD, and Construction or Project documents. These provide the design foundation for the facility and the construction drawings.
   Section III: Facility Systems and Assemblies Information:
   Describe the use and location of the systems and assemblies information. This includes the project specifications, approved submittals, manufacturer's installation instructions, operational and maintenance information, warranties, and listing of design team, contractors, and suppliers. This provides specific information on the facilities systems and assemblies that can be used for operation and maintenance functions.
   Section IV: Facility Operations:
   Describe the Facility Guide and its use in daily operation of the facility. If included in the owner's requirements and the project contracts, include maintenance plans and schedules, utility measurement and reporting, Measurement and Verification Plans, ongoing commissioning plans and requirements, and janitorial plans and requirements.

Section V: Training:

Describe the training conducted during the project and the location of the training material. Include training information on the updating requirements and procedures for Systems Manual.

Section VI: Commissioning Process Report

Describe the commissioning process and results for the project, and list the locations for the testing plans, checklists, and results.

5. Update and Systems Manual Maintenance.

Describe the requirements, process, and responsibilities for the maintenance and updating of the Systems Manual.

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INFORMATIVE ANNEX E

Owner's Project Requirements and Current Facility Requirements

The following are examples of the requirements and formats for the documents to be included in the Systems Manual. This annex provides an example of how to implement part of this guideline. It is not intended to be a comprehensive representation or a best practice example. Practitioners applying the Cx Process should carefully follow ASHRAE Standard 202 and Guideline 0-2005 and applicable Cx technical guidelines tailored to their specific projects.

Owner's Project Requirements

The OPR is developed and defined in the beginning of the project delivery process. Information about the project is gathered, including program requirements, community context, codes and regulations, site and climate, facility context and function, facility technology, sustainability, cost, schedule, and the client's (including Owner, occupants, operators, and maintenance personnel) needs and capabilities. The OPR provides the basis from which all design, construction, acceptance, and operational decisions are made. An effective Cx Process depends upon a clear, concise, and comprehensive OPR document, which includes information to help the project team properly plan, design, construct, operate, and maintain systems and assemblies. The OPR is often developed in an OPR workshop that is described in ASHRAE Guideline 0-2005.

The Owner is encouraged to provide a minimum of five participants that equably represent the various groups associated with the existing building or future project.

The OPR are considered the heart and soul of the Cx Process. When the OPR are not developed, the Owner, designer, contractors, and O&M personnel each interpret the building requirements, including their individual responsibilities, from the standpoint of their own specific needs. This often creates a range of diverse views of the constructed project's needs. Developing OPR that reflect the actual needs of the Owner, the users or occupants, service and operating units, and sometimes the community is one of the, if not the, most difficult and important aspects for successful implementation of the Cx Process.

The following sections detail an example format to follow in developing the OPR and a discussion of how to obtain the required information. Note that historically, the OPR has often been referred to as "design intent" or "project intent."

Format

Key sections of the OPR document are:

- Background – a narrative description to provide context about the project.

- Objectives – for any project, there are goals that must be achieved for the project to be successful. Goals can range from first cost, to time schedule, to number of change orders, or to life cycle cost. Regardless of which goals are identified, they must be summarized up front to ensure everyone is on the same page.

- Green building concepts – this is an optional section for Owners who wish to focus upon the sustainability aspects of their building.

- Functional uses and requirements – in addition to general documentation produced by the architect on functional uses of the building (office, storage, kitchen, etc.), the specific requirements for each functional area must be documented. This can include such items as security, safety, comfort, energy, maintainability, and indoor air quality.

- Lifespan, cost, and quality – it is important to clearly document the Owner's expectations for lifespan of materials, cost of construction, and the level of quality desired. By providing this information, unrealistic expectations are identified and eliminated.

- Performance criteria – often the most difficult to define, performance criteria detail minimum acceptable performance benchmarks for various aspects of the facility.

- Maintenance requirements – the maintenance requirements are a mixture of the level of knowledge of the current O&M staff (what can they maintain) and the expected complexity of the proposed systems (what they can learn). If there is a significant gap between the two, no matter how well the building is constructed, it will not be maintained or operated properly.

The following are examples of OPR elements that are common to most of the Technical Commissioning Process Guideline topics.

- Benchmarks for performance – specific criteria for the functional use of each space, assembly, and system must be defined. These include temperature, humidity, airflow, light, noise, durability, aesthetics (materials and colors), service life, reliability, redundancy, and the like. Typically, upper and lower limits are provided for general spaces, with exceptions noted as required.

- Problems to avoid – since occupant/user/operator complaints are common, it is important to identify and document those problems that have caused complaints in the past. If these problems are not documented and the situation recurs, the occupants often consider the entire project as a failure.

- Specific occupant requirements – specific items that are deemed important to the various occupants in a building must be identified and documented. In speculative-built buildings, this section would detail the limits to which occupants can make use of their spaces. For example, a chemical laboratory cannot be put in a space designed and constructed for general office use without significant changes to the systems and possibly to the building as a whole.

Obtaining the Information

While it may be easy to obtain the basic information related to development of the OPR, it is difficult to obtain quality information that the Owner, O&M staff, service contractors, customers (i.e., students, patients, retail customers, renters), visitors, sub-tenants, occupants, and the community all agree upon. In quality-based processes, it is critical that input be obtained from all the users (the various user groups) and that the consensus of and differences between the groups are documented. There usually are requirements for which users do not all agree. These must be documented as unresolved items. Normally, the Owner will make final decisions on what the priority order of OPR will be. However, the Owner and the rest of the Cx Team must be aware of all requirements so that the final product will include as many individual group requirements as are deemed appropriate and within the budget.

A simple, three-step process is recommended for developing the OPR:

1. OPR Workshop.

2. OPR Documentation (Report).

3. Project Team Approval of the OPR.

OPR Document

A general format for an OPR document is presented below. The structure provided is intended to encompass the facility requirements and enable the addition of sections depending upon the systems and assemblies to be constructed and commissioned.

Introduction – Includes an overview of the project and the general reasons why the project is being undertaken. A description of the Owner's processes (Cx Process) is typically contained in this section.

Key Owner's Requirements – Includes a listing of the key Owner's requirements that the Cx Process will focus upon and that the Owner (Cx Team) has determined are critical to the success of the project.

General Project Description – The size and scope of the project are included in this section.

Objectives – The objectives for accomplishing this project are detailed in this section.

Functional Uses – The expected functional uses (spaces) for the facility are detailed in this section. A short description of each functional use is included to provide the context in which it was detailed.

Occupancy Requirements – Includes the number of occupants (users and visitors) and the schedule of occupancy, including all special conditions.

Budget Considerations and Limitations – The expected budgetary restrictions and considerations are contained in this section.

Performance Criteria – The performance criteria upon which the project will be evaluated by the Cx Team are included in this section. Each system and assembly performance criterion should be measurable and verifiable. Include subsections as appropriate to organize and explain the criteria:

- Commissioning Program Requirements
- Economic and efficiency requirements
- Environmental and sustainability goals
- Environmental Requirements Construction Process if a project requirement
- Maintainability and Maintenance Program Requirements
- Operations Training Requirements
- Benchmarks
- Documentation and Format Requirements, including Systems Manuals.

Owner's Project Requirements Version History – Includes a summary of the changes made throughout the Pre-Design, Design, Construction, and Occupancy and Operations Phases. This information is critical to understand and document the trade-offs made over time and the resulting impact on the project.

Current Facility Requirements

The key to a successful existing building commissioning project is well defined CFR. The CFR form the foundation of any design meeting the Owner expectations. When the CFR are given the time and effort necessary in documenting the Owner's present and future requirements, there is a high probability that the facility will be effectively commissioned and the Owner will be satisfied.

For those facilities commissioned using a process similar to that defined in Guideline 0, the OPR become the CFR for the existing facility and are updated by using the same process outlined in Informative Annex I. The update of the original OPR should also focus on all modifications to the facility and those systems and assemblies that are underperforming.

As the EBCx proceeds during the different phases, the CFR may require updating or amending. This may occur, for example, as the budget and costs change. No changes to the CFR will occur without the Owner's written approval. For example, the CFR may require that new windows be impact rated certified to Category 5 hurricane level. If the window replacement bid exceeded the budget, the CFR could be changed (and approved by the Owner) to design non-impact rated windows with provisions for field installed protection during a hurricane.

Developing the CFR includes contributions from all the stakeholders that use, occupy, operate, and maintain the facility. The CFR will contain both technical and non-technical requirements (e.g., technical requirement: replace roof with an R-30 roofing assembly; non-technical requirement: comply with LEED for existing buildings at Gold level). The CFR contains specific and measurable requirements (e.g., instead of "the light level in offices will be adequate," the CFR may read, "the light level in offices will be 40 foot-candles measured at 30 inches above the floor level"). The CFR must be concise, clear, correct, and complete, reducing the risk for any misinterpretation.

Some of the more general requirements for the CFR are listed below. These CFR requirements may expand or contract following focused discussions with the Owner.

Suggested CFR contents are:

1. User/Occupant Requirements
2. Owner Directed Requirements
3. Specific facility requirements such as environmental and energy goals, level of systems control, and/or sustainability certification
4. Training requirements
5. Sustainability requirements
6. Equipment and systems maintainability requirements
7. Capabilities of operators and maintenance team
8. Documentation requirements
9. Regulatory requirements
10. Ongoing commissioning requirements
11. Benchmarks
12. Financial requirements and investment criteria.

Current Facility Requirements
Outline Example

The CFR are developed from all stake holders requirements that are gathered during CFR workshop(s). Where an OPR exists, it would be updated and modified. The resultant document will be the CFR.

The following example document provides a template for how a CFR document may be formatted and what types of information should be covered in typical applications. The document is structured as a template given that in most cases, any specific content from example projects will serve to limit the scope towards the specific issues and objectives of that application. For each section of the template, normal text fonts provide example language specific to that section while *italicized font* provides the reader with guidance as to the type of information that would be added to that section specific to the facility under consideration.

1.0 User Occupant Requirements

This section should be used to define any specific requirements of the facility occupants and users that are necessary to meet the overall mission requirements. These may be current facility features that must be maintained or those that need to be added to support facility operation.

1. Private offices occupants will be able to adjust the temperature set point in the offices.

2. The ground floor (southwest quadrant) will be converted to a cafeteria for users and occupants of the building.

2.0 Owner Directed Requirements

This section should define any directives given that need to be addressed by the EBCx process. This is an interactive process to generate information between all of the stakeholders.

1. The existing windows shall be replaced with impact rated windows in a 150 mph zone.
2. The roof shall be replaced with a green roof with minimum R-35.
3. The fire alarm system shall be manufactured by Notifier.
4. Building shall be sprinkled.

3.0 Specific Facility Requirements

This section should define specific functional requirements for each area of the facility and space use variation. This will include parameters such as functional uses, space needs, occupancy requirements, systems or assemblies replacement, and comfort requirements—space temperature and humidity for occupant comfort. This may also include specific parameters for critical environments such as tolerances for minimum lighting levels, temperature variation, ventilation rates, room pressurization, noise levels etc. All variations in occupancy schedules should be defined along with any subsequent changes in operational parameters.

1. Indoor lighting requirements: Offices 45 foot candles at 30” AFF.
   List other areas and any specific non-standard requirements. E.g., pendant-mounted lighting, illumination requirements, special applications.

2. Occupant lighting control requirements: Each office shall be fitted with dual technology occupancy sensors.
   List any non-standard requirements. E.g., multi-mode controls for assembly spaces.

3. Thermal comfort requirements: maximum temperature/humidity 72°F DB at 50% RH.
   List any non-standard temperature or humidity requirements.

4. Ventilation and filtration requirements: ventilation shall meet current ASHRAE Standard Filters for occupied areas. Shall be Min MERV 12.
   List any non-standard requirements.

5. Occupancy HVAC control requirements: occupants shall be able to adjust the temperature set point 2°F
   List any non-standard requirements. E.g., integration with existing control systems.

6. Acoustic environment requirements: office shall be maximum 35 RC.
   List any non-standard requirements. E.g., local noise sources requiring mitigation, spaces such as classrooms that require low background noise and short reverberation times.

7. Other Owner requirements: *e.g., natural ventilation, operable windows, daylight.*

4.0 Training Requirements

This section should define the expectations for the core competency level of the facility personnel responsible for operating the facility. This will serve as an evaluating metric to determine any training requirements necessary to achieve the required competency level at all necessary levels of the facility staff.

1. Factory or onsite training for the Owner, whether owner staff, contracted staff, or users/occupants, shall include a description and overview of systems, not just the

components and equipment that comprise each system.

2. Training 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 & solutions.
3. Training shall be performed for the following building systems and assemblies:

   i. List all systems and assemblies that have been affected, e.g., lighting control security systems, roof assembly.

   ii. List all systems and assemblies that were not affected, e.g., chiller plant.

4. Building systems that the *occupants/users shall be trained on include*:

   i. *List all systems and assemblies that the occupant/user needs to operate, e.g., lighting controls.*

5. Most training shall be completed prior to the end of the Implementation Phase and an electronic copy (DVD format) provided for the Owner's use.

5.0 Sustainability Requirements

The facilities systems and assemblies shall be renovated/upgraded to provide long life while promoting environmental quality and resource conservation through sustainable design and construction.

1. The commissioning process shall result in a LEED –EB 2009 certification at no lower than silver level.

i. *List specific sustainability goals, e.g., water efficiency, energy efficiency, etc.*

2. Ongoing commissioning shall achieve the 2030 Challenge to result in zero possible fuel based energy.

6.0 Equipment and Systems Maintainability Requirements

This section should define the minimum requirements for the maintainability of facility systems and assemblies.

1. All equipment shall be installed with manufacturer's recommended clearance.

2. All equipment shall be easily accessible to maintenance staff.

3. Adequate sized doors/access panels shall be provided for equipment replacement.

7.0 Capabilities of Operators and Maintenance Team

This section should define the capabilities of the operators and maintenance team, including their experience, training in specific systems and assemblies, and level of education.

1. The HVAC chillers will be maintained by an outside vendor.

2. The Owner fire alarm technicians have been factory trained and certified in Notifier systems.

3. All the Owner technicians have obtained craft certification from technical institutes.

8.0 Regulatory Requirements

This section should define specific regulatory requirements placed on the operation of the facility and what impact this may have on the manner in which the facility, systems, and

assemblies are operated, monitored, and maintained. The specific requirements may vary throughout the facility based on different functional requirements of specific areas of the facility. Examples would be references to specific Environmental Health and Safety standards such as College of American Pathologists (CAP) and Clinical Laboratory Improvement Act (CLIA) and Federal, State, and provincial civic and county requirements.

1. Fire sprinkler systems – NFPA 13 - latest edition (even if not adopted by the Fire Marshall).

2. Florida Building Code.

9.0 Ongoing Commissioning Requirements

This section should define the ongoing commissioning requirements. This will include the frequency for the ongoing commissioning of each system and assembly.

1. Ongoing commissioning for mechanical systems will be performed every 3 years.

2. Ongoing commissioning for electrical and plumbing system will be performed every 5 years.

10.0 Benchmarks

This section should define the evaluation methods that will be used to compare existing performance of the overall facility, systems, and assemblies. There are innumerable criteria that may be employed based on the type of facilities, systems, and assemblies under evaluation. This may involve easily quantified criteria such as indoor environmental quality issues (temperature, humidity, ventilation rates) or energetic performance (overall or component energy usage). However, this may also include more subjective criteria such as occupant satisfaction, improved occupant productivity, etc. The CFR should define what specific parameters will be used, how they will be quantified (baseline), and what improvements can be expected. The CFR should also define what benchmark criteria will be used to evaluate the baseline performance. This can be through established database information for similar facilities (such as energy usage index [kBtu/ft^2]). However, this may be difficult when evaluating parameters for which no database exists for comparison.

1. Temperature changes throughout each floor shall not vary more that 4°F.

2. Energy consumption shall be 30% less than present consumption.

3. Post-occupancy surveys shall be used. Acceptable responses for all categories shall not be less than 70% of the responses.

11.0 Financial Requirements and Investment Criteria

This section should be used to define how identified recommendations will be evaluated for implementation. In many cases, this may be some method of economic evaluation (simple payback, life cycle cost, return on investment, etc.). However, there may be other cases where monetary impacts of the expected improvements are secondary to other benefits or difficult to quantify. It should also be discussed whether measures will be evaluated individually or whether bundling of recommended measures can be used. Bundling may allow for high priority improvements with less attractive singular evaluation criteria to be combined with other higher performing measures to provide a combined project that meets the overall investment criteria.

1. Project having a Simple payback of less than 2 years will be implemented.

2. For major changes to systems and assemblies, life cycle costs determine the option to be implemented. *List discount rate, period of study, escalate rate criteria for energy, etc.*

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INFORMATIVE ANNEX F

Commissioning Plan

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

This annex provides an example of how to implement a Cx Plan from project initiation through occupancy. It is not intended to be a comprehensive representation or a best practice example. Practitioners applying the Cx Process should carefully follow ASHRAE Standard 202 and ASHRAE Guideline 0-2005 and applicable Cx technical guidelines tailored to their specific projects.

The following is an example outline for a Cx Plan. The basic structure of this example is such that each phase of the plan has its own section detailing what activities will be accomplished and guidance on who accomplishes it and how it is completed. The deliverables for each activity are included in an appendix. Each section of the plan will have a description of the requirements for that subject. The intent of this format is for the Cx Plan to become the Final Cx Process Report at the end of the project by updating the plan and filling in the results for each section as the project progresses.

Depending upon the size and scope of the Cx Process activities, it may be beneficial to have three Cx Plans: one for the Pre-Design Phase, one for the Design Phase, and one for the Construction Phase. If separate Cx Plans are used, then care must be taken to inform those that are involved in only a portion of the process of the previous material.

Commissioning Plan

Table of Contents

CONSTRUCTION ACTIVITIES
- Conduct Pre-Construction Meeting
- Contractor Submittal Review
- Construction Checklists
  - Delivery Process
  - Pre-Installation Checks
  - Installation and Start-Up Checks
  - Performance and Coordination Checks
- Testing
- Documentation
- Systems Manual
- Training
- Preliminary Commissioning Report

OCCUPANCY AND OPERATIONS ACTIVITIES
- Seasonal Testing
- On-Going Training
- Warranty Review
- Lessons-Learned Meeting and Report
- Final Commissioning Report

CONTACT AND RESPONSIBILITY INFORMATION

SCHEDULE REQUIREMENTS

Provide a detailed description of Cx Process activities and a schedule of activities. The design milestones shall include the Cx Team meetings, OPR development, design reviews, and the completion of the BOD and the Cx specifications. For construction and renovation activities, the additional milestones shall include the Cx Team meetings, submittals, installation checklists completion, start-up plan start and finish, performance testing, Owner move-in, training, O&M and record drawing completion, deferred seasonal testing, warranty review, and final Cx Process Report. For commissioning in existing buildings, milestones shall include representative tasks from the planning, investigation, testing, implementation, and hand-off phases.

Appendices in the initiation and design stages of the project will state the requirements and responsibilities for that deliverable. The final results and documentation for each item will be inserted in the final report.

It is not necessary to include copies of documents included in the Systems Manual in the final Cx Report if that Cx Report is included in the Systems Manual, but the location of the document(s) shall be noted.

APPENDIX A – OWNER'S PROJECT REQUIREMENTS
APPENDIX B – BASIS OF DESIGN
APPENDIX C – PROJECT SPECIFICATIONS
APPENDIX D – COMMUNICATION STRUCTURES
APPENDIX E – ROLES AND RESPONSIBILITIES
APPENDIX F – COMMISSIONED SYSTEMS [listing of systems and assemblies]
APPENDIX G – COMMISSIONING PROCESS SCHEDULE
APPENDIX H – PRE-BID MEETING
APPENDIX I – PRE-CONSTRUCTION MEETING
APPENDIX J – SUBMITTAL REVIEW
APPENDIX K – COMMISSIONING PROCESS ISSUES
APPENDIX L – CONSTRUCTION CHECKLISTS
APPENDIX M – TESTS AND DOCUMENTATION
APPENDIX N – SYSTEMS MANUAL ASSEMBLY
APPENDIX O – TRAINING
APPENDIX P – MEETING MINUTES
APPENDIX Q – CORRESPONDENCE
APPENDIX R – WARRANTY REVIEW

APPENDIX S – OPEN ISSUES
APPENDIX T – LESSONS LEARNED

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INFORMATIVE ANNEX G

Basis of Design

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

This annex addresses specific requirements for the Systems Manual, requirements developed and included in the BOD document, and must be coordinated with the Basis of Design documents of other technical guidelines. The BOD document records the major thought processes and assumptions behind the facility design decisions made to meet the OPR as they relate to the System Manual. The design professional must read the entire OPR before starting the BOD. The BOD document captures important information linking the “what” of the OPR and “how” of the system design.

The objective of specifically documenting the Systems Manual requirements in the BOD information is to provide the parties involved in a project, at each phase in the process, an understanding of the underlying thinking that led to the selection of specific components, systems, and system integrations. This includes documenting the type of system chosen as well as documenting those rejected during the initial phase of the project and why they were selected or rejected. A design narrative that provides an overview of systems in verbal format is usually an integral element of the BOD.

The specific contents of the BOD document will vary from project to project and system to system, but in general should address the following for the information required in the Systems Manual:

1. List specific codes, standards, and guidelines considered during the design of the facility.

    - List the specific building codes being utilized for the design of the project. This should include the title of the code and the year.
    - List specific standards (including year of publication) being utilized in the design of the project (e.g., ANSI/ASHRAE 62.1-2004, NFPA 45-2000).

Basis of Design

The BOD should be reviewed and updated as part of each design submission during development of the design, after issue of supplementary instructions during the construction process, prior to occupancy, and after completion of acceptance testing.

Sample Basis of Design Requirements to be contained in Owner’s Project Requirements

Introduction: The BOD is a written document that shall detail the design team’s approach to the OPR.

Process:

The general process for producing the BOD shall be:

1. The OPR shall provide a list of required information and the format for the BOD to the design team prior to the start of design.

2. The design team shall gather and organize the information during the creation of the design.

3. The design team shall submit the BOD to the Owner and CxA for review and comment with each design document submittal.

4. The BOD shall be updated by the design team to provide increasing levels of detail as the design evolves.

5. The BOD shall be updated by the design team to reflect changes to design criteria and systems during the subsequent phase of the project and the reason for those changes.

6. The design team shall work with the Owner and CxA to resolve review comments.

7. The BOD shall include signature blocks for acceptance by the Owner and CxA.

Basis of Design Content

The content of the BOD shall be as follows:

The following BOD contents will be edited for each project based on discussions between the Owner, CxA, or other parties. Ideally, the requirements for the BOD, 3rd party Cx, sustainable rating certifications, measurement and verification, energy modeling, and other non-traditional design elements are identified prior to receiving proposals for services from the design team.

HVAC

Schematic Design

- Occupancy schedule (time and number of people)
- Climatic design criteria
- Indoor design criteria, including tolerances (allowable temperature and humidity ranges)
- Design diversity per system
- Redundancies
- Applicable building codes
- Additional design requirements (LEED and energy goals, other special requirements)
- Sustainable code requirements
- Design narrative, including description of how each sustainable design requirement is met
- Controls system narrative
- Renewable energy systems narrative

Optional

- Design narrative (system options described in sufficient detail for energy modeling)
- Ventilation calculations for each above system option

Design Development

- Preliminary energy modeling report
- Ventilation optimization narrative
- ASHRAE Standard 62.1 calculations
- Heating and cooling loads calculations (input and output files)
- Equipment cut sheets (equipment around which the design was based)
- Control schematics, database, points list, sequences, alarm conditions, and operator interface elements

Construction Documents

- Any modifications to Design Development BOD

Lighting

Schematic Design

- Design power capacity (W/sf)

- Design illumination levels (FC)
- Lighting performance goals and standards
- Lighting and lighting control narrative
- Anticipated lighting power density (LPD) for each space type

Design Development

- Lighting calculations
- Power load calculations
- Lighting control zoning diagrams
- Lighting system control information distributed to potential suppliers

Optional

- Short circuit study

Construction Documents

Ensure lighting controls CDs include:

- Finalized specification language
- Dimension locations of ceiling-mounted sensors
- Controls initial calibration criteria
- Defines the timing of final calibration (for daylighting controls) after partitions/furniture in place
- Defines initial scheduling or time clock requirements
- Identifies interface coordination requirements
- Defines any other programming such as scenes, overrides, or special events

Other Systems

Develop BOD requirements for other systems as required by the OPR.

Format and Organization

The format and organization of the BOD shall detail the design response to the OPR requirements as follows:

1. Major sections shall include **<edit as appropriate for each project>** Envelope Systems, Interior Systems, Electrical and Lighting Systems, HVAC Systems, Renewable Energy Systems, and Plumbing and Service Hot Water (SHW) Systems. Within each major section shall be sub-sections labeled for each required design submittal (Schematic Design, Design Development, etc).

2. An updated BOD shall be required to be submitted with each design submittal. Updates shall include descriptions of changes to the design since the previous submittal, the reasons for those changes, and additional detailed information that becomes available as the design progresses. Design submittals for this project include **<edit as appropriate for each project>** SD, DD, and 50%, 95%, and 100% Contract Documents.

3. The BOD shall reflect the progression of the design within a single document. Sections previously submitted shall not be modified, but rather be addressed, as necessary, in the new section related to the current submittal.

4. Non-narrative type information shall generally be provided in a BOD appendix for each submittal and be referenced in the narrative.

5. The main-body of the BOD shall be concise, providing the reader with concise descriptions of systems and later modifications and detail on those systems.

6. The BOD shall not duplicate information provided in plans and specifications, but shall reference that information as appropriate.

7. The BOD shall address how the OPR are implemented into the design. For any criterion of the OPR that could not be met, documentation detailing what was done, its impact on the OPR, and how the

OPR was modified shall be included. It is not intended that the BOD repeat the text of the OPR with comments addressing each individual OPR criterion, but rather that the BOD remain a concise, readable document that is useful throughout the design and construction processes and into occupancy.

Acceptance

The BOD shall include signature blocks for acceptance by the Owner and CxA of each BOD submittal.

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INFORMATIVE ANNEX H

Construction/Project Record Documents Process

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

The collection and retention of record documents is essential to the ongoing operation of the building and can be critical in any building upgrades and modifications. If the record drawings and documents are digitized they may be able to be included in the Systems Manual computer file. This is highly recommended. If the drawings are available in paper or transparency format, the location of the documents should be included in the Systems Manual.

Documents can include:

Drawings:
- Architectural
- Site
- Civil
- Landscape
- HVAC
- Plumbing
- Electrical
- Fire Protection and alarms
- Communication Systems
- Other

Other record documents include change orders, architect's supplemental instructions, and additional information that reflect actual constructed conditions.

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INFORMATIVE ANNEX I

Project Documents and Submittal Review Reports

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

Design Review Report

This annex provides an example of how to implement a sampling process if directed by the Owner. It is not intended to be a comprehensive representation or a best practice example. Practitioners applying the Cx Process should carefully follow ASHRAE Standard 202 and ASHRAE Guideline 0-2005 and applicable technical information tailored to their specific projects.

Design Submissions

A critical step in the Cx Process is the review of the design submissions from the design professionals. It is important to remember that the role of the CxA is to verify that the OPR are met and that the system is designed in a quality manner. There are three distinct reviews that are completed on a drawing set – general, coordination, and field specific. A review of the specifications is also required.

The use of sampling in the design review and the sampling process must be defined in the OPR. The Cx Plan can also add requirements and information to the design review process and procedures.

The general steps of completing a drawing review are as follows:

General Review

1. Review the OPR: since the drawing review is to verify the OPR were met, prior to the review, the OPR should be reviewed to familiarize the reviewer with the key criteria of the facility.
2. Document the General Review Criteria: the criteria from which to accomplish the general review of the submission must be documented. The criteria should be based on general quality characteristics and specific OPR criteria. The general quality characteristics should include items such as:

    - Continuation of items (ductwork, pipes, walls, electrical wiring, etc.), from page to page
    - Labeling, including correct room numbering
    - Details corresponding to actual components
    - Schedules include BOD information
    - All information is legible (not hidden by crossing lines or text)

- OPR information is included on documents.

3. Accomplish Quick General Review: the general review is intended to familiarize the reviewer with the submission. If during this review significant items are identified as poor quality, then the review process should be stopped and the design professionals contacted to discuss the quality concerns. If the general quality is good, move on to the Coordination Review.

Coordination Review

1. Determine Sampling Areas: for each floor plan area (e.g., if there are five sheets for each floor, then there are five floor plan areas for each floor) select a single building area randomly. A simple way to do this is to divide the drawing sheet into 15 squares (5 by 3) and select square number 3 on the first sheet (area) and then 5, 7, etc., for each remaining area. This selection is accomplished typically using the architectural sheets.

2. Select Review Samples on Drawings: using the sampling strategy chosen in Step 1, mark the sample areas to be reviewed in each area. This should be accomplished for each trade (landscaping, architectural, structural, plumbing, mechanical, electrical, etc.).

3. Accomplish Coordination Review: for each area, compare the squares between each discipline. The intent of this review is to identify coordination problems with the placement and installation of components. Items of specific interest include:

   - Placement of multiple pieces of equipment/components in the same location
   - Accessibility to equipment/components for maintenance/replacement
   - Use of consistent terminology (e.g., room numbers)
   - Elevations provided where multiple systems are placed in the same area
   - Other trade duties clearly identified (e.g., window assemblies, roof drains, electric wiring for HVAC equipment, holes for sinks).

If significant coordination problems are identified, stop the review and contact the design professionals to discuss. If the coordination is good, continue on with the Field Specific Review.

Field Specific Review

1. Determine the Review Sampling Procedure as defined in the project OPR and Cx Plan: use random sampling that selects every x^{th} square on the drawings to be verified. Squares that are completely blank (no walls, equipment, etc.), are not included in the counting. For example, if there are 10 pages of drawings and each drawing is split into 15 grids (5 x 3), there will be 150 potential grids to review. If a 20% sample rate is desired, then 30 grids would be reviewed, or every 5 grids. The starting grid should be chosen using a random selection process (die, 1-6 in a hat, etc.).

2. Document Review Criteria: the criteria from which to review the drawings should be based on specific OPR criteria. This typically includes items such as accessibility, maintainability, meeting sustainability goals, comfort conditions, documentation of OPR and BOD, and operating details.

3. Select Review Samples on Drawings: using the sampling strategy chosen in Step 1, mark the sample areas to be reviewed.

4. Accomplish Detailed Statistical Review: using the review criteria from Step 2 and the selections from Step 3, accomplish a detailed review of the drawings. This includes verifying that the specifications match that shown on the drawings (see below for specification review details). For example, if an air terminal box is in the selected square, the steps in accomplishing the detailed review might include:

    a. Review design calculation inputs for matching architectural assumptions and the OPR.

    b. Compare calculation results with the total airflow of the diffusers downstream of the air terminal box and with the terminal box schedule.

    c. Compare location of air terminal box with maintenance requirements of the selected make and model (BOD).

    d. Compare air terminal box location on drawings with requirements in the specifications.

    e. Review the OPR for other issues that the air terminal box could impact.

1. Document Concerns: during the review of the drawings, keep detailed notes of problems found or concerns with certain items. Also, at the end of the review, a general summary of the quality of the drawings should be developed. A letter detailing the quality of the drawings should then be sent to the design professionals and the Owner with specific recommendations and directions given.

2. Review the Drawing Review Procedure: after the drawing review is completed, this document should be reviewed and modified to improve the process for the next time.

Specification Review

1. Determine the Review Sampling Procedure: the purpose of this review is to determine the general quality of the specifications. During the Field Specific Review, the actual details are checked. The sampling procedure should check approximately 10% of the specifications.

2. Accomplish General Review: the review should focus on the quality of the specification, specifically:

    - Are there extraneous sections that do not pertain to the project (i.e., medical gas in an office building, 15 types of valves when only 2 used, etc.)?

    - If a manufacturer has been listed, has the engineer checked to verify that the OPR are met?

    - Are there any “or as equals?” (“As equal” should always be defined.)

    - Are the directions clear and concise?

3. Develop Summary of Review: develop a summary of the review. If there are problems with the specifications, contact the design professionals and discuss.

Design Professional Actions

Comments provided by the CxA need to be formally replied to by the design professionals. If systemic issues are identified during the CxA’s review, the design process should be resolved. Back-checking of the specific items may be appropriate, but not as the sole means of verifying resolution of the issue.

Design Review Report

The design review report should contain the following information:

Project title, number, and date of review

1. Executive Summary.
   Include a summary of the process used for the review and for processing the comments and responses.

2. List of documents reviewed by title and issue number or date.
   Include a list of all the documents reviewed.

3. Issues, comments, and variances from OPR.
   Include copies of all reviews, distribution lists, and responses.

4. Coordination of drawings and systems.
   Include a copy of the reviews on drawings and systems coordination.

5. Access, constructability, and maintainability questions and recommendations.
   Include a copy of the reviews on systems and assemblies access, constructability, and maintainability.

Submittal Review Report

The review of the manufacturer's and contractor's submittals is intended to verify conformance to the project OPR and gather information for the testing and commissioning of the equipment and system.

The use of sampling in the submittal review and the sampling process must be defined in the OPR. The Cx Plan can also add requirements and information to the review process and procedures. See Annex B in this standard for additional information on submittal reviews.

The submittal review report should contain the following information:

Project title, number, and date of review

1. Executive Summary.
   Include a summary of the process used for the review and for processing the comments and responses.

2. Descriptive outline of submittals reviewed.
   Include a list of all the documents reviewed.

3. Issues, comments, and variances from OPR.
   Include copies of all reviews, distribution lists, and responses.

4. Coordination with project systems.
   Include a copy of the reviews on submittals and systems coordination.

5. Conformance to functional requirements and maintainability.
   Include a copy of the reviews on systems and assemblies access, constructability, and maintainability.

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INFORMATIVE ANNEX J

Building and Equipment Specifications

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

Commissioning Specifications

This annex provides an example of how to implement part of this guideline. It is not intended to be a comprehensive representation or a best practice example. Practitioners applying the Cx Process should carefully follow ASHRAE Standard 202 and ASHRAE Guideline 0-2005 and applicable technical information tailored to their specific projects.

Building and System Specifications

All of the relevant design specifications should be retained in the Systems Manual. These are usually entered by CSI specification number.

Specification Index:

Specification #	Title	Publish Date	System or Equipment Included	Notes

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INFORMATIVE ANNEX K

Approved Submittals

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

Insert final copy of specific approved submittals by project specification section sequence. These documents provide specific information on the exact equipment and materials installed in the project.

Submittals Index:

Specification #	Submittal Title	Submitted Date	Approval Date	Notes

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INFORMATIVE ANNEX L

Manufacturer's Operation and Maintenance Data

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

Insert manufacturer provided installation and O&M manuals that have been verified and localized to the installed building system or equipment by specification section sequence. They should be organized to be easily located and updated.

Manufacturer's Installation, Operation, and Maintenance Index:

Submittal #	Equipment O&M Title	Publish Date	System or Equipment Included	Notes

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INFORMATIVE ANNEX M

Warranty Information

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

The warranty information and copy of the warranty documents are provided along with the effective and expiration date to facilitate building operation and expediting repairs of any defective systems or equipment.

Warranty Index:

Submittal #	Equipment or System Included	Effective Date	Expiration Date	Notes

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INFORMATIVE ANNEX N

Contractor and Supplier Listing and Contact Information

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

Contractor Listing and Contact Information are provided for emergency operations, maintenance, and materials replacement information.

Contractor Index

System, Material, or Equipment	Contractor Name and Contact	Address	Phone Number	Email address

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INFORMATIVE ANNEX O

Facility Guide

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

This annex provides an example of how to implement a Facility Guide. It is not intended to be a comprehensive representation or a best practice example. Practitioners applying the EBCx Process should follow ASHRAE Guideline 0.2 and applicable commissioning technical information tailored to their specific projects.

The Facility Guide is similar to an operator's manual. It is intended to provide the basic information needed for the building operations staff to operate the building on a day to day basis. It includes a simple description of the building systems and their normal operation, schedules, set points, and limitations. Also included is routine maintenance for the systems to keep them in good condition but not major maintenance or repair functions. Scheduled start up and shut down functions should be included.

Developing the Facility Guide encompasses gathering all of the information related to the systems and assemblies that require regular attention and incorporating it into a usable information resource, with indexes and cross references. This information is edited and organized to focus upon the key systems (HVAC, plumbing, electrical, vertical transportation, fire alarm, security systems, etc.), in the building. Coordination with maintenance personnel in developing building standard formats and reporting procedures is necessary for the long term operation of the facility. The Facility Guide is usually located in the Operations Section of the Systems Manual, but it can be developed independently if needed. Annex M of this guideline includes a more complete description of the Systems Manual.

Based on the needs of the Owner and building operations, the Facility Guide and Systems Manual could also include information for insertion into a computer maintenance management system (CMMS), including equipment make and model information, checking requirements, maintenance requirements, and troubleshooting items. This can be a very complex and costly endeavor and the ultimate payback should be evaluated before this type of system process integration is included.

The CxA shall be responsible for verifying the development of the Facility Guide.

The entity responsible for developing the Facility Guide shall include all items involved in the building operation in either an electronic or printed version. This entity (Owner, contractor, design professional, or other entity) shall have the skills of design, construction, and operations required to develop a comprehensive Facility Guide.

It should be noted that some projects may not include all of the information outlined below. The outline is provided to supply organization and sources for information available for the building or project.

Sources and Content of the Documents in the Facility Guide

Executive Summary

The executive summary contains an overview of the building design, construction and operational requirements. The information is intended to provide general guidance on the intended operation of the building in conformance to the Owner's Project Requirements and Current Facility Requirements.

1. Facility Operations Instructions

A. Operating Plan

Insert a copy of the completed facility operating plan with explanations of the intended use and operation of the facility.

Included in "General Building Information."

B. Building and Equipment Operating Schedules, Set Points, and Ranges

Insert a copy of set points of all equipment with operational adjustments. Include the set point normal intended ranges and limitations.

Included in "System Set point Requirements."

C. Sequences of Operation and Limitations

Insert a copy of the sequences of operation for all operating equipment in language and format that is understandable to the property managers.

Included in "BUILDING ENERGY SYSTEM DESCRIPTIONS & SEQUENCE OF OPERATIONS."

D. Start Up and Shut Down Actions

Insert a copy of routine system start up and shut down procedures and locations of applicable controls.

Included in "BUILDING ENERGY SYSTEM DESCRIPTIONS & SEQUENCE OF OPERATIONS."

The following items, 2 through 6, can be added to the Facility Guide and Systems Manual when required by the Owner's Project Requirements/Current Facility Requirements and are available.

2. Maintenance Procedures, Checklists, and Records

Insert procedures, forms, and checklists for facility operation and maintenance. Include updating requirements. Describe inspections and testing required on a routine basis and standard forms required.

Checklists included in "Key Elements to Monitor."

3. Maintenance Schedules

Include recommended maintenance schedules for systems and equipment along with update requirements.

4. Utility Measurement and Reporting

Include description of utility metering and monitoring systems if that is included in the property management functions.

Provide document formats and procedures for tracking utility usage and reporting this information to meet Owner's and jurisdictional requirement as required.

Included in "BUILDING ENERGY USAGE" section.

5. Ongoing Commissioning Operational and Maintenance Record Keeping

Include ongoing commissioning and optimization procedures and documentation to monitor and improve the performance of facility systems.

6. Janitorial and Cleaning Plans, and Procedures

Insert a copy of facility cleaning and janitorial plan with procedures and intended chemicals and equipment if this is a function of the building property management. These janitorial plans could also be used to contract for those services.

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INFORMATIVE ANNEX P

Facility Operating Plans

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

A. Facility Operations Instructions

1. Operating Plan

Describe the intended use and operation of the facility.

2. Facility Layouts

Include simplified line drawings showing facility site plan, floor layouts, and locations of major systems, control centers and utility shut off points. This assists in the orientation of operating staff and others.

3. Operating Schedules:

Describe and list planned operating hours for the facility. This is the basis for the more detailed schedules and sequences of operation.

4. Roles and Responsibilities:

Describe the facility management organization and staff and their responsibilities. Include the planned use of contractors and consultants in building operation such as security and janitorial functions.

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INFORMATIVE ANNEX Q

Building Operation Schedules and Set-points

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

PROJECT:_____
DATE_____ REVISION_____
ADDRESS:_____
OWNER:_____

INSTRUCTIONS:

1. Facility Owner or operator defines the initial operating schedules, anticipated occupancy, and outside air requirements for each room or area.

2. Facility Owner or operator defines the initial desired temperature for each room or space and any humidity, airflow, and pressure requirements.

3. Design team for new buildings, or commissioning team for existing buildings, sets initial tolerances and maximum functional ranges for temperatures, humidity, air flow, and pressure requirements.

4. Design team for new buildings, or commissioning team for existing buildings, using the BOD, defines the equipment and sequences of operation necessary to accomplish the requirements above.

5. Contractors or building operations personnel for existing buildings provide and install systems to accomplish the defined requirements.

6. Commissioning team tests and validates the systems performance to the requirements and updates the requirements and sequence documents to reflect final conditions.

7. Documentation from the above items is entered in the Facility Guide and Systems Manual.

8. Building operators are trained and operate the building based on the documentation, which is updated as changes occur.

I. SCHEDULES

EXAMPLE
ROOM 100, Office Area

PROJECT: Example Building
SPACE OCCUPANCY SCHEDULE

DAY OF WEEK	STATE	MORNING WARM UP-COOL DOWN	OCCUPIED TIME	UN-OCCUPIED TIME	SPECIAL EVENTS TIME	NUMBER OCCUPANTS--MIN/MAX		NUMBER OCCUPANTS -- MIN/MAX Spec Event	OUTSIDE AIR REQUIRED	NOTES
MONDAY THRU FRIDAY	ON	6:00AM	7:00AM	6:00PM	6:00PM	6/50		6/80	ASHRAE 62.1 When Occ.	
	OFF	7:AM	6:00PM	6:00AM		10:00PM	----------	----------	‘	
SATURDAY	ON	N/A	9:00AM	1:00PM		1:00PM	0/20	0/100	ASHRAE 62.1	
	OFF	N/A	1:00PM	6:00AM		MIDNIGHT	----------	----------	Min.	
SUNDAY	ON	N/A	N/A	ALL		1:00PM	----------	0/100	ASHRAE 62.1	
	OFF	N/A	N/A	ALL		MIDNIGHT	----------	----------	Min	
HOLIDAY	ON	N/A	N/A	ALL		ALL	----------	----------	Min	
	OFF	N/A	N/A	ALL		ALL	----------	----------	Min	

SPECIAL CONDITIONS:

II. SET POINTS

Approval: _____Date_____

Project: _____

ROOM OR AREA	**TEMP OCCUPIED – SUM/WINTER** ºF	**TEMP UN-OCCUPIED – SUM/WINTER** ºF	**TEMP RANGE +/-** ºF	**SYSTEM TEMPLIMITS-Min/Max** ºF	**PRESSURE OCCUPIED-IN. H2O**	**PRESSURE UNOCCUPIED- IN. H2O**	**PRESSURE RANGE +/- IN. H2O**	**SYSTEM PRESSURE LIMITS – Min/Max IN. H2O**
Building	75/72	82/68	2	68 Summer 78 Winter	+.05	+.03	+.02	.01/.1

III. SEQUENCES OF OPERATION Approval: _____Date: _____
Project:_____AHU#_____Location:_____

1. Constant Volume Air Handler w/Supply Fan, Chilled Water Coil, HW Coil, Demand Controlled Ventilation

SEQUENCE OF OPERATION

A. OCCUPIED MODE

1. The supply fan shall be energized by:
   _____
2. The space temperature shall be controlled by:
   _____
3. Heating and cooling space temperature set points shall have a _____5°F dead-band between the heating and cooling.
4. The heating coil valve and cooling coil valve shall modulate in sequence to maintain supply air temperature set point and space temperature.
5. Outside air shall be provided by:
   _____
   _
   Minimum/maximum outside air shall be controlled by:
   _____
   Demand controlled ventilation shall be provided by:_____
6. Supply air temperature set point shall be reset based on space temperature.

B. UNOCCUPIED MODE

1. Unoccupied Off: the supply fan shall be de-energized except when operation is called for as described below. Outside air dampers and exhaust dampers shall be closed and return air damper open. Heating and cooling valves shall be closed.
2. Unoccupied OFF Coil Protection: when the supply fan is de-energized and the outside air temperature is below the Outside Air Low Temperature Protection Set point of 35°F (adjustable) and the mixed air temperature is less than the Mixed Air Low Temperature Protection Set point of 45°F (adjustable), OR the Low Temperature Limit trips, then the heating coil valve shall cycle to maintain mixed air temperature protection set point of 45°F.
3. Unoccupied Setback for Space Temperature: the supply fan shall cycle on with the outside and exhaust dampers closed when the space temperature drops below the unoccupied space

temperature set point of 65°F (adjustable). When the fan is energized, the heating shall modulate to maintain supply air temperature set point of 95°F (adjustable).

4. Morning Warm-up for Space Temperature: if the space temperature is below the occupied temperature set point and the outside air temperature is below 40°F, Morning Warm-up shall be initiated by the optimum start program. The outside air and exhaust air dampers shall be closed and return air damper open during the morning warm-up cycle. If the space temperature is below set point, the unit shall warm the space to set point by raising the unit supply temperature to 95°F (adjustable) until the space temperature equals the occupied space temperature set point. If the space reaches the occupied space temperature set point before occupancy, the system shuts off. If occupancy occurs before the space reaches the heating set point, the system switches to occupied mode. Morning warm-up shall occur only once in a day.

5. Morning Pre-cooling for Space Temperature: if the space temperature is above the occupied space temperature set point and the outside air temperature is above 70°F, Morning Pre-Cooling shall be initiated by the optimum start program. The outside air and exhaust air dampers shall be closed during the Morning Pre-Cool cycle. The unit shall cool the space to set point by lowering the unit supply air temperature set point to 55°F until the space temperature equals the occupied space temperature set point. If the space reaches the occupied space temperature set point before occupancy, the system shuts off. If occupancy occurs before the space temperature reaches the occupied space temperature set point, the system switches to occupied mode. Morning Pre-Cool shall occur only once per day.

C. SAFETY SHUTDOWNS

1. Duct smoke detection, space smoke detection, and low temperature limit trips shall de-energize the supply fan and close the outside air dampers. Manual reset of the tripped device shall be required to restart the system.

2. When the OA temperature is below the Outside Air Low Temperature Protection Set Point 35°F (adjustable) and the air handler has shut down in alarm, the heating and cooling valves shall cycle as described previously in the unoccupied off coil protection mode.

2. Fan Coil Unit w/Chilled Water Coil, Hot Water Coil

SEQUENCE OF OPERATION

A. OCCUPIED MODE

1. The unit fan shall be energized by:_____.

2. The heating coil valve shall modulate in sequence to maintain a 70°F space heating set point.

3. The cooling coil valve shall modulate in sequence to maintain a 75°F space cooling set point.

B. UNOCCUPIED MODE

1. Unoccupied Off: the supply fan shall be de-energized except when operation is called for as described below. Heating and cooling valves shall be closed.

2. Unoccupied Setback for Space Temperature: the supply fan shall cycle on when the space temperature drops below the unoccupied set point of 65°F (adjustable) and shall operate until the space is 4°F (adjustable) above the unoccupied set point. Cooling shall be locked out. When the fan is energized, the heating shall modulate to maintain 95°F adjustable discharge temperature.

3. Morning Warm-up for Space Temperature: if the space is below the occupied temperature set point, morning warm-up shall be initiated by the optimum start program. If the space temperature is below set point, the unit shall warm the space to set point by raising the unit supply temperature to 95°F (adjustable) until the space is satisfied. When the space has reached set point, the unit shall operate in the occupied mode. If the space reaches the heating set point before occupancy, the system shuts off. If occupancy occurs before the space reaches the heating set point, the system switches to occupied mode. Morning warm-up shall occur only once in a day.

C. SAFETY SHUTDOWNS

1. Duct smoke detection or space smoke detection shall de-energize the supply fan. Manual reset of the tripped device shall be required to restart the system.

3. Variable Air Volume Air Handling Units w/ Supply Fan, Relief Fan, Chilled Water Coil, Economizer, Hot Water OA Preheat

SEQUENCE OF OPERATION

A. OCCUPIED MODE

1. The supply fan shall be energized by: _____
2. The supply air duct static pressure set point shall be slowly ramped from zero to the final set point value after the supply fan is started.
3. The air handling unit supply fan speed shall modulate to maintain duct static pressure set point of 1.5"w.g.(adjustable).
4. The static pressure set point shall be reset so that at least one of the VAV boxes is at 90% (adjustable) open.
5. A high limit duct pressure function shall reduce the supply fan speed to keep the supply duct pressure from exceeding 2.5 inches of water regardless of the demand from the VAV boxes.
6. The pre-heating coil valve, mixed air dampers, and cooling coil valve shall modulate in sequence to maintain supply air temperature set point. Provide a dead-band of 5°F between heating and economizer cooling.
7. The supply air temperature set point shall be reset from T-min (53°F) when the outside air temperature is 70°F and above, up to T-max when the outside air temperature is 65°F and below. T-max shall range from 55°F to 65°F. T-max shall vary such that the VAV box with the highest cooling demand is at 90% of its cooling max set point.
8. Outside Air shall be provided by:

   _____

   Minimum/Maximum Outside Air shall be controlled by:

   _____

   Demand controlled ventilation shall be provided by:_____
9. In demand control ventilation, the zones with CO_2 sensors shall send the air handler outside air controller a $\%CO_2$ signal varying from 0-100%. As the largest $\%CO_2$ signal from the zones served by the system varies from 50% to 100%, the outside airflow set point shall vary from $V_{ot\text{-}min}$ (the unoccupied design minimum outside air quantity) to V_{ot} (the occupied design outside air quantity).

10. Economizer cooling is enabled whenever the outside air temperature is less than 55°F. When the outside air temperature is greater than the supply air temperature set point, economizer cooling is disabled.

B. UNOCCUPIED MODE

1. Unoccupied Off: the supply fan shall be de-energized except when operation is called for as described below. Outside air dampers and exhaust dampers shall be closed and return air damper open. Heating and cooling control valves shall be closed.

2. Unoccupied Off Coil Protection: when the supply fan is de-energized and the outside air temperature is below the Outside Air Low Temperature Protection Set Point of 35°F (adjustable), and the mixed air temperature is less than the Mixed Air Low Temperature Protection Set Point of 45°F (adjustable), OR the Low Temperature Limit trips, then the heating coil valve shall cycle to maintain mixed air temperature of 45°F (adjustable), and the cooling valve shall be open.

4. Morning Warm-up: the optimum start program shall start the zone heating terminal boxes or the unit if reheat is the heating source at the latest possible time to reach the desired occupied space temperature set point at occupancy time. If the average space temperature is below the occupied space temperature set point, the zone fan or supply fan shall energize and the outside and exhaust dampers shall remain closed and return damper open. The heating coil valve shall modulate to maintain supply air temperature set point of 95°F (adjustable) until the average space temperature equals the occupied space temperature set point. The supply fan speed shall be controlled as described in the occupied mode. The VAV boxes shall modulate to maintain the occupied space temperature while the unit is delivering warm air. When the occupied space temperature set point is reached, the unit shall operate in the Occupied Mode. Morning warm-up shall occur only once in a day.

5. Morning Pre-cooling: if the month is between May and October (adjustable), the outside air temperature is below 55°F (adjustable), and the average of the three highest space temperatures exceeds Pre-Cool Space Temperature set point, Morning Pre-cooling may begin. The unit shall start in the pre-cool mode as determined by an optimum start program at the latest possible time to have the space at the occupied set point at occupancy time. The economizer cooling mode shall modulate the outside air and return air dampers to provide 55°F (adjustable) supply air. The heating and cooling valves shall be closed. The supply fan speed shall be controlled as described in the occupied mode. When the average of the three highest space temperatures falls below the occupied space temperature set point, the unit shall return to unoccupied mode. When the space has reached this set point, the unit shall operate in the occupied mode. Morning cool-down shall occur only once in a day.

C. SAFETY SHUTDOWNS

1. Duct smoke detection, space smoke detection, duct pressure safety, and low temperature limit trips shall de-energize the supply fan and close the outside air and exhaust air dampers. Manual reset of the tripped device shall be required to restart the system.

2. When the outside air temperature is below the Outside Air Low Temperature Protection Set Point 35°F (adjustable) and the air handler has shut down in alarm, the heating and cooling valves shall cycle as described in unoccupied mode.

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INFORMATIVE ANNEX R

Maintenance Plan, Procedures, Checklists, Schedules, and Records

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

Inspections/maintenance documentation shall be placed in a computer based maintenance system. The following checklist details items that are included in HVAC inspections as an example. Specific facility and equipment inspections shall occur as follows:

GUIDELINES FOR BUILDING AND EQUIPMENT INSPECTIONS

SYSTEM	FUNCTION	Cycle:	CORRECTIVE ACTION
1.Air filters	Inspect filters for use of specified type, function, pressure drop, dirt loading, contamination, installation with tight fit to eliminate air bypass.	Monthly	Replace filters that exceed allowed pressure drop; are loaded with dirt; have become wet or contaminated. Assure proper installation.
2. Dampers	Inspect dampers for proper function and adjustment. Verify airflow rates…visual check mark on damper handle to verify it has not been tampered with since balancing.	Monthly	Repair dampers and seals and ensure they operate as required. Exercise damper operation from stop to stop (full open, full closed).
3. Drain pans	Inspect drain pans and adjacent surfaces. Test drain function by pouring water or leaning agent into pan and observing entire drainage cycle. All anti-fungal chemicals shall be in place where bio-films, slimes, or fungus grow.	Monthly	Clean if dirty or if there is evidence of growth or dirt.
4.Air plenums	Inspect for cleanliness, blockage, improper materials in plenum, microbial growth, or hazardous materials	Semi-Annually	Clean out dirt and microbial growth. Remove contaminated insulation. Coat/paint with antimicrobial coatings.
5. Coils	Inspect coils for cleanliness, microbial	Semi-	Degrease, sanitize, and

	growth, and pressure drop.	Annually	clean dirty coils.
6.Major air handling components	Inspect for cleanness and damage.	Semi-Annually	Clean dirt and dust with HEPA vacuum. Clean grease and oils components with degreaser chemicals. Remove and replace, or repair damaged areas with like materials.
7.Intake louvers	Inspect louvers, adjacent areas, and bird screens for cleanliness and functionality.	Semi-Annually	Repair as required.
8.Trap primers	Inspect for proper function.	Semi-Annually	Repair or replace if not operational.
9.Access panels	Inspect for function and condition.	Semi-Annually	Repair defective panels and equipment.
10.Outside air	Test, adjust, and balance outside air supply flow to design rate and mark damper or control position.	Annually	Repair equipment as required.
11. Zone box controls	Verify control operation and set points.	Annually	Correct set points and make necessary repairs.
12. Lighting	Verify operation of lighting controls and dimming.	Annually	Re-adjust or replace defective controls.

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INFORMATIVE ANNEX S

Ongoing Commissioning and Record Keeping with the Systems Manual

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

GENERAL REQUIREMENTS

Scope, Purpose, Responsibility, Training, Security

SCOPE:

This document provides the facility description and operational requirements to implement an environmental and maintenance quality plan for the title facility after construction.

PURPOSE:

The purpose of this plan is to provide a summary of the information needed to understand and operate the title facility in a manner to provide an acceptable indoor environment. The training and procedures as well as the materials used by the custodial and maintenance staffs are of particular importance. Included in this information is: a facility description; building function and uses; custodial and maintenance chemicals, custodial procedures, training requirements, the location and use of record documents; systems modification criteria; operating and maintenance schedules, ventilation standards, and outdoor air flow rates; environmental inspection checklists; and an environmental complaint procedure.

KEY PLAYERS AND RESPONSIBILITIES:

The **Facilities Manager** has the primary responsibility to ensure that the appropriate facility standards are utilized and conformance is maintained to provide acceptable indoor environmental quality to the facility occupants. They are also responsible for ensuring that service contractors are contracted and trained to conform to the green requirements. The facilities manager is tasked with the coordination and communication with the necessary departments affected by this plan and has the primary responsibility for the plan updates. They are also responsible for the training of personnel and supervision for the green facility maintenance function.

The **contracted service provider** has the overall management oversight for the program and provides the motivation for plan accomplishment. They must:

- Provide research and acquisition of materials and services to GreenSeal Standards (see Section D or greenseal.org) to accomplish the plan elements.
- Be responsible for ensuring that custodial manager and custodial technicians are trained to conform to the GreenSeal requirements.
- Ultimately reports to the Facilities Manager.
- Special events may be scheduled in the meeting room or elsewhere. After such events, the facility should be serviced according to this plan.
- Noisy custodial work, such as vacuuming or floor polishing, should be done at night.
- Maintain records as required.
- Have a minimum of one qualified custodial technician on site during the work hours of 8AM to 5PM Monday through Saturday who will respond quickly when called to perform specific tasks as needed.
- These provisions apply to the entire building.

The occupants of the building have the authority to call upon on-site contractor personnel for specific and immediate housekeeping issues that may arise.

The **contracted custodial manager** is responsible for the training of personnel and supervision for the green custodial functions to execute this plan.

The **contracted custodial technicians** are responsible for the execution of the green custodial plan.

TRAINING:

Training of the indoor air quality team is essential in the operation of an environmental quality program. All persons in the facility have an impact on the quality of the indoor environment. Each group of building operators and occupants should have a training program appropriate to their involvement. These groups could include:

1. Building management and operations.

2. Security.

3. Maintenance.

4. Custodial.

5. Occupants.

All of these groups receive safety training. It is equally important to require environmental training to maintain the building environment.

A training program will be developed for each group based on their specific function and chemicals used. Each program will include: basic understanding of building function and operation; location and use of written procedures, standards, and record documents specifically including material safety data sheets (MSDS) for all chemicals; basic understanding of the building environmental programs; and procedures and standards for their job function.

In addition to the basics above, each group will have specific training as follows:

1. Building management will have training in: environmental management procedures and plans, including EPA, ISO, and industry standards; chemical and materials procurement; chemical and materials management and storage requirements; building occupant complaint procedures and record keeping; and the review and updating of this plan.

2. Security personnel training will include: environmental and safety building requirements; general overview of custodial and maintenance functions; chemical storage requirements; and emergency chemical and environmental procedures.

3. Maintenance personnel training will include: environmental factors in facility and equipment maintenance; equipment operations and schedules; chemical and materials procurement and storage requirements; record keeping requirements; and emergency operating procedures.

4. Custodial personnel training will include: effective cleaning procedures; permitted chemicals; use and mixing of cleaning chemicals used in the building; chemical storage requirements; and emergency environmental procedures.

5. Building resident training will include: chemical and materials allowed and specifically excluded in the building; chemical storage requirements; and emergency procedures.

SPECIAL SECURITY REQUIREMENTS

All personnel and contractors entering the building to perform housekeeping or maintenance must be authorized by the Owner and Facility Manager. Persons may be subject to background checks and training to comply with current NERC standards CIP-004 and CIP-006. This may include passing a 7 year criminal background check, completion of annual training, and attendance at a quarterly Awareness Program meeting. Authorized persons will be reviewed and re-approved quarterly by the Owner and Facility Manager.

BUILDING AND EQUIPMENT CHECKLISTS

(Select specific items for each area/system/unit from master inspection list.)

Inspector:_____ Date:_____

Equipment/System Name:_____ Designation:_____
Location:_____ System Associated:__

Manufacturer: _____ Model #:_____

Serial #_____ Date of Mfg:_____

Item	Component	OK/NA	Needs/ Results	Comments	Follow up

Notes:

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INFORMATIVE ANNEX T

Janitorial and Cleaning Plans and Procedures

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

CUSTODIAL PROCEDURES

General Procedures Overview:

All offices, classrooms, and building service areas shall be operated and maintained in an environmentally responsible manner, with the following being addressed:

1. Effective recycling program for paper and other commodities (cardboard, glass, plastic, and aluminum) that can be recycled, through programs that emphasize reuse and waste minimization.
2. Waste minimization of paper and other disposables.
3. Substantial compliance with the procedures and products recommended in the *Pennsylvania Green Building Operations and Maintenance Manual* is recommended wherever applicable, with respect to:
    - Custodial services
    - Landscaping
    - Roofing and parking.

    "Substantial compliance" with the manual means that the facility must demonstrate for each area covered in the manual that it complies with 80% of the procedural guidelines (Action Items or Key Points or equivalent, in bold) and is using products that conform with recommended criteria for at least 50% of custodial products and at least 75% of other products.
4. Renovations or new build outs use environmentally preferable materials and systems.

The facility will have policies and procedures ensuring that green facilities operation and maintenance are applied on a continual basis; in particular, the building:

a. Provides training to all relevant staff on environmentally responsible products and practices for green facilities operation and maintenance, and
b. Routinely monitors its performance by conducting an internal audit at least every six months that involves periodic collection and tracking of data on performance in green facilities operation and maintenance, evaluation against explicit performance

targets, and management review for improvement or realignment.

Specific Custodial Procedures

Housekeeping Guidelines (Ref. IICRC S001-1994, Carpet Cleaning Standard, Institute of Inspection, Cleaning, and Restoration Certification, Vancouver, Washington)

1. *Soil control systems*. Soil control systems are the first defense against surface soil and grit. Walk-off mats shall be placed at all entries to carpeted areas, including outside entries, stairwells, and entries to all other surfaces.

   a. If walk-off mats are used, they should be vacuumed according to the following schedule:

BUILDING AREA	VACUUMED
Private Areas	1 TIME DAILY, 4 PASSES
Public or Semi-Public	2 TIMES DAILY, 4 PASSES

   b. If a carpet surface is used, it should be vacuumed daily using the schedule above. Carpets should also be extracted according to the following schedule:

BUILDING USAGE	EXTRACT
Private Areas	ONCE A WEEK
Public or Semi-Public	TWICE A WEEK

2. *Vacuuming*. Daily vacuuming is the most important part of the total carpet care program. Improper or ineffective vacuuming will accelerate wear and allow dirt and grit to penetrate surfaces.

   a. *Vacuum Specifications*: all areas should be vacuumed with a dual (2) motor vacuum with an internal filtering system for cleaner discharge of 3 microns or less. The vacuum should have a 3500-RPM chevron brush with pile height adjustment, brush wear adjustment, and top loading bag. No single motor, cloth bag vacuums, or backpack vacuums will be used.

   b. *Vacuum Frequency*: all areas classified as heavy and moderate traffic should be vacuumed daily. Low traffic areas should be vacuumed two (2) times weekly. Heavy traffic areas are typically classified as lobbies, traffic lanes, interior aisles, entrances, elevators, and break rooms. Moderate traffic areas are classified as interior aisles and conference rooms. Low traffic areas are typically classified as cubicles and general office space.

3. *Spots and stains.* Spots and stains are a detriment to an expected high appearance level. These should be attended to on a daily basis.

   a. *Pretreatment*. Pre-spray the spot with a water-based solvent (pH 8.5 to 9.5), and

allow 10 minutes dwell time. Agitate soiled area with a soft-bristled nylon brush and extract residue with warm water.

b. *Coffee Spills.* If the water extraction stain is a coffee spill, use interface Coffee Breaker and follow manufacturer recommended procedures. Do not extract or blot. Simply spray affected area.

4. *Extraction*. Hot water extraction provides rapid soil emulsification since most of the cleaners used for extraction are low foaming and non-corrosive. They penetrate into the carpeting and loosen the soil for easy removal while extracting. The pH of the detergent used should not exceed 10.5.

   a. *Extractor Specification*. Equipment performance characteristics are critical to ensure effective and complete extraction. Use a self-contained hot water extractor with a minimum of 100-psi water pressure through the injection nozzles, a reel-type soft bristled agitation brush, and water lift of 130 inches.

   b. *Schedule.* Schedule of hot water extraction cleaning.

      i. *High Traffic.* Heavy and high traffic areas shall be extracted on monthly basis.

      ii. *Medium Traffic*. Moderate traffic areas shall be extracted every three months.

      iii. *Low Traffic*. Low traffic areas shall be extracted every six months.

      iv. *Special Areas*. Heaviest traffic areas may require additional attention once traffic patterns have been established within the buildings. These areas very often include entrances, lobbies, and aisles directly adjacent to entries.

5. *Carpet Cleaning Chemicals*. Only pre-approved carpet cleaning chemicals will be used. Be sure that the chemical manufacturer's recommendations and safety procedures are followed. Do not exceed the recommended dilution ratios for any cleaning product. Chemical use should conform to all regulatory guidelines.

   a. *Pre-spray Spotter* (pH 8.5 to 10). Pre-spray the area to be cleaned. Allow the pre-spray eight (8 to 10) minutes dwell time. Extract the pre-sprayed area with hot water only. Note: do not pre-spray too large an area. If the pre-spray is allowed to dry prior to extraction, it is ineffective.

   b. *Detergent* (pH not to exceed 10.5). Dilute the detergent to the chemical manufacturer's specified ratio per gallon of hot water. Extract the carpet. If there are any large stains, it is advisable to pre-spray them prior to extracting. (See "Housekeeping Guidelines" Section 3, Spots & Stains.)

6. *Vinyl Composition and Concrete Floors*. Vinyl tile, composition, and concrete floors shall be swept daily with an oil free dust mop or vacuum cleaner. Damp mopping may be necessary to remove dried liquids or materials.

a. *Schedule*. Floor scrubbing shall be done quarterly in high and moderate traffic areas and annually in light traffic areas.

b. *Scrubbing*. Scrubbing shall be preceded by a non-oily dust mop. Using a neutral liquid floor cleaner recommended by the flooring manufacturer, scrub the floor with a commercial scrubbing machine of 170 - 250 rpm capability equipped with a moderately abrasive scrubbing pad (blue or green pad). Keep the flooring wet at all times during the procedure but do not flood the floor. Absorb up the cleaning solution with a mop or wet vacuum. Rinse the floor with clean water after washing followed by a wet pickup vacuum or damp mop.

c. *Finishing.* After the floor has been cleaned, apply three to five coats of a good metal cross-linked liquid acrylic finish that is resistant to water spills and is non-removable by a neutral floor cleaner.

7. *Mold Removal.* All mold in the building or building systems shall be professionally removed according to the IICRC Standard S520, Standard and Reference Guide for Professional Mold Remediation.

This annex is not a mandatory part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline. It has not been processed according to the ANSI requirements for a guideline and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.

INFORMATIVE ANNEX U

Utility Measurement and Reporting M&V Plans

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

Include description of utility metering and monitoring systems, including type and model number, and location for each meter and submeter.

Meter	type	Model Number	Location	Notes:
Water				
Electric				
Natural Gas				

Provide document formats and procedures for tracking utility usage and reporting this information to meet Owner's and jurisdictional requirements.

Month	Water Usage K Gallons	Water Cost - $	Electrical Usage KWhr	Electrical Cost - $	Fuel Usage - Therms	Fuel Cost - $
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
TOTAL						

Measurement & Verification Plan
Project Name
Project Address

TABLE OF CONTENTS

NEW CONSTRUCTION BUILDING:

SECTION 1: BUILDING DESCRIPTION

The Seven office building is a 236,000 sq. ft, two story structure recently built and currently unoccupied. Tenants are being sought, and lease negotiations are currently underway with at least one potential tenant. The building is expected to be fully occupied by the third quarter of 2010 with two to six tenants. The Seven was constructed as a core and shell building on its own site in any city, with adjacent ground level parking.

Tenants will rent space with Green lease provisions, including owner access to utility use information, measurement & verification (M&V) reporting requirements, and Green equipment procurement standards. The building and lease are intended to help tenants achieve LEED CI certification. Tenants will be responsible for purchasing and installing their own rooftop units to provide heating and cooling.

SECTION 2: INTENT

The purpose of this M&V plan is to describe the methodology to measure building performance and compare it to the base year of the as-designed/as-built and to the ASHRAE 90.1-2004 code baseline facility. This allows the building owner/operator to determine if the facility is maintaining its planned level of usage and ultimately whether it is improving or deteriorating. The intent for implementing this M&V plan is to:

a. Increase energy savings by giving feedback on the operation of the building, allowing the operator to adjust facility management to deliver higher levels of energy savings, greater persistence of savings, and reduced variability of savings.

b. Operation and maintenance troubleshooting by providing feedback, which should facilitate improvements in the O&M process and improve training and building performance.

c. Provide continued documentation of the performance of the building for owners, investors, tenants, designers, and potentially, government agencies, when required.

d. Satisfy the requirements of LEED.

SECTION 3: APPROACH

3.a. Summary of Approach

The various Options and Boundary to the M&V Process are shown on page 11. These options were developed by the US Department of Energy and other organizations as the "International Performance Measurement and Verification Protocol" *(IPMVP) that provides an overview of current best practice techniques available for verifying results of energy efficiency, water efficiency, and renewable energy projects. More information on this process can be found on the Efficiency Valuation Organization web page http://www.evo-central.org.

The option used in this plan and facility is Option D, calibrated simulation. Building systems that operate with energy (natural gas, electricity, etc.), shall be monitored on a relevant time frame. This monitoring system will be as sophisticated as required to accurately deliver pertinent building performance data to the M&V team.
The base year energy utility usage will be developed with computerized modeling. This building model has been developed using the Acme software. The options of use of the model for the

building are included in Section 5 of this plan. After the building has a year of data recorded, the 'base year' can be established, once the model has been calibrated and its accuracy verified by recording building monthly meter readings over the first year of full occupancy operation. Forms are included in Appendix A for this purpose. These are available as Microsoft Excel forms and can be used to produce comparative graphs for better visualization. Microsoft Word documents do not have those calculation capabilities.

Accurate utility rates will also need to be acquired before the calibrated model can be completed and the base year values documented.

The Reporting Period for the initial comparison with the model provided should start at the beginning of the first month meter start schedule that is 60-90 days after the building reaches full occupancy. This will allow for system and operational stabilization before a comparison is made. Full occupancy is not expected until the 3rd quarter of 2010, so the first performance year will most likely end December 2011.

The responsible person for implementing and monitoring this plan is the Facility Manager. This is initially Mr. Joe Crow and will be reassigned upon building occupancy. Mr. Crow will be assisted by the Owner's Energy Team as explained in Section 3 of this plan.

The plan assumes that the basic building usages and the facility construction and systems will stay relatively constant.

a. Building configurations and construction details can be reviewed on the construction record documents.

b. Air conditioning systems are shown on the mechanical record documents supplemented by the systems manuals. Future tenant mechanical systems will be shown on future lease finish drawings.

c. Plumbing systems and metering are shown on the plumbing record documents and risers, supplemented by the systems manuals.

d. Electrical systems and metering are shown on the electrical record documents and risers, supplemented by the systems manuals. Future tenant electrical and lighting systems will be shown on future lease finish drawings.

These building plans and the desired rigor to be used in measuring performance should guide the building operator in the selection of the type of measurement and comparison methods. The specific equipment installed may also allow the system to be used for short term and 'spot check' testing, such as before and after equipment replacement.

Since this is a new building, the as-designed/built utility usage is developed by the energy model described above with assumed loads and schedules. The water usage has not been modeled and is determined by recording the monthly water usage from the building meter. Forms are included in Appendix A for this purpose. These forms are available as Excel forms and can be used to produce comparative graphs for better visualization. As noted, available are the initial energy computer simulations that have estimated monthly usages. As noted

above, these energy models need to be calibrated to actual energy utility costs and current weather conditions in order to compare with actual usage. For the first complete performance year, the as-designed model will be calibrated such that the actual and the modeled monthly electricity and gas usage agree to ±20% on a monthly basis and ±10% on an annual basis. The model will not be calibrated to electrical demand. (Computer models estimate hourly demand while buildings measure demand on a 15-minute basis, rendering comparisons unfair.) This calibrated model will be referred to as the as-operated model.

Subsequent year utility use variation of greater than 10% from the previous year (the first year will compare to the calibrated model) will trigger an analysis of building and equipment operation to determine the cause and remediation actions. If significant deviations in operating or occupancy characteristics are noted, the as-operated model will be re-calibrated to reflect actual conditions.

The accuracy of the readings and the calculations is determined by the meters and test instruments used. This accuracy must be considered when evaluating both the results of the readings and potential equipment changes.

The maintenance of the installed equipment is the most important factor in maintaining building efficiency. There must be adequate manpower and budgets to perform inspections and routine maintenance. Inspection forms and additional instructions are provided in the Re-commissioning Management Manual to facilitate that process.

There are many different types of equipment in mechanical and electrical systems. Some of these are listed in Section 8 of this plan along with energy efficiency considerations and measurements. See the mechanical drawings for current installations.

The level of accuracy in the M&V process depends upon the type of equipment and training of the testing and maintenance staff. Care should be taken to select the compatible new or replacement equipment and to continually train the staff on maintenance and energy efficiency practices.

Reports can be produced monthly and yearly by using the utility meters. If one of the systems is suspected of not maintaining its efficiency, temporary meters or data loggers should be installed for verification. The building energy management system can also be used for trending, measurements, and calculations. Equipment that can be used for this temporary metering purpose can be developed as needed. The utility meters for this building are shown in separate attachments.

Remedial or corrective action would depend on the elements of the building systems that are causing the performance problems. Some of these might include:

1. Adjustment of building operating schedules to meet actual schedules.

2. Deterioration of fluorescent lamp efficiencies requiring bulb replacement

3. Deterioration of HVAC equipment, e.g., fans, compressors, zone boxes, etc., requiring

cleaning, adjustment, and/or replacement. Monitoring of temperature, air flow, humidity, fan RPM, and amperage is of special importance.

4. HVAC and lighting control system operation or scheduling problems requiring reprogramming, adjusting, or upgrading systems.

3.b. Energy Team

The Owner's Energy Team will assist Mr. Crow in these M&V activities. Some of these individuals/functions are as follows: (since the building is now vacant, some of these positions have not been filled.)

1. Mr. Joe Crow, Facility Manager, will manage the process and hire the other participants, including the energy modeling professionals.

   Engineer Associates developed the original energy model at a cost of $5,000. Engineer Associates will contract to calibrate the model using the first years full occupancy stabilized energy use data for the additional fee of $3,500.

   Budgeted cost for the management process is $10,000 for the first year, then $6,500 per year thereafter.

2. Building Manager, Ms. Ann Robin of Real Estate Management, LLC, will manage the building, data collection process, the analysis of data, report generation, and potential building system remediation when necessary.

   The building manager's function includes this data management process, but the budgeted cost for this local building management of the process is approximately $5,000 per year.

3. Building operating and maintenance personnel (names TBD) will maintain the building systems, read the building meters, obtain weather data, and assist in the analysis and potential remediation efforts.

   Budgeted cost for the M&V process by maintenance operations is $20,000 per year.

4. Building maintenance and construction contractors (names TBD) will provide construction and maintenance assistance.

   Budgeted cost for contractor operations is to be determined at a later date.

5. Mr. Evan Sparrow AIA, LEED AP, sustainability consultant, will assist in analysis and resolution of sustainability issues.

   Budgeted cost for sustainability consulting is $12,000 per year.

The validation and adjustment of the energy model will require a modeling professional familiar with the modeling program.

6. Mr. Tim Hawk, PE, energy modeling professional, and his team will provide model calibration, energy use trend analysis, and solutions to utility issues and improvements.

   Budgeted cost for model calibration is $3,500 per calibration cycle.

7. Mr. Joseph Eagle, PE, Commissioning Authority, will assist in the calibration and functional testing of systems.

3.c. M&V Approach: Systems and Monitoring Criteria

This section is used to describe the measurement approach to building energy using systems. Each system has the following detail structure:

1) Description of item to be monitored

2) What criteria will be used to monitor it

3) Frequency of monitoring.

These details will be monitored and provided to the Energy Team.

Examples:

1) Building chilled water usage (gallons) will be metered by the mag meter located in the basement from the central plant chilled water distribution system. The meter will be installed in the return chilled water line and will be sending pulse signals to the BMS. Chilled water supply and return temperature will be measured by the water temperature sensors installed on the chilled water lines in the attic and signal will be sent to the BMS. Building chilled water usage and temperature difference between supply and return lines will be recorded by BMS and charted on an hourly basis with reports generated by the BMS for hourly, daily, weekly, monthly, and yearly energy usage in gallons.

2) The Air Handling Units (AHU-1,2, & 3) use temperature sensors to control the economizer dampers. The economizer dampers are also controlled by the Carbon Dioxide Sensors that are located in each classroom. These CO2 Sensors override the minimum outdoor position when CO2 level is exceeded in any classroom.

3) The Chilled Water to the Air Handling Units is controlled by the Chiller Plant and is not reset locally

Item	As-Designed Model	Baseline (90.1) Model	Units	Assumptions to be updated during calibration
Building Physical Information				
Size, SF	236,000	236,000	SF	
Stories	2	2		
Wall Insulation	R-20	R-13		
Roof Insulation	R-35	R-20		
Common area	23,600	23,600	SF	

Item	As-Designed Model	Baseline (90.1) Model	Units	Assumptions to be updated during calibration
Window Area (overall)	23,600	23,600	SF	
Window U value	0.4	0.6	BTU/SF-HR-F	
Window SHGC	0.4	0.8		
Infiltration	0.2	0.4	ACH	X
Equipment Information				
Lighting Power Density	1.0	1.2	W/SF	
Equipment Power Density	2.0	1.2	W/SF	X
Process Load Density	0.5	0.5	W/SF	X
HVAC Information – Common Area				
HVAC Type	DX Air-cooled	DX Air-cooled		
HVAC Capacity	6	6	tons	
HVAC performance rating	13	10	EER	
Fan Type	VAV	CV		
Heating	Gas	Gas		
Outside Air	20	20	CFM/person	
HVAC Information – Tenant Area				
HVAC Type	DX Air-cooled	DX Air-cooled		X
HVAC Capacity	60	60	tons	
HVAC performance rating	13	10	EER	X
Fan Type	VAV	VAV		X
Heating	Electric	Electric		
Outside Air	20	20	CFM/person	X
Operating Characteristics				
Occupancy (leased space)	100%	100%		X
Occupancy (# tenants / meters)	3	3		X
Occupants (# people)	66	66		X
Heating Setpoint, Occupied	70	70	ºF	X
Heating Setpoint, Unoccupied	60	60	ºF	X
Cooling Setpoint, Occupied	74	74	ºF	X
Cooling Setpoint, Unoccupied	80	80	ºF	X
Schedule	8 AM – 5 PM M-F	8 AM – 5 PM M-F		X
Weather, Dallas, TX	TMY	TMY		X
HDD, base 65	2,407	2,407	ºF-days	X
CDD, base 65	2,603	2,603	ºF-days	X
Results				
Electricity Use	3,307,443		kWh	X
Gas Use	3,536		therms	X
Total Energy Use	11,642		MMBTU	X
Energy Use Intensity	49.3		kBTU/SF	X

3.d. Project Energy Reduction Devices

This section should provide fairly detailed information describing the systems which are expected to reduce energy use and therefore costs in the building.

The building is using ground loop heat pumps to reduce energy cost of the building. This is in part due to the high efficiency ‘condenser’ which is located underground. It would be a good idea

to give a couple examples of efficiencies and capacities of the system described. Some examples:

- The building also plans on using so many kW of photovoltaic cells to supplement its energy usage and therefore reduce the energy cost. Give some data on the photovoltaic panels.

- Solar water heating is also to be used on the building, which will help reduce energy required to heat water and reduce electric load in the building. Provide some specific data.

- The building envelope has increased insulation levels and windows with low solar heat gain coefficients to reduce heating and cooling energy use.

- Lighting fixtures are high-efficiency T-8/T-5 with electronic ballasts to achieve adequate illumination levels with a 1.0 W/SF lighting power density.

- The building is designed to achieve an energy use intensity of 49.3 kBTU/SF, which is less than ASHRAE 90.1-2004 standards to satisfy LEED-C&S 2.0 EAP1.

- The HVAC system for the building core areas are packaged roof mounted cooling systems using air-cooled condensers. Heating is provided by natural gas.

- For tenant areas to be finished out, HVAC and air distribution is expected to be from roof mounted variable air volume air handlers with VAV and fan-powered zone boxes. Controls are electronic/DDC. Unit heaters and roof mounted solar domestic water heaters are included for the leased spaces.

- Outside air is brought into the building through the rooftop packaged units. The building uses no natural ventilation.

SECTION 4: COMMISSIONING

This section will describe how the commissioning will progress and how it will help the M&V Plan fulfill its use. This section will also describe the commissioning procedures.

Definition of Commissioning

A quality process for achieving, verifying, and documenting the performance of equipment to meet the operational needs of the facility within the capabilities of the design and to meet the design documentation and the Owner's functional criteria, including training of operator personnel and documentation.
Commissioning is a process, a combined effort between all the members of the design and construction team to ensure quality and efficiency when building a building for the Owner. The job of a commissioning agent is to ensure that the building’s systems are well coordinated and operating properly. A check on the systems is used to provide the Owner with a document and therefore expertise describing that the systems of the building have been installed and started within the standard required by code.

SECTION 5: M&V OPTIONS AND PROJECT BOUNDARY

5.a. M&V Options and LEED®

The USGBC cites the standard implementation methods for the M&V process in the International Performance Measurement and Verification Protocol (IPMVP) Volume III using either Options B or D. The table gives an overview of the appropriate methods (go to www.ipmvp.org for more information).

M&V Option Description	How Baseline is Determined	Typical Application	Savings Calculations
B. Energy Conservation Measure Isolation			
Savings are determined after project completion by short term or continuous measurements taken throughout term of the contract at the device or system level. Both the performance and operations factors are monitored.	Projected baseline energy use is determined by calculating the hypothetical energy performance of the baseline system under measured post-construction operating conditions.	Variable speed control of a fan motor. Electricity needed by the motor is measured on a continuous basis throughout the M&V period.	Engineering calculations using metered data.
D. Whole Building Calibrated Simulation			
Savings are determined at the whole building or system level by measuring energy use at main meters or sub-meters, or using whole-building simulation calibrated to measured energy use data.	Projected baseline energy use is determined by energy simulation of the Baseline under the operation conditions of the M&V period.	Savings determination for the purposes of a new building Performance Contract, with the local energy code defining the baseline.	Calibrate energy simulation and modeling: calibrated with hourly or monthly utility billing data and/or end use metering.

Standard Definitions

- Baseline – the base period that is used to compare subsequent building performance using similar conditions.
- Baseline Adjustments – the non-routine adjustments arising during the post construction period that cannot be anticipated and which require custom engineering analysis.
- Base year Conditions – the set of conditions which give rise to the energy use/demand of the base year.
- Base year Energy Data – the energy consumption or demand during the base year.
- Base year – a defined period of any length before comparison of subsequent data.
- Degree Day – a measure of the heating or cooling load on a facility created by reference temperature such as 18°C for one day, it is defined that there is one heating degree day. When the ambient temperature is below the reference temperature it is defined that heating degree days are counted. When the ambient temperatures are above the reference, cooling degree days are counted. Any reference temperature may be used for recording degree

days, usually chosen to reflect the temperature at which heating or cooling is no longer needed. The number of heating or cooling degree days is a relative measure of the amount of heating or cooling required from outside conditions.

- MS or Energy Management System – a computer that can be programmed to control and/or monitor the operations of energy consuming equipment in a facility or group of facilities.

- Energy Savings – actual reduction in electricity use (kWh), electric demand (kW), or thermal units (Btu).

- M&V or Measurement and Verification – the process of determining savings using one of the four IPMVP Options.

- Metering – collection of energy and water consumption data over time at a facility through the use of measurement devices.

- Monitoring – the collection of data at a facility over time for the purpose of savings analysis.

- Post-Construction Period – any period of time following commissioning of the facility.

- Verification – the process of examining the report of others to comment on its suitability for the intended purpose.

5.b. Measurement and Verification Boundary

The M&V boundary will typically coincide with the project scope. Certain buildings might be attached to campuses or similar areas where energy/heat/chilled water are delivered from outside the scope of work and may or may not be available for monitoring. Things such as this will need to be addressed here to provide information pertaining to the individual project.

- ***Extra-Boundary Devices Interacting with Building Systems***
  - Systems outside the scope of the project boundary and the M&V boundary should be addressed here to ensure the total collection of data.

- ***Standards and Versions***
  - International Performance Measurement and Verification Protocol; Concepts and Options for Determining Energy and Water Savings, Volume 1. September 2009.

  - LEED BD&C 2009.

SECTION 6: BASELINE

6.a. Baseline Information

The building's baseline may be derived from two sources. First, a calibrated energy model which has a year's worth of data that replaces a Baseline Period. Second, as mentioned, a Baseline Period of energy usage of an existing building will give data previous to ECM installation.

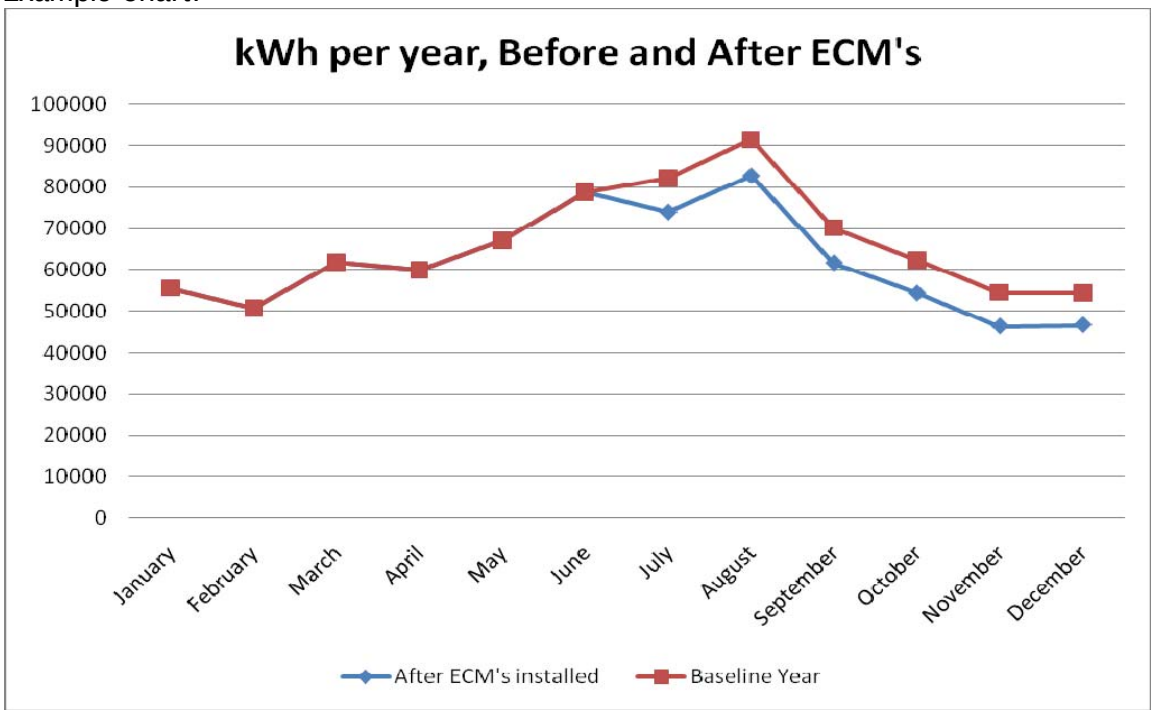
This data, that is taken from either of the above two methods, will be used to generate a 'base year'. This will describe all the conditions for the building before extra ECM's have been installed

and will show how they affect the cost of energy during the following year.

The building is a one story building, totaling 2,500 square feet. It is located in Plano, TX. The expected occupancy is nearly 10 people.

A description of the 90.1 Baseline model, combined with IPMVP Protocol, should be written here to further describe what will be done to the building, and also be used to help quantify the results of the M&V Process.

Example Chart:



9.

SECTION 7: REPORTING PERIOD

One of the key aspects of LEED is sustainability. Recording and watching a building's energy use monthly will greatly anticipate problems with maintenance and energy usage. Reporting data for years to come is a crucial step to take when preparing future tenants and owners of the building.

Reports from the metering devices will be delivered and reviewed by the Owner and any maintenance staff, and the commissioning agent, should they choose.

The following reports should be produced to maintain building efficiency (obtain the data from the utility bills in most cases to provide consistency and ease of entry):

- Electricity KW-HR and $ on a monthly basis
- Natural Gas or other fuel gas MCF and $ on a monthly basis
- Domestic water gallons and $ on a monthly basis
- Landscape irrigation water gallons and $ on a monthly basis.

Using the tables in the Appendices, this data can be recorded, compared, and analyzed.

The degree day table facilitates the recording of weather variations from month to month and year to year. Degree day data can be obtained from the national weather service. The change in building energy usage is caused by internal building loads (people and process) and external loads caused by the weather. The latter loads are usually more variable than the building usage and thus need to be considered when comparing energy usage and revising the baselines for comparison.

Base building meter systems are available: these can be read by the local utility and/or maintenance staff and recorded for comparison and/or analysis (for example, comparing the energy use of the heating system to the air conditioning system).

SECTION 8: ADJUSTMENTS

If the actual building performance does not track the initial performance year modeling, analysis and possibly additional spot metering and added energy management systems should be added. Other areas of concern in the yearly adjustment include:

- Changes in equipment efficiencies or replacement of equipment.
- Installation and use of spot metering to determine specific equipment efficiencies.
- Calibration of sensors and control for ongoing performance.
- Variation to the utility charges, particularly for fuel charges.
- Changes to building use and operation schedules.

Finally, if the building changes or the usage (occupancy, schedules, etc.), changes, these

variations need to be accounted for in the comparison of current and baseline energy and water usages.

From ASHRAE Guideline 14-2002

Section 5.2.8.2 Baseline Adjustments. When changes are made to a facility's use or operations, the baseline model usually needs to be adjusted. These situations commonly arise from renovations, expansion, changes in usage, or addition of new equipment. Even the gradual addition of minor electrical equipment over an extended period of time may warrant baseline adjustment.

When there is a permanent change to the facility (other than the ECM"S being assessed), the energy use and demand impacts of the change shall be determined by the specific measurements and/or engineering calculations that reflect baseline conditions. The impact of the changes shall be reflected in a direct modification to the baseline model. The modification shall account for the impact under conditions of the baseline period.

Some changes in facility operations are only temporary in nature, such as where energy-using system services are curtailed due to equipment breakdown or suspended operating procedures. In such situations, the algorithm for savings determination may be temporarily supplemented with specific measurements and/or calculations to account for the change in the relevant period. These supplementary calculations shall be shown to fully account for the change.

Baseline adjustments may be recognized as necessary long after the actual change. It may also be known when the baseline model is being developed that the normal pattern of baseline conditions changed during the baseline period. In this latter case, unadjusted data shall be used to demonstrate compliance under Clause 5.3.2 before any baseline adjustments are made.

SECTION 9: ANALYSIS

9.a. End of Year, Cost Savings Equation:

$$\text{Cost Savings} = C_b - C_r$$

C_b = Cost of the baseline energy plus any adjustments.*
C_r = Cost of the reporting period energy plus any adjustments.

****Adjustments:***

Routine Adjustments.

For energy-governing factors expected to change routinely during the reporting period, such as weather or production volume, a variety of techniques can be used to define the adjustment methodology. Techniques may be as simple as a constant value (no adjustments) or as complex as several multiple parameter, non-linear equations each correlating energy with one or more independent variables. Valid mathematical techniques must be used to derive the adjustment method for each M&V plan.

Non-Routine Adjustments.

For those energy-governing factors which are not usually expected to change, such as: the facility size, the design and operation of installed equipment, the number of weekly production shifts, or the type of occupants, these static factors must be monitored for change throughout the reporting period.

SECTION 10: ENERGY PRICES

Energy prices and expected energy seller should be described in detail here.

SECTION 11: METER SPECIFICATIONS

The following metering and analysis systems can be used for temporary and/or permanent metering. The equipment shown is an example of available equipment for permanent metering.

Included are Data Industrial water meters for totalizing water flow and individual equipment analysis.

For various power and environmental measurements, information on controllers is included.

For power quality monitoring equipment and building control systems, information is available from the systems manuals.

Note:
Please see Meter Data Sheet
Please see Appendix B1_Metering Devices

SECTION 12: MONITORING RESPONSIBILITIES/M&V TEAM

The responsibility for implementing and maintaining the M&V Plan rests with the property manager and the Owner. Many others will share in the installation, maintenance, and monitoring of the facility and its systems. The organization of these functions remains the overall responsibility of the Owner and the Owner's organizational management listed below.

Program Manager:
Name
Address
Contact Information

Owner:
Name
Address
Contact Information

SECTION 13: ACCURACY

The level of accuracy in the M&V process depends upon the type of equipment and training of the testing and maintenance staff.

Care should be taken to select the compatible new or replacement equipment and to continually train the staff on maintenance and energy efficiency practices.

Efficiencies of existing equipment are shown on the equipment submittals and the Systems Manuals.

The electric and water utility meter accuracy is determined and can be obtained from the respective utility. Utility-grade electrical meters are required to have an overall accuracy of 0.5% of registration as set by ANSI standard C-12. Further, the IPMVP (2007, Section 4.9.5) states “Utility-meter data is considered 100% accurate for determining savings because this data defines the payment for energy.” [Emphasis in the original]. Although this section is from Option C, the Option D method being used defines savings as the difference between the calibrated baseline model and the actual (measured) energy use.

SECTION 14: QUALITY

Quality assurance measure can consist of the following:

Ensure that all equipment purchased has been analyzed for proper use, application quality, and accuracy.

Train all maintenance personnel on the proper methods and schedules for maintenance and operation of the systems.

Management should review program application and results on a quarterly basis.

Complete routine equipment maintenance on a monthly basis.

Complete a recalibration and total inspection on an annual basis.

Make repairs as necessary.

This annex is not a mandatory part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline. It has not been processed according to the ANSI requirements for a guideline and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.

INFORMATIVE ANNEX V

Use of Systems Manual in Training

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

Pre-Design Phase

Training Requirements and Implementation begin at project conception and are part of the Owner's Project Requirements (OPR). At the implementation stage, the Owner needs to address the source of operating personnel, in-house or out-sourced labor and services, and the level of responsibility assigned to the Facilities/Project Manager for the site. OPR requirements for extended warranty and service agreements with the contractor or OEM (original equipment manufacturer) need to be addressed at the time of project inception.

In the implementation stage, beginning with assigned individual roles and responsibilities, the OPR for training are considered in a manner similar to choosing any of the varied systems, components, and assemblies that establish the level of quality and performance expectations expressed by the Owner in the OPR.

The criteria used to determine the minimum level of acceptance required by the Training OPR will guide the development and coordination of the training of personnel who are assigned responsibilities of maintaining the HVAC&R system's performance in the OPR. This includes energy, fire and safety, indoor environment, and occupant comfort requirements related to the HVAC&R systems. During the Pre-Design Phase, the initial training agenda needs to be developed to a level that reflects the Training required to meet the OPR. This provides the initial guidance to the design team. It includes:

- Establish development requirements for the Training Plan.
- Identify essential components or systems requiring formal training and the estimated time designated for training by hours (unit cost).
- Determine skill level requirements for operating staff meeting the OPR levels of performance.
- Create checklist of training requirements necessary to maintain warranty conditions and service life.
- Specify requirements for acceptable organization and implementation of the OEM training requirements prior to occupancy.
- Clearly identify the training requirements of contractor's work force for the equipment

maintaining the interior environment during the Construction Phase.

- Develop training methods that meet the OPR, including incorporating OEM training with service bulletins, recalls, and implantation of changes in operating procedures as facility systems and components age and degrade in performance levels.

- Provide clear understanding of the OPR for training material, training sessions (schedule), and trained personnel necessary, prior to and after occupancy by the Owner.

Training responsibilities and the position or person assigned these responsibilities must be clearly defined in the OPR and reviewed before moving into the Design Phase. This is of extreme importance when essential equipment or systems are provided by the Owner.

The HVAC and refrigeration design needs to satisfy the operating personnel for the following OPR topic areas, including consideration of training required to continuously achieve the benefits of designs that optimize each requirement.

- Reparability
- Interchangeability
- Accessibility
- Replaceability
- Maintainability
- Extendability
- Adaptability
- Lifecycle Replacement Sequence
- Cost Analysis of Component Servicing and Maintenance cycles
- Complexity of the OEM and systems in day to day operation.

Controls at the system and component level are essential for all HVAC&R systems and assemblies. There must be special effort directed at the training requirements as the design develops versus considering the training afterward as a result of the controls design.

Beyond mechanical maintenance, the skill set required at each level of the operating hierarchy for Direct Digital Control (DDC) systems needs to be defined in the OPR. These DDC systems have various levels of control, hierarchy; some levels require computer programming skills that are beyond the means of an Owner to support. At a minimum, the OPR should define the responsibilities and training necessary for in-house and out-sourced contractors (service plan) of site DDC systems. The level of interoperability and any additions to interoperability not currently used at the site or organization requires additional training for the systems to be successful. Issues addressed in the OPR should include the following:

- DDC in-house engineering, operations, and maintenance (EOM) requirements
- DDC service plans and warranty requirements
- Procedures for maintaining record documents and service records of DDC Systems
- Training and Certifications requirements for in-house and service contractor personnel
- Written training matrix updated to each level in the DDC Hierarchy.

Design Phase

During the Design Phase, the Design Professional, following the OPR, will define the training requirements and implementation schedule for the project in the contract documents. Sometimes this may require specific needs for each installing contractor, for in-house maintenance, and out-sourced service personnel. The performance of these training services is verified both as part of the submittal review process and as the training sessions occur. There will be additional training requirements that continue to evolve during the design and construction phases of the project. It is recommended to have “Needs Development Workshops or Sessions” during design and construction. These need to be defined in the specifications. Special note should be given to the training and service requirements of equipment and systems not provided by the project Contractor. This is usually owner provided equipment or systems that occur outside the project submittal review. In some cases, there may be two or more construction projects, with separate contractors or in-house construction. This requires coordination of training needs to prevent duplication and acceptable scheduling of trainers and trainees.

Procedure training on spare parts availability and service response times should be clearly defined by the Design Professional and verified in the submittal process.

During the Design Phase, the Design Professional should clearly define all special requirements for storage of equipment or systems prior to installation. Training necessary to maintain the equipment prior to Owner acceptance is identified and monitored by proper application of the Contractors QA/QC program. Special training of Contractor personnel handling equipment with special requirements should be monitored by the CxA, demonstrating training and competence meeting the OPR during all periods that the HVAC&R equipment and systems are operated during construction and warranty. Equipment must be maintained to prevent any degradation prior to turnover to the Owner for operations.

Contractor Special Training, Licensing, Certification (Construction Phase)

After the notice to proceed, the Contractor is required to provide initial submittals in the stated period of time. One of the initial submittals usually required is the Contractors QA/ QC Program. This program outlines the methods used by the Contractor to ensure his personnel have the proper Training, Licensing, and Certifications to perform assigned tasks. In addition, the criteria necessary to maintaining the project-specific OPR identified in the Contractor QA/QC Program. On a frequent basis, the CxA should verify and note compliance by the Contractor to required Training, Licensing, and Certification requirements or activities and other quality checks identified in the Contractors QA/QC program or required by the contract.

Certification Training for procedures in the use of unique equipment or assemblies should be required at locations other than the actual job site. In such cases, the Design Professional may require verification of current and up-to-date certification and valid accreditation documents for the organization or individual issuing the certification. The role of the CxA in verification of proper training for certification is to randomly check the documentation necessary to demonstrate compliance with the OPR. The requirement for ensuring that the proper documentation is valid remains with either the design team or Owner’s Project or Construction Manager.

Construction Phase Training

There should be an initial training session during the construction period and prior to

contractor training for the Owner's EOM and users by the design team on the OPR and BOD, including system limitations. This is especially required for all HVAC&R systems that are critical to the success of the facility.

The CxA should hold a training development workshop with the EOM (including any service contractors) several months before the final training sessions are scheduled and the scope of training-sessions content is set. This workshop is for gathering information from the EOM staff to determine the actual training requirements based upon the approved equipment, assemblies, and systems for the building, upon a walk-through of the building, and upon the review of final plans and specifications. This may require an increase or decrease in actual training requirements than the requirements included in the contract documents. This is frequently related to the final equipment, components, and HVAC&R systems selected by the Owner, design team, and contractor.

Systems Manuals need to be complete before Owner's personnel are provided training and used in the training sessions.

Training on the use of the Systems Manuals should be a combined training effort of the design team, the commissioning process team, and the contractor.

The CxA should review the contractor's schedule for all HVAC&R related training. Resources and time for HVAC&R training can place great demand on both the contractor and the EOM and service firm personnel at the end of the Construction Period. HVAC&R systems are especially impacted both because of a high level of training required and the HVAC&R systems are some of the last systems installed in the construction process. Early training must be scheduled for project success. The CxA must document that training and the required level of competence learned in the training meets the OPR.

The contractor is responsible for the start-up, testing, adjusting, balancing, Systems Manual, and training for all systems and equipment prior to the functional testing or M&V of these systems and equipment. The Cx Team must verify through assembled documentation that the Contractor Personnel are trained and competent to perform these activities.

The contractor must begin early training on any major changes in the automated preventive maintenance and service program that is included by systems installed and required by the contract.

Testing and verification demonstrating compliance of systems and equipment to the OPR should be witnessed by the Owner's O&M staff as part of Contractor's Training Plan. The CxA facilitates the monitoring of functional and commissioning tests by designated Owner personnel performed as part of the GC's acceptance plan. The benefits to the Owner in monitoring these tests are lessons learned and corrective review of O&M procedures prior to Substantial Completion and operation of the systems by the Owner. Using the information developed in this start-up phase, the Owner and the CxA should evaluate the abilities of in-house personnel to perform the O&M necessary for successful operation of various systems and to prevent future warranty issues. A value analysis of OEM service programs and maintenance by the CxA during this period is useful information for the Owner's consideration. Documentation gathered by the CxA during this monitoring phase is useful to the training program and in the acceptance phase.

The majority of HVAC&R systems and assemblies training should occur in the Construction Phase, prior to Substantial Completion. The initial training is developed at a level to ensure that the Owner's O&M personnel are competent in the proper operation of the systems and equipment during occupancy. The training prior to Final Acceptance takes place after the facility has been occupied during the warranty period between Substantial Completion and Final Acceptance. This allows for training in seasonal operation and site-specific issues to be addressed in the training program. Using a two step training program, the CxA will facilitate the coordination of site-specific issues:

- Warranty/Guaranty
- Service Call-up or Call-back
- Systems and Equipment Performance
- Seasonal Transition of Equipment
- Spare Parts Inventory
- Equipment or Systems Service Bulletins
- Life-cycle analysis
- Modified Preventative and Predictive Maintenance Procedures.

Construction Phase Close Out:

As systems are completed, the Contractor may be required to or may elect to use these systems to maintain an environment at the worksite meeting specified requirements in executing the construction process. Prior to turnover, these systems operated by the Contractor need to be validated for proper O&M by contractor personnel. The validation of operating equipment at turnover must include documentation that the Contractor Personnel were properly trained in both operation and maintenance of the system and that the equipment maintenance schedule was maintained during the period of contractor operation. Lessons learned and information gathered on the operations of the systems during start-up and operations are valuable to the Owner and must be included in the turnover training of the Owner's Operating Staff and coordinated by the CxA before the Owner assumes these responsibilities.

Occupancy and Occupancy Phase:

At Substantial Completion and Owner Operations and Occupancy, the major training responsibilities become the responsibility of the Owner. Specifically, it will become the responsibility of the Owner's Facility Chief Engineer and Building Manager. The CxA will coordinate this shift in responsibilities until Final Acceptance or beyond as required by the Owner's ongoing and continuous commissioning process activities. The CxA/Chief Engineer/Building Manager relationship in this phase will coordinate the training requirements to implement and optimize the performance of:

- Existing Service and Outsourcing of Service Plans and Programs
- Organization and Training of O&M staff
- Qualification of Training Requirements of staff positions
- Warranty/Guaranty implementation and enforcement

- Service Call-up or Call-back tracking and evaluation
- Systems and Equipment Performance in:
  - Measurement
  - Verification
  - Analysis (Benchmarking and Life-cycle)
  - Optimization
  - Re-commissioning Cycle
  - Optimization
- Seasonal Transition of Equipment and tracking impact of weather cycles and systems performance
- Spare Parts Inventory and response times for service
- Equipment or Systems Service Bulletins and training updating
- Life-cycle and Maintenance Budget Planning
- Modification of Preventative and Predictive Maintenance Procedures to meet site-specific conditions.

The Facility/Building Manager will assess the benefits and costs of maintaining a Training Cycle that represents the interests of the Owner. The CxA can be of great benefit to the Building Manager in the initial organization of construction documents providing a method to keep training up-to-date with the cycle of changes in equipment and use of the building throughout the lifecycle.

Summary:

The processes of training and systems optimization will remain a responsibility of the Chief Engineer and Facility/Building Manager for the life of the Facility. To assure the continuing need for training and understanding of systems and O&M, a paper-trail of the learning process is essential to the continuing success of site operations. The CxA is an essential part in getting this process off the ground, and with continuing commissioning efforts, provides the guidelines to optimize the training process through the life of the building. The documentation of the training process coordinates the:

- Coordination and Organization of Responsibilities for training assigned to a position
- Verification of understanding and competence in what was learned in training and O&M
- Proper application of Preventative and Predictive Maintenance of Systems
- Organization of application of Service Bulletins and OEM call-backs
- Clear application of system performance and degradation information

- Optimal benefits from lessons learned
- Coordination of Personnel Changes and Mentoring for a position.

Training Plan and Records

Pre-Design

Training Requirements and Implementation begin at project conception and are part of the OPR. At the implementation stage, the Owner needs to address the source of operating personnel, in-house or out-sourced labor and services, and the level of responsibility assigned to the Facilities/Project Manager for the site. OPR requirements for extended warranty and service agreements with the Contractor or OEM need to be addressed at the time of project inception.

In the implementation stage, beginning with assigned individual roles and responsibilities, the OPR for training are considered in a manner similar to choosing any of the varied systems, components, and assemblies that establish the level of quality and performance expectations expressed by the Owner in the OPR.

The criteria used to determine the minimum level of acceptance required by the Training OPR will guide the development and coordination of the training of personnel who are assigned responsibilities of maintaining the facility systems performance in the OPR. This includes, for example, energy, electrical, plumbing, fire, and safety, and indoor environment and occupant comfort requirements that are related to the facility systems. During Pre-design, the initial training agenda needs to be developed to a level that reflects the training required to meet the OPR. This provides the initial guidance to the design team. It includes:

- Establish development requirements for the Training Plan.
- Identify Essential Components or Systems requiring formal training and the estimated time designated for training by hours (unit cost).
- Determine Skill level requirements for Operating Staff meeting the OPR levels of performance.
- Create checklists of training requirements necessary to maintain warranty conditions and service life.
- Specify requirements for acceptable organization and implementation of the OEM training requirements prior to Occupancy.
- Clearly identify the training requirements of contractor’s work force for the equipment maintaining the interior environment during the Construction Phase.
- Develop training methods that meet the OPR, including incorporating OEM training with service bulletins, recalls, and implantation of changes in operating procedures as facility systems and components age and degrade in performance levels.
- Provide clear understanding of the OPR for training material, training sessions (schedule), and trained personnel necessary, prior to and after occupancy by the Owner.

Training responsibilities and the position or person assigned these responsibilities must be clearly defined in the OPR and reviewed before moving into Design. This is of extreme importance when essential equipment or systems are provided by the Owner.

The design needs to satisfy the operating personnel for the following OPR topic areas, including consideration of training required to continuously achieve the benefits of designs that optimize each requirement.

- Reparability
- Interchangeability
- Accessibility
- Replaceability
- Maintainability
- Extendability
- Adaptability
- Lifecycle Replacement Sequence
- Cost Analysis of Component Servicing and Maintenance Cycles
- Complexity of the OEM and Systems in day to day operation.

Controls at the system and component level are essential for all systems and assemblies. There must be special effort directed at the training requirements as the design develops versus considering the training afterward as a result of the controls design.

Beyond mechanical maintenance, the skill set required at each level of the operating hierarchy for DDC systems needs to be defined in the OPR. These DDC systems have various levels of control and hierarchy; some levels require computer programming skills that are beyond the means of an Owner to support. At a minimum, the OPR should define the responsibilities and training necessary for in-house and out-sourced contractors (service plan) of site DDC systems. The level of interoperability and any additions to interoperability not currently used at the site or organization requires additional training for the systems to be successful. Issues addressed in the OPR should include the following:

- DDC in-house EOM requirements
- DDC service plans and warranty requirements
- Procedures for maintaining record documents and service records of DDC Systems
- Training and Certifications requirements for in-house and service contractor personnel
- Written training matrix updated to each level in the DDC Hierarchy.

Design

During design, the design professional, following the OPR, will define the training requirements and implementation schedule for the project in the contract documents. Sometimes this may require specific needs for each installing contractor and for in-house maintenance and out-sourced service personnel. The performance of these training services is verified both as part of the submittal review process and as the training sessions occur. There will be additional training requirements that continue to evolve during design and construction of the project. It is recommended to have “Needs Development Workshops or Sessions” during design and construction. These need to be defined in the specifications. Special note should be given to the training and service requirements of equipment and systems not provided by the project contractor. This is usually owner provided equipment or systems that occur outside the project submittal review. In some cases, there may be two or more construction projects, with separate contractors or in-house construction. This requires coordination of training needs to prevent duplication and acceptable scheduling of trainers and trainees.

Procedure training on spare parts availability and service response times should be clearly defined by the design professional and verified in the submittal process.

During design, the design professional should clearly define all special requirements for storage of equipment or systems prior to installation. Training necessary to maintain the equipment prior to Owner acceptance is identified and monitored by proper application of the Contractor’s QA/QC Program. Special training of contractor personnel handling equipment with special requirements should be monitored by the CxA, demonstrating training and competence and meeting the OPR during all periods that the equipment and systems are operated during construction and warranty. Equipment must be maintained to prevent any degradation prior to turnover to the Owner for operations.

Contractor Special Training, Licensing, Certification (Construction Phase)

After the notice to proceed, the Contractor is required to provide initial submittals in the stated period of time. One of the initial submittals usually required is the Contractor’s QA/QC Program. This program outlines the methods used by the Contractor to ensure his personnel have the proper Training, Licensing, and Certifications to perform assigned tasks. In addition, the criteria necessary to maintaining the project-specific OPR are identified in the Contractor QA/QC Program. On a frequent basis, the CxA should verify and note compliance by the Contractor to required Training, Licensing, and Certification requirements or activities and other quality checks identified in the Contractor’s QA/QC Program or required by the contract.

Certification Training for procedures in the use of unique equipment or assemblies should be required at locations other than the actual job site. In such cases, the design professional may require verification of current and up-to-date certification and valid accreditation documents for the organization or individual issuing the certification. The role of the CxA in verification of proper training for certification is to randomly check the documentation necessary to demonstrate compliance with the OPR. The requirement for ensuring that the proper documentation is valid remains with either the design team or Owner’s Project or Construction Manager.

Construction Phase Training

There should be an initial training session during the construction period and prior to contractor training for the Owner's EOM and users by the design team on the OPR and BOD, including system limitations. This is especially required for all mechanical and electrical systems that are critical to the success of the facility.

The CxA should hold a training development workshop with the EOM (including any service contractors) several months before the final training sessions are scheduled and the scope of training-sessions content is set. This workshop is for gathering information from the EOM staff to determine the actual training requirements based upon the approved equipment, assemblies, and systems for the building, upon a walk-through of the building, and upon the review of final plans and specifications. This may require an increase or decrease in actual training requirements than the requirement included in the contract documents. This is frequently related to the final equipment, components, and HVAC&R systems selected by the Owner, design team, and Contractor.

Systems Manuals need to be complete before Owner's personnel are provided training and used in the training sessions.

Training on the use of the Systems Manuals should be a combined training effort of the design team, the Cx Process team, and the Contractor.

The CxA should review the Contractor's schedule for all required training. Resources and time for training can place great demand on both the Contractor and the EOM and service firm personnel at the end of the Construction Period. Building operating systems are especially impacted because of a high level of training required. Early training must be scheduled for project success. The CxA must document that training and the required level of competence learned in the training meets the OPR.

The Contractor is responsible for start-up, testing, adjusting, balancing, Systems Manual, and training for all systems and equipment prior to the functional testing or measurement and verification of these systems and equipment. The Cx Team must verify through assembled documentation that the contractor personnel are trained and competent to perform these activities.

The Contractor must begin early training on any major changes in the automated preventive maintenance and service program that is included by systems installed and required by the contract.

Testing and evaluation demonstrating compliance of systems and equipment to the OPR should be witnessed by the Owner's O&M staff as part of Contractor's Training Plan. The CxA facilitates the monitoring of functional and commissioning tests by designated Owner personnel performed as part of the General Contractor's acceptance plan. The benefit to the Owner in monitoring these tests are lessons learned and corrective review of O&M procedures prior to Substantial Completion and operation of the systems by the Owner. Using the information developed in this start-up phase, the Owner and the CxA should evaluate the abilities of in-house personnel to perform the O&M necessary for successful operation of various systems and to prevent future warranty issues. A value analysis of OEM service programs and maintenance by the CxA during this period is useful information for the Owner's consideration. Documentation

gathered by the CxA during this monitoring phase is useful to the training program and in the acceptance phase.

The majority of the systems and assemblies training should occur during construction, prior to Substantial Completion. The initial training is developed at a level to ensure that the Owner's O&M personnel are competent in the proper operation of the systems and equipment during occupancy. The training prior to Final Acceptance takes place after the facility has been occupied during the warranty period between Substantial Completion and Final Acceptance. This allows for training in seasonal operation and site-specific issues to be addressed in the training program. Using a two-step training program, the CxA will facilitate the coordination of site specific issues:

(a) Warranty/Guaranty

(b) Service Call-up or Call-back

(c) Systems and Equipment Performance

(d) Seasonal Transition of Equipment

(e) Spare Parts Inventory

(f) Equipment or Systems Service Bulletins

(g) Life-cycle analysis

(h) Modified Preventative and Predictive Maintenance Procedures.

Construction Close Out

As systems are completed, the Contractor may be required to or may elect to use these systems to maintain an environment at the worksite meeting specified requirements in executing the construction process. Prior to turnover, these systems operated by the Contractor need to be validated for proper O&M by contractor personnel. The validation of operating equipment at turnover must include documentation that the Contractor Personnel were properly trained in both operation and maintenance of the system and that the equipment maintenance schedule was maintained during the period of contractor operation. Lessons learned and information gathered on the operations of the systems during start-up and operations are valuable to the Owner and must be included in the turnover training of the Owner's Operating Staff and coordinated by the CxA before the Owner assumes these responsibilities.

Occupancy and Operations

At Substantial Completion and Owner Operations and Occupancy, the major training responsibilities become the responsibility of the Owner. Specifically, it will become the responsibility of the Owner's Facility Chief Engineer and Building Manager. The CxA/Chief Engineer/Building Manager relationship in this phase will coordinate the training requirements to implement and optimize the performance of:

- Existing Service and Outsourcing of Service Plans and Programs
- Organization and Training of O&M staff
- Qualification of Training Requirements of staff positions

- Warranty/Guaranty implementation and enforcement
- Service Call-up or Call-back tracking and evaluation
- Systems and Equipment Performance in:
  - Measurement
  - Verification
  - Analysis (Benchmarking and Life-cycle)
  - Optimization
  - Re-commissioning Cycle
  - Optimization
- Seasonal Transition of Equipment and tracking impact of weather cycles and systems performance
- Spare Parts Inventory and response times for service
- Equipment or Systems Service Bulletins and training updating
- Life-cycle and Maintenance Budget Planning
- Modification of Preventative and Predictive Maintenance Procedures to meet site-specific conditions.

The Facility/Building Manager will assess the benefits and costs of maintaining a Training Cycle that represents the interests of the Owner. The CxA can be of great benefit to the Building Manager in the initial organization of Construction Documents, providing a method to keep training up-to-date with the cycle of changes in equipment and use of the building throughout the life-cycle.

Summary

The processes of training and systems optimization will remain a responsibility of the Chief Engineer and Facility/Building Manager for the life of the Facility. To assure the continuing need for training and understanding of systems and O&M, a paper-trail of the learning process is essential to the continuing success of site operations. The CxA is an essential part in getting this process off the ground, and with continuing Cx efforts, provides the guidelines to optimize the training process through the life of the building. The documentation of the training process coordinates the:

- Coordination and Organization of Responsibilities for training assigned to a position
- Evaluation of understanding and competence in what was learned in training and O&M
- Proper application of Preventative and Predictive Maintenance of Systems
- Organization of application of Service Bulletins and OEM call-backs
- Clear application of system performance and degradation information
- Optimal benefits from lessons learned
- Coordination of Personnel Changes and Mentoring for a position.

a) Instructor qualified to train on the specific topic areas for each training session are to

include the following:

1. Specific experience of the systems, equipment, and/or project knowledge that relate to the instructional topics.
2. Experience related to the systems, subsystems, equipment, and assemblies.
3. Formal education and factory training.
4. Skills related to the operation and maintenance of systems, sub-systems, equipment, and assemblies.

b) Training materials employed during the instructional process shall be provided.

1. Systems Manual information.
2. Handouts and written information.
3. Vendor and manufacturer information.
4. Visual aids.

c) Training agenda

1. Training participant evaluation form.
2. Training acceptance evaluation form.

This annex is not a mandatory part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline. It has not been processed according to the ANSI requirements for a guideline and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI**.**

INFORMATIVE ANNEX W
Issues and Resolution Logs

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

Issues and Resolutions Log

The Issues and Resolutions Log is the ongoing listing of issues and questions on a project that needs to be communicated to the project team for resolution or action. These are often shown in table format and supplemented with pictures and drawings where necessary.

The following items can be included in an effective Issues and Resolutions Log:

- Project title
- Project location
- Name of CxA managing Issues and Resolution Log with email address and phone number
- Issue number
- Issue description
- Pictures of item if available and appropriate
- Date issue discovered
- Issue found by name
- Effects of issue on project or building operation
- Possible cause of issue or problem
- Recommendation for resolution if available
- Person(s) assigned to resolve issue
- Actions taken
- Approvals of issue resolution.

This annex is not a mandatory part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline. It has not been processed according to the ANSI requirements for a guideline and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.

INFORMATIVE ANNEX X

Commissioning Process Report and Testing Records and Reports

The following are examples of the requirements and formats for the documents to be included in the Systems Manual.

Construction Observation and Testing Checklists and Report

OVERVIEW

Construction Checklists consist of two general types:

Component/Equipment Based: these Construction Checklists are utilized for components and pieces of equipment that are delivered, installed, and started up during construction. There is an individual checklist for each individual component or piece of equipment.

System/Assembly Based: these Construction Checklists are utilized for systems and assemblies where separate checklists cannot be applied to sub-components of the system or assembly. There is a single checklist for the entire system, often assembled around the sequence of operation.

For each Test Procedure, Test Data Records shall be developed. Test Data Records capture test data, observations, and measurements. Data may be recorded on photographs, forms, or other means appropriate for the application. The following information shall be recorded:

1. Test number.
2. Date and time of the test.
3. Indication of whether the record is for a first test or retest following correction of a problem or issue.
4. Identification of the system, equipment, or assembly under test. List the location and the construction document designation.
5. Conditions under which the test was conducted.
6. Expected performance of the systems and assemblies at each step of the test.
7. Observed performance of the system, equipment, or assembly at each step of the test.
8. Issue number, if any, generated as a result of the test.
9. Dated signatures of the person performing the test and of the witness, if applicable.

SAMPLE [insert equipment/component name] CHECKLIST

TAG ID: Location: Date:

General Instructions:

1. This form is to be completed as the work is completed.
2. Section 1 – Model Verification upon delivery of equipment/component to either the jobsite or storage location.
3. Section 2 – Pre-Installation Checks just prior to initial installation.
4. Section 3 – Installation as installation progresses.
5. Section 4 – Fill in performance data and initial.

There are a number of websites of testing and Cx organizations and agencies that have inspection and testing forms that can be adapted for specific needs and projects.

Commissioning Report

The Cx Progress Report is the documentation of the Cx work and results accomplished during construction. The Cx Process Report contains the following:

(a) Identification of any systems or assemblies that do not perform in accordance with the OPR. For various reasons, the Owner may choose to accept performance that is at variance with the OPR, either permanently or until schedule and budget constraints allow for correction. The Owner's acceptance of these conditions should be documented along with the environmental, health, safety, comfort, energy, and operating and maintenance cost impacts. The OPR must be updated to match the revised expectations.

(b) Evaluations of the operating condition of the systems at the time of test completion.

(c) Construction Checklist completion and evaluation summary.

(d) Results from the Issues Log, including the descriptions of issues and the measures taken to correct them. The description should assess the importance of the issues and estimate the value of their correction in terms of environmental impact, improved health, safety, comfort, energy, operating and maintenance costs, and the ability of the facility to support its mission.

(e) Test procedures and data. This section should incorporate the original test procedures and signed data forms, including additional data such as photos, computerized documentation, and other records of the tests. Data should include the final accepted test, as well as earlier tests that failed to meet the specified criteria. This section should also include a set of blank data forms for future use in the ongoing Cx Process and re-commissioning.

(f) Cx Progress Reports. Copies of progress reports generated throughout the Cx Process.

(g) Deferred Tests. Execution of some tests may be deferred until appropriate natural loads, such as occupancy or design weather conditions, are available. For these deferred tests, the prerequisite conditions and an estimated schedule for their completion should be included.

(h) Lessons-Learned. Evaluation of the Cx Process used and changes that will improve the delivered project and form the basis for the Final Cx Progress Report developed during Occupancy and Operations. This is essential to ensure that issues, benefits, and recommendations are captured in a written document while all team members are available and information is fresh.

A preliminary Cx Progresss Report should be submitted for Owner review. Submittal of the preliminary Cx Report to other Cx Team members or for jurisdictional requirements may also be appropriate.

The final Cx Process Report should incorporate review comments from the Owner, and, optionally, from other Cx Team members.

The following is an example outline for a Cx Progress Report. The basic structure of this example is such that each phase of the plan has its own section detailing what activities were accomplished and who accomplished it and how it was completed. The deliverables for each activity are included in an appendix. Each section of the report will have a description of the results for that subject. The intent of this format is for the Cx Plan to become the Final Cx Progress Report at the end of the project by updating the plan and filling in the results for each section as the project progresses.

Commissioning Progress Report

Table of Contents

1. Executive Summary

2. Commissioning Process Description and Plan(s)

Insert the final Commissioning Process Plan.

3. Commissioning Design Summary and Design and Submittal Review Reports

Insert a copy of the Cx design and submittal reports.

4. Testing Reports

Insert completed Commissioning Progress Report with documents and testing forms and records for each building, system, and assembly included in the Cx Process in the Annexes below.

Insert copies of all relevant manufacturers and installers testing reports in appropriate annex. This creates a unified record of all required testing performed during purchasing and installation.

Insert copies of installers' and commissioning authorities' completed validation checklists in annex below. This provides a record of installation checks and observations for future

reference.

Insert copies of installers' and commissioning authorities' completed functional performance checklists of assemblies, equipment, and integrated system in annex below. This provides a record of performance check and observations for future reference.

5. Cx Progress Reports

Insert a copy of all Cx progress reports in annex below.

6. Issue and Resolution Logs

Insert a copy of all issue and resolution logs with resolution or status of each item in annex below. This provides a record of problems and issues found and resolved during the design and construction process for future reference.

7. Item Resolution and Open Items

Insert a list of any open items and seasonal or additional testing required.

8. Contact Information.

Appendices in the initiation and design stages of the project will state the requirements and responsibilities for that deliverable. The final results and documentation for each item will be inserted in the final report.

It is not necessary to include copies of documents included in the Systems Manual in the final Cx Process Report if that report is included in the Systems Manual.

APPENDIX A – OWNER'S PROJECT REQUIREMENTS
APPENDIX B – BASIS OF DESIGN
APPENDIX C – FINAL PROJECT SPECIFICATIONS
APPENDIX D – COMMUNICATION STRUCTURES
APPENDIX E – ROLES AND RESPONSIBILITIES
APPENDIX F – COMMISSIONED SYSTEMS [listing of systems and assemblies]
APPENDIX G – COMMISSIONING PROCESS SCHEDULE RESULTS
APPENDIX H – PRE-BID MEETING RECORDS
APPENDIX I – PRE-CONSTRUCTION MEETING RECORDS
APPENDIX J – SUBMITTAL REVIEW RECORDS
APPENDIX K – COMMISSIONING PROCESS ISSUES AND RESOLUTION RESULTS
APPENDIX L – CONSTRUCTION CHECKLISTS COMPLETED
APPENDIX M – TESTS AND DOCUMENTATION COMPLETED
APPENDIX N – SYSTEMS MANUAL ASSEMBLY PROCESS
APPENDIX O – TRAINING RECORDS
APPENDIX P – MEETING MINUTES and CORRESPONDENCE
APPENDIX Q – Cx PROGRESS REPORTS
APPENDIX R – WARRANTY REVIEW AND STATUS
APPENDIX S – OPEN ISSUES
APPENDIX T – LESSONS LEARNED REPORT

POLICY STATEMENT DEFINING ASHRAE'S CONCERNFOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered. ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.