

# Laney Library & Learning Resource Center

## Commissioning Plan

October 2020



# Contents

- 1. Executive Summary ..... 4
  - 1.1. Abbreviations..... 4
  - 1.2. General Project Information ..... 4
- 2. Commissioning Team Roles and Responsibilities ..... 5
  - 2.1. Commissioning Team Directory ..... 5
  - 2.2. General Descriptions and Responsibilities ..... 6
  - 2.3. Project Management Protocols..... 8
  - 2.4. Project Management Protocols..... 9
- 3. Systems to be Commissioned ..... 9
- 4. Commissioning Process – Design Phase ..... 10
  - 4.1. Title 24 Cx Schematic Design Kickoff Meeting ..... 10
  - 4.2. Owner’s Project Requirement ..... 11
  - 4.3. Basis of Design ..... 11
  - 4.4. Commissioning Plan ..... 11
  - 4.5. Commissioning Design Review ..... 11
  - 4.6. Title 24 Code Design Review ..... 12
  - 4.7. Commissioning Specifications ..... 12
  - 4.8. Development of the System Manual..... 13
  - 4.9. Development of Training Requirements ..... 13
  - 4.10. Controls Integration ..... 13
- 5. Commissioning Process – Construction Phase ..... 14
  - 5.1. Commissioning Kick-Off Meeting ..... 15
  - 5.2. Commissioning Schedule..... 15
  - 5.3. Submittals and Documentation ..... 16
  - 5.4. Equipment Submittals..... 17
  - 5.5. Contractor Documentation ..... 17
  - 5.6. CxA Reviews ..... 18
  - 5.7. Special Submittals and Notifications ..... 18
  - 5.8. Controls Integration Meetings ..... 19
  - 5.9. Miscellaneous Meetings..... 19
  - 5.10. Startup ..... 19
  - 5.11. Test and Balance (TAB)..... 20

<b>5.12.</b>	<b>Functional Performance Test (FPT) and Verification Procedures</b> .....	<b>21</b>
<b>5.12.6.</b>	<b>Execution of Functional Testing Procedures</b> .....	<b>23</b>
<b>5.13.</b>	<b>O&amp;M Manuals and Warranty Documentation</b> .....	<b>23</b>
<b>5.14.</b>	<b>Final Commissioning Report</b> .....	<b>24</b>
<b>5.15.</b>	<b>Systems Manual</b> .....	<b>24</b>
<b>5.16.</b>	<b>Training and Orientation of Personnel</b> .....	<b>24</b>
<b>5.17.</b>	<b>Current Facility Requirements</b> .....	<b>25</b>
<b>5.18.</b>	<b>Warranty Period Commissioning</b> .....	<b>26</b>
<b>5.19.</b>	<b>Ongoing Commissioning Plan</b> .....	<b>26</b>

# 1. Executive Summary

The Red Car Analytics Commissioning Team has developed this Commissioning Plan to provide direction on the commissioning process and scope of commissioning, defining related activities and team responsibilities. The Plan includes definitions of commissioning terms, descriptions of commissioning processes, a comprehensive team directory, detailed information on roles and responsibilities, project and system descriptions, lists of documents related to commissioning, commissioning schedule milestones, coordination and communication protocols, and resolution pathways and procedures. It describes the scope, approach, time frame, responsibilities, and technical requirements for the commissioning activities.

The Commissioning Authority (CxA) is Red Car Analytics.

## 1.1. Abbreviations

A/E	Architect & Design Engineers	IC	Irrigation Contractor
BAS	Building Automation System	IOM	Installation and Operations Manuals
BOD	Basis of Design	IOR	Inspector of Record
CC	Controls Contractor	MC	Mechanical Contractor
CM	Construction Manager	MEP	Mechanical Electrical Plumbing
Cx	Commissioning	O&M	Operations and Maintenance
CxA	Commissioning Authority (Red Car)	OPR	Owner’s Project Requirements
CxC	Commissioning/MEP Coordinator (GC)	OR	Owner’s Representative
EC	Electrical Contractor	PC	Project Coordinator
EOR	Engineer of Record	PM	Project Manager
FM	Fire Marshal	SOO	Sequence of Operation
FPT	Functional Performance Test	TAB	Test-Adjust-Balance
GC	General Contractor		

## 1.2. General Project Information

<b>Project:</b>	Laney Library and Learning Resource Center
<b>Location:</b>	Oakland, CA
<b>Building Certification:</b>	targeting LEED NC v4 Certification
<b>Total Square Footage:</b>	73,746 gsf
<b>Construction Period:</b>	Nov 2021 to Nov 2023

## 2. Commissioning Team Roles and Responsibilities

The Commissioning Authority (CxA) reports results, findings, and recommendations directly to the Owner. In general, the CxA shall coordinate the commissioning activities directly with the design team and the MEP coordinator (CxC), and shall distribute reports to the General Contractor, Project Manager, Architect/Engineers, and Commissioning Coordinator. The design team roles and responsibilities are identified in this Cx Plan. The contractors’ commissioning responsibilities are detailed in the project specifications and this Cx Plan.

Where items in this plan differ from the specifications, the CxC shall bring these issues to the attention of the Owner’s Representative and the Commissioning Authority for resolution.

### 2.1. Commissioning Team Directory

Name	Company	Role	Phone	email
Greg Cheifetz	Peralta Community College	Owner		
Eric Skiba	Noll & Tam	Architect	510.542.2200	eric.skiba@nollandtam.com
Gavin Ross	Noll & Tam	Architect	510.542.2260	gavin.ross@nollandtam.com
Anna de Anguera	Cavagnero	Architect	510.499.6427	annad@cavagnero.com
Angela Wisely	Brightworks	Sustainability Consultant	415.230.2136	angela.wisely@brightworks.net
Glenn Friedman	Taylor Engineering	Mechanical & Plumbing Engineering	510.220.5895	gfriedman@taylor-engineering.com
Joe Arnstein	Taylor Engineering	Mechanical & Plumbing Engineering	704.582.2081	jarnstein@taylor-engineering.com
Stefan Gracik	Alter Engineering	Energy Modeling	724.968.6938	stefan@alterengineers.com
Paul Carey	O’Mahony & Myer	Electrical Engineering	415.218.0629	pcarey@ommconsulting.com
Sean Henderson	Mantlela	Landscape/Irrigation Engineering	513.532.4685	sean@mantlela.com
Michele Sagehorn	Red Car Analytics	Commissioning Authority	707.591.4555	michele@redcaranalytics.com

## 2.2. General Descriptions and Responsibilities

General descriptions of the commissioning roles are as follows:

### Owner or Owner's Representative (OR)

- Oversees the work of the CxA
- Assists the CxA with directing the project team
- Provides final approval and sign-off of Cx Plan
- Responsible for the development of the Owner's Project Requirements document
- Arbitrate disagreements between the CxA and others

### Commissioning Authority (CxA)

- Defines the project specific scope and requirements of commissioning
- Develops and oversees the Commissioning Plan and related activities
- Assists the team with implementation of the Commissioning Plan
- Advises the Owner on acceptance of design, construction and commissioning

### Architect

- Assists Owner in development of the Owner's Project Requirements document
- Coordinates/Manages submittal documents
- Provides resolution to design-related issues
- Participates as needed in commissioning process

### Engineers

- Provides Basis of Design document
- Completes and signs T24 Commissioning Design Checklist Compliance forms
- Reviews submittals and provides comments
- Provides clarifications to design intent
- Provides resolution to design-related issues
- Participates as needed in commissioning process

### General Contractor (GC)

- Provides a competent person in the role of MEP Coordinator (CxC)
- Provides coordination with subcontractors for all commissioning related activities
- Incorporates commissioning activities into the master construction schedule
- Directs subcontractors to provide resolution to construction issues
- Notify the commissioning agent of any change orders that may affect commissioned systems
- Coordinates owner training with subcontractors and commissioning agent
- Assists in resolving any warranty issues raised during the End-of-Warranty Review

### **MEP Coordinator of the GC (CxC)**

- Acts as the representative of the construction team and main point of contact for the CxA
- Delegates commissioning tasks to the subcontractors
- Coordinates and manages subcontractors and commissioning schedule
- Collects, assembles and manages commissioning documentation from subcontractors
- Works with subcontractors to correct installation/commissioning deficiencies as quickly as possible
- Provides support for functional testing as needed

### **MEP Subcontractors (Subs)**

- Reviews and comments on multiple releases of the Cx Plan
- Provides competent personnel to execute commissioning tasks
- Coordinates with GC on scheduling of commissioning tasks and potential conflicts
- Demonstrates and documents approved installation and operation of equipment
- Assists the team to provide resolution to construction issues
- Coordinates with equipment vendors for proper documentations and procedures

### **TAB Subcontractor**

- Coordinates with the commissioning team in the weeks prior to balancing
- Completes air and water balancing, per AABC or NEBB requirements and project specifications
- Provides a field copy to CxA prior to functional testing
- Identifies and reports on issues discovered in the field while balancing
- Demonstrates TAB results to CxA during Functional Performance Tests
- Coordinates with MEP Coordinator and CxA for resolution to issues

### **Controls Subcontractor (CC)**

- Performs all the tasks of MEP Subcontractors as listed above
- Provide Point-to-Point checks and calibration of all sensors prior to FPTs
- Provide point trends and assistance with remote access to building automation system
- Provide a person capable of demonstrating Functional Performance Test scripts and proper system operation
- Provide list of all schedules, set points, and alarms

### **Equipment Vendors**

- Provides documentation on furnished equipment, including complete submittals, equipment data, installation manuals, O&M manuals, start-up procedures, and warranties

### 2.3. Project Management Protocols

The following protocols will be used on this project:

- The CxA will communicate directly to the appropriate party and inform both the OR and CxC
- Deficiencies found during testing shall be corrected by the contractor within 7 days of receiving an Issues Log from the CxA
- Resolution of minor deficits during Functional Performance testing may be permissible, as determined by the CxA at the point when the deficient are found
- Problem solving: The CxA may recommend solutions to problems, however the burden of responsibility to solve, correct and retest problems is with the contractor
- The OR shall arbitrate disagreements between the CxA and others.

Issue	Protocol
Requests for information or formal documentation requests:	The CxA goes through the architect, engineer, or CxC.
Minor or verbal information and clarifications:	The CxA communicates directly to the informed party and informs the CxC.
Notifying contractors of significant deficiencies:	The CxA documents and communicates deficiencies through the CxC and OR. The CxA may discuss deficiency issues with contractors on an informal basis and will immediately notify the CxC or GC.
Scheduling commissioning meetings:	The CxA coordinates with the CxC. The CxC will coordinate meeting attendance for all required parties and will provide advance notification to the CxA.
Making a request for significant changes:	The CxA has no authority to issue change orders or construction directives. Any actions or observations of the CxA that might result in changes to the contract documents shall be approved by the PM and the design team will issue the changes.
Making small changes in specified Sequences of Operation (SOO)	The CxA notifies A/E of suggested change, which, if approved, is then implemented via RFI. Implemented changes in the SOO shall be documented by the CC in the as-built records, will become part of the O&M/ Systems Manuals, and the CC will notify the CxC and OR of the change in writing.
Making small changes to correct deficiencies	The CxA may request small changes to correct deficiencies from the responsible contractor. The CxA will immediately inform the GC's CxC of any such request. The respective contractor will be required to notify the CxC of the deficiency and correction.
Subcontractors disagreeing with requests or interpretations by the CxA	The OR will arbitrate disagreements between the CxA and others.



## 2.4. Project Management Protocols

The CxA will use a platform to store and share the commissioning documents, so that they can be viewed/downloaded at any time by all commissioning team members. The platform used will be either **Microsoft sharepoint or box**, where specific folders will be organized to make it easy to find the essential documents (e.g. – current version cx plan, etc.).

Red Car Analytics uses a cloud based program to document and maintain the commissioning issue logs (design/construction). The use of this program is simple and requires no password or special software, only the participants' email. The issue log(s) are essentially an excel spreadsheets, but allows parties to collaborate and to always have access to the latest update. The software also allows attachments to be stored and tracked with the associated issue. The use of this software allows for more detail and history that may prove useful to the owner or operator of the building.

## 3. Systems to be Commissioned

The following systems and equipment will be commissioned in this project. All general references to equipment in this document refer only to systems and equipment that will be commissioned.

### Mechanical

- HVAC System & Controls
- Air Handling Unit(s)
- Hydronic Pump(s)
- VAV Terminal Unit(s)
- Building fan(s)
- Building Management System/Controls

### Plumbing

- Domestic HW System

### Electrical/Lighting

- Lighting and Controls

### Miscellaneous

- Irrigation/Irrigation Controls

#### 4. Commissioning Process – Design Phase

The general sequence of Cx tasks and timing within the design schedule is shown below. The Architect and/or General Contractor are responsible to include commissioning tasks into the design and construction schedules and organize the participants.

Commissioning Schedule	Schematic Design	Design Development	Construction Documents	Bidding and Contract Award
Cx Review/Kickoff Meeting	[Red bar spanning Schematic Design, Design Development, and Construction Documents]			
Verify Owner Project	[Red bar spanning Schematic Design, Design Development, Construction Documents, and Bidding and Contract Award]			
Basis of Design	[Red bar spanning Schematic Design, Design Development, Construction Documents, and Bidding and Contract Award]			
Develop Cx Plan		[Red bar spanning Design Development, Construction Documents, and Bidding and Contract Award]		
LEED Design Review	[Red bar spanning Schematic Design, Design Development, Construction Documents, and Bidding and Contract Award]			
Title 24 CXR-E Design Review		[Red bar spanning Design Development, Construction Documents, and Bidding and Contract Award]		
Cx Specifications		[Red bar spanning Design Development, Construction Documents, and Bidding and Contract Award]		
Controls Integration Meeting		[Red bar spanning Design Development, Construction Documents, and Bidding and Contract Award]		
Development of Training Requirements		[Red bar spanning Design Development, Construction Documents, and Bidding and Contract Award]		
Development of System Manual Content		[Red bar spanning Design Development, Construction Documents, and Bidding and Contract Award]		

[Red bar] MEP Cx

##### 4.1. Title 24 Cx Schematic Design Kickoff Meeting

Title 24-2013 requires a meeting in early Schematic Design between the owner, Cx Design Reviewer, and the design team. The intent of the meeting is to lay out the process and timing for the design review(s) and provide the team with the Title 24 forms. It is recommended that the facility manager and/or facility mechanics participate in the design phase.

## **4.2. Owner's Project Requirement**

Identifying and documenting the project's design intent, or Owners Project Requirements, provides the design and construction teams with an understanding of the design goals for the project. The OPR is used to evaluate the design and construction efforts, assuring the goals are met, as well as helping to develop Functional Performance Tests. The OPR is developed by the CxA with guidance from the owner/owner representative at the beginning of the project. It is a living document and should be updated throughout the project. The CxA reviews the OPR for clarity and completeness.

The OPR should be documented during programming or schematic design, including:

- Energy efficiency goals
- Ventilation requirements
- Project program, including facility functions and hours of operation, and need for afterhours operations
- Equipment and systems expectations

## **4.3. Basis of Design**

The Basis of Design documents the thought processes and assumptions behind design decisions and is meant to show compliance with the OPR. The Basis of Design includes general information about the project, as well as specific technical design information about the proposed equipment and systems. This includes HVAC load calculations, overview of the sequence of operations, assumptions about temperature, light, hours of occupancy, etc. Plumbing and electrical BOD are developed to indicate how the domestic hot water and lighting controls are integrated into the building as well. This document may also be used during functional testing to confirm the design strategy and to help troubleshoot issues that may arise.

## **4.4. Commissioning Plan**

The Commissioning Plan (Cx Plan) is the roadmap for all activities related to Title 24 2013 and LEED commissioning. Commissioning begins during early design and continues through construction and into the post-occupancy period; therefore this document is intended to provide requirements for both design and construction teams. A preliminary Cx Plan is developed during the early design phase and updated by the CxA as needed throughout the project.

## **4.5. Commissioning Design Review**

A review of the project's design drawings and specifications is performed as a part of the commissioning requirements prior to the completion of Construction Documents. An initial review is initiated at mid-construction documents, with a back-check in subsequent issues. These reviews are conducted by the CxA, as a consultant to the owner, but not as the Engineer of Record. Issues related to the design must ultimately be resolved by the Engineer of Record.

The review focuses on the functionality of the systems, completeness and coordination of the drawings and specifications, maintainability of the systems, and overall compliance with the OPR and BOD. A Design Issue Log is maintained by the CxA to track all issues, responses, and actions related to commissioning. A/E members shall provide a written response to items found in the Design Issues Log.

#### **4.6. Title 24 Code Design Review**

There is a compliance form that are required by code to be submitted to the building department when filing for a building permit. The initial in-person design review meeting is to be held during the schematic phase of design. The owner, design team representatives (including the project architect and mechanical and electrical design engineers), and Design Reviewer meet to discuss the following:

- Project coordination, including involvement with the Design Reviewer
- Project scheduling, including design review
- Project scope
- Owner's Project Requirements
- Basis of Design
- Design elements and assumptions
- HVAC system selection
- Construction Documents Design Review checklists
- Energy efficiency measures

At the 90% CD phase, drawings and specifications are provided to the Design Reviewer, who reviews the construction documents using form NRCC-CXR-E. The Design Reviewer reviews the construction documents for clarity, completeness, and adherence to the owner's goals.

The NRCC-CXR-E acknowledges the design review has been executed, with signatures from the responsible engineer(s), and Design Reviewer. The form is provided to the Architect and placed on drawings to be submitted with the application for the building permit.

#### **4.7. Commissioning Specifications**

Commissioning specification language is incorporated into the construction documents. Section 019113 in Division 1 is dedicated to the General Commissioning Requirements. This language communicates commissioning roles and responsibilities to the construction team including the following:

- Components and systems that are commissioned
- Parties involved and their respective responsibilities for the commissioning process
- Commissioning schedule management
- Issue and non-compliance management
- Submittal review requirements and approval
- Definition of terms
- Scope and rigor of the start-up process, including responsibility for developing and executing startup checklists, and for the approval of these documents
- Scope and rigor of Functional Performance Testing, including responsibility for writing, executing, witnessing, and signing-off the tests
- Operations and Maintenance documentation requirements
- Training requirements for facility staff and building users (or Owner's representatives?)
- System manual requirements

#### **4.8. Development of the System Manual**

The CxA shall develop and outline the requirements of the Systems Manual with input from the Owner. The Systems Manual provides future operating staff with the information needed to understand and optimally operate the commissioned systems. It provides Facilities staff with the information necessary to monitor, maintain, and optimize system operations on an ongoing basis, and aids in the long-term success of building operations' energy efficiency strategies according to the design intent. The Systems Manual will be updated after Functional Performance Tests are complete, and within ten (10) working days of receiving as-built BAS drawings, Sequences of Operation, and other documentation from the CxC.

The Systems Manual will include the following documentation submitted by the CxC:

- 1) System Single Line Diagrams
- 2) As-built Sequences of Operations, control drawings, and as-built setpoints
- 3) Operating instructions for integrated building systems
- 4) Recommended schedule of maintenance requirements and frequency, if not included in the project O&M manuals
- 5) Recommended schedule for calibrating sensors and actuators
- 6) Basic Operation:
- 7) Written narrative of equipment operation
- 8) Interfaces, interlocks and interaction with other equipment and systems

#### **4.9. Development of Training Requirements**

The CxA shall review the training requirements and confirm that they meet the scope of the owner's requirements for the operator training. The training requirements must be completed before the bid documents are finalized, and be incorporated into the commissioning specifications as part of the bid package.

The training requirements shall include the following:

- List of those who should receive operational training, by position and name
- List of systems that require operator training
- Level of instruction required for each system
- Determination of whether the training provided by the equipment manufacturer is acceptable
- Tracking method to ensure that all required positions or persons receive training

#### **4.10. Controls Integration**

They are essentially a series of meetings that go over the project's control issues to enhance an understanding of the full sequences of control and interactions. When conducted during design, the meeting will reduce change orders and Requests for Information (RFIs). When conducted during design and again during submittal review in construction, the meetings will shorten the time required to program and reprogram the controls, perform testing and troubleshooting, and will enhance building operation and control for facility staff.

In design phase the meeting(s) include at minimum; the MEP engineers, controls contractor (if available), CxA, and owner representative. Discussion will include integration and interoperability issues between equipment, systems and disciplines to ensure that integration issues and responsibilities are clearly described in the specifications. The controls design as well as the sequence of operations for each system will be reviewed and clarified for all parties.

### 5. Commissioning Process – Construction Phase

The general sequence of Cx tasks and timing within the construction schedule is shown below.

Commissioning Schedule	Early Construction Phase	Installation	Start-up	Project Close-out	Post-Occupancy
Construction Team Kickoff Meeting	██████████	██████████	██████████		
Submittal Review	██████████	██████████	██████████	██████████	██████████
Controls Integration meeting	██████████				
Installation Verification Checklists or Mockup Performance Test Witness	██████████	██████████			
Equipment Start-up (Verification) or Witness Installation		██████████	██████████	██████████	██████████
Test and Balancing (Verification)		██████████	██████████		
Functional Testing		██████████	██████████	██████████	██████████
Owner Training / Verification		██████████	██████████	██████████	
Cx Report					██████████
Systems Manual					██████████
Post-Occupancy / Warranty Review			██████████	██████████	██████████

MEP Cx

### **5.1. Commissioning Kick-Off Meeting**

A commissioning kick-off meeting shall be conducted by the CxA. In attendance shall be the respective representatives of the OR, GC, CC, PC, MC, EC, IC, TAB, and all subs installing equipment to be commissioned. At the meeting, the commissioning process will be reviewed, and management and reporting lines will be determined. The flow of documents will be reviewed, and process questions will be addressed. The general list of each party's responsibilities, including the development of the Installation Verification and Startup Checklists and Functional Performance Tests for each piece of equipment, deliverables, proposed commissioning schedule, training and close-out will be presented and finalized.

The intent of the meeting is to provide an understanding with all parties as to the project's commissioning process and their respective responsibilities. The CxA will develop meeting minutes and a list of action items to be distributed to all key participants.

### **5.2. Commissioning Schedule**

The CxA shall develop an initial commissioning schedule. The CxC shall incorporate the Cx schedule into the overall construction schedule. The Cx schedule shall be updated and refined by the CxA as construction progresses.

The following sequential priorities will be followed in the development of the commissioning schedule:

1. Equipment is not temporarily started (for heating or cooling), until Installation Verification Checklist and Start-up checklist items and all manufacturers' pre-start procedures are completed, and moisture, dust and other environmental and building integrity issues have been addressed.
2. TAB is not performed until the envelope is completely enclosed and ceiling complete, unless the air is ducted.
3. The controls system and equipment it controls are not functionally tested until all points have been calibrated and Installation Verification Checklists have been completed.
4. Functional testing does not begin until Installation Verification Checklists, Start-up and TAB have been completed for a given system. This does not preclude a phased approach.

### 5.3. Submittals and Documentation

#### 5.3.1. Submittals and Sequence of Approvals

Description	Responsible Party	Delivery
<b>HVAC, DHW, Lighting Controls, Electrical, Renewable Energy Systems, Irrigation Systems</b>		
Equipment Submittal	Subcontractors	Prior to ordering equipment
Manufacturer's Installation and Operations Manuals	Subcontractors	8 weeks prior to startup
Single Line Diagram - showing equipment configuration	A/E or Subcontractor	8 weeks prior to startup
Sequence of Operations	A/E	Prior to construction (100% CD)
Startup & Installation verification Checklist - Draft Submittal	Subcontractors	8 weeks prior to startup
Procedure for piping, flushing and ductwork testing	MEP Sub	8 weeks prior to startup
Completed Startup & Installation Verification Checklists	Subcontractors	After Startup Checklist approval
Draft Functional Test Scripts for Team review	CxA	4 weeks prior to FPTs
Completed Controls Point-to-Point Checklist	BAS Sub	After Start-ups
Vibration/Sound Control Devices	MEP/TAB Sub	Provide report to CxA
Completed Piping, Flushing, Ductwork documentation	MEP Sub	After approval of procedures
Test and Balance Report-including vibration/sound requirements	TAB Sub	After approval of Completed Startup Checklists
Title 24 Acceptance Tests	Subcontractors	Prior to Functional Performance Tests
Functional Performance Tests (FPT)	Team	After approval of TAB Report
Response to Issues Logs	Team	As Issues are remedied
Training Agenda Submittal	Subcontractors	2 weeks prior to training
Training of Staff & Maintenance	Subcontractors	After Training Agenda approval
Training Log	GC	After Training is complete



#### **5.4. Equipment Submittals**

Equipment submittals are provided to the CxA at the same time as the EOR is reviewing the documents. The CxA will send all comments to the EOR several days prior to the architect's deadline. The EOR will review and merge the comments as necessary. It is the responsibility of the architect to incorporate all party's comments prior to returning the equipment submittal to the subcontractor. CxA review is based on adherence to contract documents, though may also have a focus on maintainability, access, and other functional aspects of the equipment.

#### **5.5. Contractor Documentation**

Once the equipment submittals are approved, each MEP subcontractor shall submit additional Contractor Documentation that is used in the commissioning process. These documents are to be provided as a package within 4 weeks of the approved submittals. Included in this package are the following:

##### **5.5.1. Manufacturer's Installation and Operations Manual (IOM)**

This manual generally can be downloaded from the manufacturer's website. The document may or may not be the same as the Operations and Maintenance Manual. It includes the recommended steps and procedures for proper installation, calibration, and configuration of the equipment. Include project Tag Numbers on all documents. Identify options that are being provided and/or cross out sections that are not appropriate to this project's installation.

##### **5.5.2. Single Line Diagrams (SLDs)**

Single line diagrams show equipment connections to integrated systems.

##### **5.5.3. Sequence of Operations (SOO)**

The contract documents generally contain the SOO, developed by the EOR. If this is not included in the drawing or specifications, the controls contractor (or subcontractor) submits the SOO to the EOR for review and approval.

Additionally, if there is a piece of equipment that is stand-alone or using its own internal controls; a sequence of operation is required from the manufacturer for that specific piece of equipment.

Other systems may finalize their sequence of operation during the submittal process. Such systems might include; Emergency Electrical/Security Protocols, Lighting systems, Automatic Shades, etc.

The SOO is a narrative describing the equipment and systems' startup, shutdown, capacity modulation, emergency and failure modes, alarms, and interlocks to other equipment. The CxA shall review and comment on the approved SOO and request clarifications and/or suggestions for all commissioned systems.

#### **5.5.4. Installation Verification Checklists**

These are the checklists that incorporate steps to install, configure, and calibrate the components of the equipment. Included are steps found in the manufacturer's recommendations, contract document requirements, and the contractor's standard procedures. These are sometimes references as Pre-Start, pre-checks, or pre-functional checks and are generally performed prior to the equipment being operated. They may be combined with the Start-up Checklists as long as all the procedures are incorporated.

#### **5.5.5. Startup Checklists**

Startup Checklists are designed to verify the equipment is configured and adjusted to comply with the manufacturer requirements and contract specifications. These steps include procedures involving the equipment's operational functions. Typically, pressure and temperature adjustments and verifications, modification of settings and schedules, and confirmation of functional operations are all part of the Startup Checklist. The contractor's standard Startup Checklist can be incorporated into these other requirements. If vendors are providing the startup, a copy of their checklist is required for review and acceptance. Ultimately, the subcontractor is responsible for the Startup procedures to be complete.

#### **5.5.6. TAB Outline Plan**

The CxC shall submit the outline of the TAB plan and approach prepared by the TAB contractor to the CxA and the BAS contractor at the same time when other submittals and contractor documentation is being processed. A full description of the procedures and the equipment to be verified, along with the design values, shall be provided.

A written explanation of the intended use and specific requirements of the BAS for the successful and timely completion of the TAB should be included in the plan. The EOR shall review and approve the plan. The CxA shall review the proposed plan for understanding and coordination issues and may provide comment, but is not responsible for approving the TAB plan.

### **5.6. CxA Reviews**

The CxC shall submit equipment and contractor documentation provided by the manufacturer and developed by the installing contractor for review by the CxA. The CxA shall suggest additional startup procedures to be incorporated, based on contract documents and manufacturers recommendations.

### **5.7. Special Submittals and Notifications**

#### **5.7.1. Changes to Previous Submittals**

The Subs, GC or A/E shall notify the CxA of any new design intent or operating parameter changes, modified control strategies or sequence of operation, or other change orders that may affect commissioned systems.

#### **5.7.2. Controls Points List**

The MEP EOR shall provide the CxA with a project specific full points list, at least thirty (30) days prior to performing the functional tests.

## **5.8. Controls Integration Meetings**

The CxA, CxC, EOR, CC and OR (or Owner’s designated Facility Representative) will conduct controls integration meeting(s) in coordination with team members as appropriate, including the controls programmer for the project. The meetings shall occur after the software and database drawings are issued for initial review, but prior to the development of the database and code for any piece of equipment. The meetings shall discuss and clarify the following issues:

- Points database
- Sequence of Operation, setpoints, and schedules
- Functional interlocks
- Operator workstation graphics
- Field sensor and panel location
- Integration with other systems

## **5.9. Miscellaneous Meetings**

The CxA may attend selected planning and job-site meetings in order to remain informed on construction progress and to update parties involved in commissioning. The CxC shall provide the CxA with information regarding substitutions, RFIs, change orders and any Architect’s Supplemental Instructions (ASI) that may affect commissioning of equipment, systems or the commissioning schedule.

During construction, meetings between various commissioning team parties will be scheduled by the CxA through the CxC.

### **5.9.1. Site Observations**

The CxA shall make periodic visits to the site to observe equipment and system installations. Additional visits may be made to observe the contractor’s pre-functional testing and verification of installations. The CxA shall be given adequate notice (no less than seven working days) by the CxC.

## **5.10. Startup**

Installing Subs are responsible for each part of Installation Verification Checklists and Startup Checklists for commissioned equipment and systems. The parties responsible for each part of these checklists are identified on the checklists. The startup procedures are directed and executed by the Sub or equipment vendor.

The Subs shall provide to the CxC the manufacturer checklists, Installation Verification, and Startup Checklists, including actual field checkout sheets used by the field technicians. The CxC shall forward the documents to the CxA. These documents shall become part of the Commissioning Final Report.

### **5.10.1. Execution of Startup Checklists and Startup**

The Installation and Startup Checklists are directed and executed by the Sub or vendor. To document the process of startup, the site technician performing the tasks shall check off items on the checklists as they are completed. Only individuals having direct knowledge of a line item being completed shall check or initial the forms.

The Subs and/or vendors execute the checklists and submit a signed and dated copy of the completed Installation and Startup Checklists to the CxC, who shall forward it to the CxA. The CxA may review Startup Checklists in progress.

#### **5.10.2. Deficiencies and Non-Conformance**

The Subs shall clearly list any outstanding items from the startup procedures that were not successfully completed. The procedures form and deficiencies shall be provided to the CxA within two (2) days of test completion. The Subs and vendors shall correct and retest any deficiencies or uncompleted items, involving the CxC as necessary, prior to the start of functional performance testing. The CxC shall notify the CxA when all deficiencies and uncompleted items have been resolved.

#### **5.10.3. Electrical Systems Checkout Plan**

The Electrical contractor shall use the approved Electrical Checkout plan; which will include MOPs (Methods of Procedure) and required testing forms as their start-up verification. The Electrical contractor shall review the FPTs in advance when provided by the CxA and provide written comments and detailed amendments no less than fourteen (14) days prior to the start of functional testing. The CxA shall consider the written comments in finalizing the FPTs within seven (7) days of receipt.

#### **5.10.4. Controls and Checkout Plan**

The BAS contractor shall utilize the BAS Point-to-Point and calibration checks as their startup verification.

All controls-related Startup Checklists and verifications must be completed and accepted by the CxA prior to TAB. The BAS contractor shall execute the assigned tests and trend logs and be available for assistance for mechanical system Functional Performance Tests.

#### **5.10.5. Startup Document Review**

The Subs shall provide the CxC with copies of the completed Installation Verification Checklists, Startup Checklists, and manufacturer's startup forms for all commissioned equipment and systems. The CxC shall forward the completed Cx documentation to the CxA as it is submitted, and in all cases, a minimum of five (5) working days prior to the start of Test Adjust Balance.

### **5.11. Test and Balance (TAB)**

The final TAB plan (as refined from the TAB outline plan) shall be provided to the CxA for review at least thirty (30) days prior to the commencement of TAB work. The TAB report shall be provided to the CxA upon completion, no later than five (5) days following completion of TAB work and 10 days prior to functional testing.

The TAB contractor shall submit weekly written lists of completed tests and reports of discrepancies to the CxC. The CxC shall forward to the CxA.

In general, TAB work does not begin until the BAS control system has been verified by Point-to-Point and calibration checks and these documents are accepted by the CxA.

The BAS contractor shall also meet with the TAB contractor prior to the start of TAB and review the TAB plan to determine the capabilities of the control system for use in TAB. The BAS contractor shall provide the TAB contractor with any necessary instruments for configuring terminal unit boxes and instruct the TAB contractor in their use. The BAS contractor shall also provide a technician qualified to operate the controls to assist the TAB contractor in performing TAB activities, as needed.

### **5.12. Functional Performance Test (FPT) and Verification Procedures**

Functional testing is the dynamic testing of systems (rather than just components) under full operation. Systems are tested under all modes of operation as defined in the sequences of operations, such as during cooling and heating loads, low and high loads, component failures, occupied and unoccupied modes, varying outside air temperatures, emergency and power failure, alarms, interlocks, and other operating conditions. Testing proceeds from components- to subsystems- to systems- and finally to interlocks and connections between systems.

Functional testing and verification shall be achieved by manual testing, by monitoring the performance and analyzing the results using the BAS trend log capabilities, or by stand-alone data-loggers, depending on the equipment and sequence as referenced in the FPTs. The systems shall be run through all of the control system's sequences of operation and verified to be responding as stated.

#### **5.12.1. Development of FPTs**

The CxA shall develop the Functional Performance Test procedures in a sequential written form. The CxA reviews all equipment submittals, manufacturer's recommended tests, and any change orders affecting equipment or systems, updated points list, control sequences and setpoints. The CxA may require clarification from the CxC, Subs and the A/E regarding sequences and operation for this purpose. The CxA shall utilize this data in preparing test forms and sequential test procedures to verify proper operation of each piece of equipment and system. Tests are prepared to yield results that are predictable and repeatable.

FPT procedures shall be distributed for review by all parties in advance of the scheduled tests. FPTs shall be submitted to the A/E for approval and finalized by the Commissioning Authority prior to the start of testing.

The BAS contractor shall review the FPTs in advance when provided by the CxA and provide written comments and detailed amendments no less than fourteen (14) days prior to the start of functional testing. The CxA shall consider the written comments in finalizing the FPTs within seven (7) days of receipt.

#### **5.12.2. Contractor Review and Approval of FPTs**

Thirty (30) days prior to performing any functional tests, proposed FPTs will be provided to the subcontractors. The Subs shall review and provide the CxA with their review of any procedures that are inconsistent with their understanding of the equipment operations, or conditions that may be unsafe or incompatible with maintaining the warranty.

#### **5.12.3. Functional Test Prerequisites**

Prior to the initiation of Functional Performance Tests, the CxA shall verify that Startup Checklists have been completed. BAS installation must be substantially completed (automatic operation) and their conformance to test requirements must be documented and accepted by

the CxA before commencing functional testing of systems. TAB for air and hydronic systems must be completed and at a minimum, the preliminary reports from the field submitted to the CxA.

#### **5.12.4. Title 24 Acceptance Tests**

Contractors are to submit a copy of all Title 24 Acceptance Tests to CxC, who will forward to CxA prior to the start of Functional Performance Tests. These tests are a further verification, beyond the other startup procedures, that the equipment is properly configured and ready for testing.

#### **5.12.5. Execution of Functional Testing Procedures**

##### **5.12.5.1. Process**

The CxA shall schedule Functional Performance Tests through the CxC. A meeting shall be held by the CxC at the start of the FPTs to review the planned tests and assure the required parties are prepared.

The CxA shall oversee, witness, and document the Sub's demonstration of the Functional Performance Test procedures for all equipment and systems according to the Specifications and the Cx Plan. The Subs or manufacturer's representatives shall execute and demonstrate the tests following the procedures developed by the CxA.

##### **5.12.5.2. Preliminary Testing**

The controls contractor, subcontractor, or vendor shall run through all functional testing prior to demonstrating the functional tests to the CxA. This is done to ensure that all readily observable deficiencies are corrected prior to witness testing. If, during functional performance testing, it becomes clear that preliminary testing by the Sub was not performed or not completed effectively, testing may be postponed at the discretion of the CxA. Testing shall recommence or resume after completion of preliminary testing.

##### **5.12.5.3. Deficiencies and Re-Testing**

In the process of witnessing Functional Performance Tests, the CxA will document non-compliant tests and significant system deficiencies on the procedure or test form. The CxA will notify the PC and CxC of deficiencies or non-conformance issues by documenting them on the Commissioning Issues Log in a timely fashion. Corrections of minor deficiencies may be made during the test demonstrations at the discretion of the CxC and CxA.

Decisions regarding minor deficiencies and corrections will be made at as low a level as possible; e.g., from the CxA, CxC and the Sub. The CxC and Subs will schedule re-testing as required, providing written notification to the CxA. For disputed items, the Owner will be the final authority.

Any additional retesting and site visits necessitated by equipment or systems not being fully functional when otherwise stated by the responsible contractor shall be at the expense of the responsible contractor.

Any additional verification or back-checks of issues due to equipment or systems not being functional when otherwise signed off by the responsible contractor shall be at the expense of the responsible contractor.

#### **5.12.5.4. Issues Log**

The CxA shall document all deficits found throughout commissioning in an Issues Log that is updated, distributed, and sent to the commissioning team. This document represents the observations by the CxA, as a third party representative of the owner. Subs shall correct deficiencies, sign them off, and notify the CxA in writing when ready for re-testing. It is the responsibility of each responsible party to address each issue by responding in writing as to what remedy or response the contractor has to the identified item. The CxA shall schedule re-testing through the GC.

#### **5.12.5.5. Facilities Staff Participation**

Facilities Operations staff is encouraged to attend and participate in the testing process. This process neither constitutes nor replaces formal training.

#### **5.12.6. Execution of Functional Testing Procedures**

Prior to functional testing, the GC's Controls Contractor (CC) shall set up trends on the BAS as specified in the FPTs and/or contract documents. The CC shall download and submit trend data to the GC, who shall forward it to the CxA for review. The data must be electronic and in spreadsheet or database format.

Trending Requirements:

- Trend logs must be established before functional testing; Commissioning Agent to review 24 hours of trend data prior to functional testing
- Remote access must be established prior to functional testing and the CxA shall be given access
- Submit trends for all points listed in specifications. Equipment should be trended during a period similar to design conditions
- Trend data must be saved in CSV (Comma delimited) (\*.csv) format or database format
- All data is to be within the 14 day trend period for any particular submittal period
- Status or Change of Value (COV) data may be saved with other COV data in a single file, but not with Time Series data
- Provide 14 continuous days of data, 24 hours a day, with time intervals as specified in Functional Performance Tests

#### **5.13. O&M Manuals and Warranty Documentation**

The CxC shall assemble all the turn-over documents required by the contract documents; this may include O&M manuals, equipment warranties, contractor guarantees, and as-builts. Typically these documents are reviewed and accepted by the A/E team. Additionally, the CxC should furnish these documents to the Operations Staff for internal review and input, and as a precursor to training. The CxC shall also review the turn-over package for completeness, approve each equipment warranty and will verify that all requirements for maintaining the warranty are valid and clearly stated. The CxA shall be provided the final turn-over package and will verify that it complies with the contract requirements.

### **5.14. Final Commissioning Report**

A final summary report by the CxA will be provided to the OR. The report shall include an executive summary, list of participants and roles, overview of commissioning and testing scope, and a general description of testing and verification methods and results. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment, system interactions or operations, future actions, commissioning process changes, etc. may also be listed.

### **5.15. Systems Manual**

The CxA shall develop the Systems Manual with input from the CxC, Subs, OR, CC, TAB, and Operations staff. The Systems Manual provides future operating staff with the information needed to understand and optimally operate the commissioned systems. It provides Facilities staff with the information necessary to monitor, maintain, and optimize system operations on an ongoing basis, and aids in the long-term success of building operations' energy efficiency strategies according to the design intent. The Systems Manual will be developed after Functional Performance Tests are complete, and within ten (10) working days of receiving as-built BAS drawings, Sequences of Operation, and other documentation from the CxC.

The Systems Manual will include the following documentation submitted by the CxC:

1. System Single Line Diagrams
2. As-built Sequences of Operations, control drawings, and as-built setpoints
3. Operating instructions for integrated building systems
4. Recommended schedule of maintenance requirements and frequency, if not included in the project O&M manuals
5. Recommended schedule for calibrating sensors and actuators if not included in O&M manuals.
6. Basic Operation:
  - a. Written narrative of equipment operation
  - b. Interfaces, interlocks and interaction with other equipment and systems

### **5.16. Training and Orientation of Personnel**

Owner training and orientation on equipment and systems shall be provided by the GC and Subs in accordance with the contract documents. The GC and Subs shall submit training plans to the CxA at least 30 days prior to scheduling training. Training plans shall include the name and qualifications of the trainer, the targeted audience, and a list of topics to be covered. The CxA shall review the training for system overview, design intent, and design criteria.

The operations personnel should be trained on the safe and proper operation, maintenance, diagnosis and repair of each piece of equipment. Submitted O&M information should be used during these training activities.

#### **5.16.1. Training Sessions / Agenda**

For each piece of equipment or system, a written training agenda will be developed and submitted for review and approval. OR and CxA will review and comment on each agenda in accordance with the training plan and project specifications. Recommended topics include:



1. Systems and equipment conceptual overview – what is the equipment, what is its function, and with what other systems or equipment does it interface
2. Sequences of operation in all modes of operation
3. Review of information in the System Manual
4. Review of the pertinent record drawings
5. Warranty details
6. Relevant health and safety practices and concerns
7. Common problems and their diagnosis and/or repair
8. Review and demonstration of servicing and preventive maintenance
9. Hands-on training for Facility staff
10. Proper maintenance schedules, tasks and procedures with demonstrations
11. Emergency response and recovery procedures in accordance with 2012 NFPA 3, Section A.1.3.2(5)
12. Emergency response and recovery procedures in accordance with 2012 NFPA 3, Section A.1.3.2(5)

#### **5.16.2. Training Record**

Following the training, the CxC and the Contractor will prepare a Training Record which will include, for each piece of equipment, a check-off of training covering each topic per the Project Training Plan. A log with the trainer and attendees signatures and date shall be included. PM, CxA, and the A/E will review the final Training Report.

#### **5.17. Current Facility Requirements**

New to LEED version 4 is the requirement for the CxA to assemble and maintain a current facility requirements (CFR) and operations and maintenance (O&M) plan that contains the necessary information to operate the building efficiently. The minimum documentation for the plan are listed below:

- Sequences of operation for the building
- Building occupancy schedule
- Equipment run-time schedule
- Setpoints for all HVAC equipment
- Lighting levels throughout the building
- Minimum outside air requirements
- Changes in schedules or setpoints for different seasons, days of the week, and times of day
- Systems narrative describing the mechanical and electrical systems and equipment
- Preventive maintenance plan for building equipment described in the systems narrative
- Cx program that includes periodic Cx requirements, ongoing Cx tasks, and continuous tasks for critical facilities.

## **5.18. Warranty Period Commissioning**

The CxA will conduct a Post-Occupancy and Warranty Period Commissioning Review. Post-Occupancy Commissioning will include a site visit approximately 8 – 10 months after occupancy, but before the warranty period has expired. During this site visit the CxA will interview the owner’s representative and/or facility staff to identify any problems with commissioned equipment, or concerns they have with operating the building as originally intended. Any unresolved items on the Issues Log will be reviewed. The CxA will participate in forming a plan with the owner to have these items resolved. The CxA may witness deferred testing. The CxA will document their findings in a site visit report.

### **5.18.1. Post-Occupancy Trend Analysis**

The CxA may analyze the trend data for systems integration issues and to review operation over variable conditions and times. Trend reviews provide a record of actual operating conditions and may reveal anomalies in settings, schedules, or responses that are inconsistent with the prescribed sequence of operations, where energy efficiencies or equipment operations may be compromised. This method of assessment is also an example of the recommended long term continuous commissioning to assure building operations are optimally maintained.

## **5.19. Ongoing Commissioning Plan**

The CxA shall issue an ongoing Commissioning Plan (Cx Plan) before or as part of the 10-month review of the building operation. The Ongoing Commissioning Plan is effectively a recurrence of the functional performance testing, monitoring based commissioning, and reporting procedures to ensure the building continues to perform according to the OPR, BOD and approved design and construction documentation throughout the lifetime of the building. The CxA shall provide blank functional performance tests for all commissioned systems, the issues log and direction for testing new and retrofitted equipment over time.

Ongoing Cx activities can be performed by in-house operating personnel or by a third party CxA and is required to occur at least twice a year to account for the seasonal variation.