

**Commissioning Plan
for the
Laramie County Library
in Cheyenne, Wyoming**

Prepared for:

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in Cheyenne, Wyoming
Commissioning Plan**

Table of Contents

1. Overview.....	1
1.1 Abbreviations and Definitions.....	1
1.2 Purpose of the Commissioning Plan (Cx Plan)	1
1.3 Commissioning Goals and Objectives.....	1
1.4 LEED Rating and Commissioning	2
1.5 Commissioning Scope.....	4
2. General Building Information	5
3. Commissioning Team Information.....	6
4. Roles and Responsibilities	8
4.1 General Management Plan	8
4.2 General Descriptions of Roles of the Cx Team	8
4.3 Specifications and Commissioning.....	8
4.4 General Management Plan and Protocols.....	9
4.5 Commissioning Team Responsibilities.....	9
5. Commissioning Process.....	13
5.1 Documentation of Basis of Design and Design Intent	13
5.2 Design Development Review	13
5.3 Construction Document Review	13
5.4 Submittals Review.....	13
5.5 Commissioning Kick Off Meeting	13
5.6 Start-Up/Prefunctional Checklists.....	14
5.7 Functional Performance Testing	14
5.8 Issues Log and Resolution Record	15

5.9	Operations and Maintenance Training	15
5.10	Develop Recommissioning Manual.....	15
5.11	Final Commissioning Report and LEED Documentation.....	16
5.12	Conduct Post-Occupancy Review.....	16
6.	Deliverables	17
7.	Scheduling	18
7.1	General Issues.....	18
7.2	Special Notes.....	18
7.3	Commissioning Activities Integrated into Construction Schedule.....	18
8.	Sample Prefunctional Checklists.....	20
9.	Sample Functional Performance Tests	22
10.	Sample Issues Log	26

1. Overview

1.1 Abbreviations and Definitions

The following are common abbreviations used in this document.

A/E	Architect and design engineers	FPT	Functional performance test
CxA	Commissioning agent	GC	General contractor/ Developer
CC	Controls contractor	MC	Mechanical contractor
Cx	Commissioning	PF	Pre-functional checklist
EE	Electrical Engineer	Subs	Subcontractors to General
Cx Plan	Commissioning Plan document	TAB	Test and balance contractor
EC	Electrical contractor	O&M Staff	Operations and Maintenance Staff
ME	Mechanical Engineer	OPR	Owner's Project Requirements

Where the term “contractors” is used in the Cx Plan, it refers to the GC and/or Subs as appropriate.

1.2 Purpose of the Commissioning Plan (Cx Plan)

The purpose of the Cx Plan is to provide direction for the commissioning process during construction, providing resolution for issues such as scheduling, roles and responsibilities, lines of communication and reporting, approvals, and coordination.

1.3 Commissioning Goals and Objectives

Commissioning is a systematic process of ensuring that the building systems perform according to the OPR. All equipment and systems should be installed according to manufacturer's recommendations, the best practices and standards of the industry, and the Contract Documents.

Commissioning will include documenting the OPR, followed by activities in the construction, acceptance, and warranty phases of the project. The participation of the contractors in commissioning activities will follow the requirements defined in the specifications. The main goal of the commissioning process is to verify and document that those building systems selected for commissioning – HVAC, Lighting and associated controls -- meet the design intent and owner's requirements for functionality and performance.

Specific commissioning objectives for this project are as follows:

- Fulfill the LEED Prerequisite Commissioning Requirement.
- Fulfill the LEED Additional Commissioning Requirement

- Verify and document that the equipment is installed and started per manufacturer's recommendations and to industry accepted minimum standards.
- Verify and document that equipment and systems receive complete operational checkout by the installing contractors.
- Verify and document equipment and system performance.
- Verify the completeness of operations and maintenance materials.
- Verify that the facility's operations personnel are adequately trained on the operation and maintenance of building equipment.

1.4 LEED Rating and Commissioning

The commissioning effort for this project will also include meeting all of the USGBC LEED commissioning requirements:

The LEED section on “Energy and Atmosphere” has a prerequisite of “Fundamental Building Systems Commissioning.” The LEED prerequisite commissioning requirement addresses the fundamental commissioning process, with specific reference to the following:

- Engage a Commissioning Authority.
- Develop Design Intent and Basis of Design documentation.
- Include commissioning requirements in the construction documents.
- Develop and utilize a Commissioning Plan.
- Verify installation, functional performance, training and documentation.
- Complete a Commissioning Report.

The LEED “Additional Commissioning” requirement addresses additional commissioning processes in the design and post-occupancy phase, with specific reference to the following:

- Review the Design Documents prior to the Construction Documents phase
- Review the Construction Documents prior to final issue
- Review contractor submittals related to commissioned equipment
- Develop and issue for O&M Staff a Recommissioning Manual that includes:
 1. Final version of the Owner's project requirements and basis of design.
 2. As-built sequences of operations for all equipment as provided by the design professionals and contractors, including time-of-day schedules and schedule frequency, and detailed point listings with ranges and initial setpoints.
 3. Ongoing operation instructions for all energy- and water-saving features and strategies.

4. Functional performance test results, blank test forms, and recommended schedule for ongoing benchmarking. Seasonal operational guidelines.
 5. Recommendations for recalibration frequency of sensors and actuators by type and use.
 6. Single line diagrams of each commissioned system. Troubleshooting table for ongoing achievement of the owner's project requirements.
 7. Guidelines for continuous maintenance of the owner's project requirements (operational requirements) and basis of design (basis of operation).
- Conduct a post-occupancy review with O&M Staff to facilitate the resolution of outstanding commissioning-related issues.

1.5 Commissioning Scope

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

System	Equipment
HVAC Systems	DX Split Systems
	Air Handling Units
	Heating Hot Water
	Chilled Water
	Condensing Water
	Cabinet Unit Heaters
	Exhaust Fans
	Fan Coil Units
	VAV Boxes
	Fan-Powered Mixing Boxes
	Unit Heaters
	Hot Water Radiant Heating Panels
	Hot Water Fintube
	Gas-fired Radiant Heater
	Domestic Water Heating
Lighting Systems	Occupancy Sensors
	Daylight Dimming System
	Central Lighting Control System

2. General Building Information

Project Name	Laramie County Library
Project Address	
Building Type	Library
Square Footage	~100,000 Gross SF
Construction Type	
Owner	Laramie County, Wyoming

3. Commissioning Team Information

Function	Name/Address	Contact Info
Owner	Laramie County Library System 2800 Central Avenue Cheyenne, Wyoming 82001-2799	Lucie Osborne Tel: 307-635-1032 x122 Fax: 307-634-2082 Mobile: 307-286-2913 losborn@lclsonline.org
Owner's Representative	Moreng Construction Consulting 6421 North County Road 15 Fort Collins, CO 80524	Jon C. Moreng Tel: 970-224-3056 Mobile: 970-217-7498 morengjon@aol.com
Architect	AndersonMasonDale 1615 17 th Street Denver, CO 80202	John Everin Tel: 303-294-9448 Fax: 303-294-0762 jeverin@amdarchitects.com
Construction Administrator	Tobin & Associates 209 East 20 th Street Cheyenne, Wyoming 82003	Nate Mulliken Tel: 307-632-3144 Fax: 307-632-6645 Mobile: 307-21-6854 nate@tobin-assoc.com
Mechanical Engineer	Cator, Ruma & Associates 1550 Dover Street, Suite 2 Lakewood, CO 80215	Dave Yeingst Tel: 303-232-6200 Fax: 303-233-3701 dyeingst@catorruma.com
Electrical Engineer	Cator, Ruma & Associates 1550 Dover Street, Suite 2 Lakewood, CO 80215	Jerry O'Brien Tel: 303-232-6200 Fax: 303-233-3701 jobrien@catorruma.com
General Contractor	FCI Constructors Inc. 4001 N. Valley Drive Longmont, CO 80504	Becket Hinson Tel: 970-535-4725 Fax: 970-535-4867 bhinson@fciol.com
Mechanical Contractor	Mechanical Systems, Inc. 1313 W. Lincolnway Cheyenne, Wyoming 82001	Matt Thomas Tel: 307-634-7419 Fax: mthomas@msiwyo.com
Electrical Contractor	Weifield Group Contracting 5835 West 6 th Avenue, Unit 4A Lakewood, CO 80214	Tel: 303-428-2011 Fax: 303-202-0466
Controls Contractor		
Test and Balance Contractor	Lawrence Finn & Associates 372 E. 16 th Street Greeley, CO 80631	Tel: 970-353-8210 Fax: 970-353-1828
Commissioning Agent	Architectural Energy Corporation Suite 201 2540 Frontier Avenue Boulder, CO 80301	Dan Bertini Tel: 303-444-4149 Fax: 303-444-4304 Mobile: 720-841-3294 dbertini@archenergy.com

4. Roles and Responsibilities

4.1 General Management Plan

AEC coordinates the commissioning activities and will report to the Owner's Representative. AEC's responsibilities, along with the designation of the Cx Team, are detailed in the specifications and the Cx Plan. The Cx process will require the coordinated effort of all members of the Cx Team in order to meet the objectives of the Contract Documents.

4.2 General Descriptions of Roles of the Cx Team

General descriptions of the commissioning roles are as follows:

- CxA: Coordinates the Cx process, writes and reviews testing plans, directs and documents performance testing.
- Owner: Reviews commissioning reports and facilitates resolution of issues
- GC: Reviews commissioning reports and facilitates resolution of issues, ensures that Subs perform their responsibilities and integrates Cx into the construction process and schedule.
- Subs: Demonstrate correct system performance.
- O&M Staff: Participate in commissioning tasks and performance testing, review O&M documentation, attend training.
- A/E: Perform construction observation, approve O&M manuals and assist in resolving issues.
- EE/ME: Perform construction observation, review commissioning reports and assist in resolving issues.
- Mfr.: Equipment manufacturers and vendors provide documentation to facilitate the commissioning work and perform contracted startup.

4.3 Specifications and Commissioning

Commissioning language in the specifications details the scope of commissioning for each of the party to the Cx process. The commissioning specifications can be found in Sections 01810.

4.4 General Management Plan and Protocols

The following protocols will be used on this project.

Issue	Protocol
For requests for information (RFI) or formal documentation requests:	AEC goes first through the GC.
For minor or verbal information and clarifications:	AEC goes direct to the informed party.
For notifying contractors of issues:	AEC documents issues through the GC, but may discuss issues with subcontractors prior to notifying the GC.
For scheduling functional tests or training:	AEC provides input and coordination of testing and training. Scheduling is done through the GC.
For scheduling commissioning meetings:	AEC schedules through the GC.
For making a request for significant changes:	AEC has no authority to issue change orders.
For making minor changes in specified sequences of operations:	All changes in sequences of operations required must be approved by the A/E. AEC may recommend changes in sequences of operation to correct operational deficiencies and/or to improve efficiency or control.
Subcontractors disagreeing with requests or interpretations by AEC shall:	Resolve issues at the lowest level possible. First with AEC, then with the GC and owner. Some issues may require input from the A/E.

4.5 Commissioning Team Responsibilities

The responsibilities of various parties in the commissioning process are derived from the 01810 specifications and updated below.

4.5.1 Commissioning Agent (CxA)

AEC is not responsible for design concept, design criteria, code compliance, general construction scheduling, cost estimating, or construction management. AEC may assist with problem-solving deficiencies, but ultimately that responsibility resides with the GC and the A/E team. The primary role of AEC is to develop and coordinate the execution of a testing plan to verify and document that systems are functioning in accordance with the design intent and the Construction Documents.

Construction and Acceptance Phase

- Coordinates and directs all commissioning activities. Work with the GC and owner to ensure that commissioning activities are scheduled.
- Maintain an up-to-date Cx Plan.
- Plan and conduct the commissioning scoping meeting.
- Request and review additional information required to perform commissioning tasks, including O&M materials, contractor start-up and checkout procedures, and sequences of operation.
- Review Contractor submittals applicable to commissioned systems, concurrent with the A/E reviews.
- Develop start-up and checkout plans with Subs. Write and distribute pre-functional checklists.
- Perform site visits, as necessary, to observe component and system installations. Attend construction job-site meetings, as necessary, to monitor construction and commissioning progress.
- Review completed pre-functional checklist and start-up reports.
- Assist with coordination of start-up requirements with TAB requirements.
- Write functional performance test procedures for equipment and systems.
- Coordinate, witness, and document functional performance tests completed by installing contractors. Coordinate retesting as necessary until satisfactory performance is verified.
- Maintain a master deficiency and resolution record. Provide the GC and Owner with written progress reports and test results with recommended actions.
- Review the training proposed by the contractors for the Owner's operating personnel.
- Develop "Recommissioning Manual" for use of the O&M Staff
- Conduct "Systems Training" for O&M Staff utilizing "Recommissioning Manual"
- Review the O&M manuals.
- Prepare a final commissioning report.

Warranty Period

- Coordinate and supervise required seasonal or deferred testing and deficiency corrections.

4.5.2 Design Team (A/E)

Construction and Acceptance Phase

- Attend commissioning scoping meeting and additional meetings, as necessary.
- Provide design intent and sequence of operation documentation as required by AEC.
- Assist in resolution of system deficiencies identified during commissioning.
- Review and approve the operations and maintenance manuals.
- Add Cx Issues to A/E punchlist.
- Optional: Review equipment start-up and pre-functional checklists. Review functional performance test plans. Witness performance testing.

Warranty Period

- Assist in resolution of system deficiencies identified during warranty period commissioning.

4.5.3 Owner

Construction and Acceptance Phase

- Arrange for facility operating and maintenance personnel to participate in commissioning activities and training sessions.
- Provide final approval for the completion of the commissioning work.

Warranty Period

- Work with GC and CxA to facilitate seasonal and deferred testing and to address deficiency issues.

4.5.4 General Contractor (GC)

Construction and Acceptance Phase

- Facilitate the coordination of the commissioning work by AEC.
- Attend commissioning scoping meeting and additional meetings, as necessary.
- Furnish copies of construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to AEC.
- Ensure that Subs execute their commissioning responsibilities according to the Specifications and Cx Plan.
- Coordinate the training of owner personnel.
- Prepare O&M manuals, according to the Specifications, including updating original sequences of operation to as-built conditions.

Warranty Period

- Ensure that Subs execute required seasonal or deferred functional performance testing.

- Ensure that Subs correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for issues identified during the warranty period.

4.5.5 Mechanical, Electrical, Controls and TAB Contractors

Construction and Acceptance Phases

- Attend commissioning scoping meeting and additional meetings, as necessary.
- Provide additional requested documentation, prior to normal O&M manual submittals, to AEC for development of start-up and functional testing procedures.
- Assist in clarification of operation and control of commissioned equipment where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
- Develop a start-up and checkout plan for all commissioned equipment based on manufacturer's recommendations and pre-functional checklists from AEC. Submit to CxA for review and approval prior to startup.
- During the startup and checkout process, execute the prefunctional checklists for all commissioned equipment. Perform and clearly document all completed startup and system operational checkout procedures.
- Resolve existing A/E punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems resolved before functional testing.
- Perform functional performance testing, under the direction of AEC, for commissioned equipment.
- Resolve equipment or system deficiencies and retest as required to verify modified performance.
- Prepare O&M manuals according to the Specifications, including updating original sequences of operation to as-built conditions.
- Provide training of the Owner's operating personnel as specified.
- Coordinate with equipment manufacturers to determine requirements to maintain the validity of warranties.

Warranty Period

- Execute seasonal or deferred functional performance testing, as necessary.
- Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for issues identified during the warranty period.

4.5.6 Equipment Suppliers

- Provide requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in effect.

- Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- Assist in equipment testing per agreements with contractors.

5. Commissioning Process

This section sequentially details the commissioning process by commissioning task or activity. Architectural Energy Corporation will perform the following activities to achieve the project goal and objectives:

5.1 Documentation of Basis of Design and Design Intent

The design requirements, relative to the building systems selected for commissioning, must be explicitly documented in order to establish a baseline of performance expectations to which the actual installed performance is compared. The CxA, with the assistance of the GRN, Owner, and A/E, prepares a Design Intent Summary that documents the design intent for those building systems selected for commissioning. The Design Intent Summary reflects the underlying assumptions and requirements that become represented in the construction documents.

5.2 Design Development Review

The design review, completed before the construction documents phase begins, will be undertaken to ensure that each commissioned system meets the design intent relative to functionality, energy performance, water efficiency, maintainability, sustainability, system cost, indoor environmental quality and local environmental impacts.

5.3 Construction Document Review

The construction document review will be undertaken to ensure that commissioning is adequately specified, that each commissioned system can be commissioned and is likely to meet the design intent relative to functionality, energy performance, water efficiency, maintainability, sustainability, system cost, indoor environmental quality and local environmental impacts.

5.4 Submittals Review

The GC will provide the CxA with a set of equipment and system submittals. This equipment data includes installation and start-up procedures, O&M data, performance data and temperature control drawings. The GRN, Subs, GC or A/E notify the CxA of any new design intent or operating parameter changes, added control strategies and sequences of operation, or other change orders that may affect commissioned systems.

5.5 Commissioning Kick Off Meeting

The kick off meeting brings together all members of the design, construction, and operations team that will be involved in the commissioning process. During the

scoping meeting, The Commissioning Plan is explained. The CX process is explained as well as the roles and responsibilities of all parties involved in the CX process. The commissioning schedule is also developed along with a detailed timeline. The timeline is fine-tuned as construction progresses.

5.6 Start-Up/Prefunctional Checklists

“Startup Checklists” are manufacturer or contractor-provided records of the startup activities that are documented by the contractor.

“Prefunctional Checklists” are supplementary forms that are prepared by the CxA from manufacturer’s data, drawings and specifications to ensure that the installations are complete and the equipment operational. The installing Subs shall use these checklists for reference in undertaking their prefunctional activities. Prior to scheduling the Functional Performance Tests, the CxA performs spot-checks in the field to verify that the items on the checklists have been completed. A sample Prefunctional Checklist is provided in Section 8 below.

The CxA shall deliver the blank Prefunctional Checklists in a “Prefunctional Checklist Binder” prior to the onset of equipment startup activities.

All Startup and Prefunctional Checklists that are completed by the contractors during construction shall be kept in the Prefunctional Checklist Binder in the GC’s jobsite trailer. This binder will include a summary “Prefunctional Test Verification Form” that each contractor shall sign and date to indicate that they have completed their respective prefunctional activities for each piece of equipment.

5.7 Functional Performance Testing

Functional performance testing verifies the intended operation of individual components and system interactions under various conditions and modes of operation. The systems are run through all of the sequences of operation and the response of components is verified. Testing proceeds from components to subsystems to systems, and finally to interlocks and connections between systems.

The CxA prepares functional performance test plans so that the complete sequence of operations is included. The CxA obtains all documentation, including an updated points list, control sequences, and setpoints. If necessary, the CxA may request clarifications from contractors and the design team regarding sequences and operation. Prior to execution, the CxA provides a copy of the primary equipment tests to the installing Subs and GC who can review the tests for feasibility, safety, warranty and equipment protection.

The CxA schedules functional tests through the GC and Subs. Under the supervision of the CxA, the installing Subs perform the hardware and/or software manipulations required for the testing. Owner maintenance staff may also be present in order to assist in system observations. The CxA witnesses and records the results of functional performance testing.

A sample Functional Performance Test is provided in Section 9 below.

5.8 Issues Log and Resolution Record

The CxA makes periodic site visits to witness equipment and system installations. Each site visit will have a specific agenda and will be coordinated with the GC site supervisor. The CxA attends selected planning and job-site meetings in order to remain informed on construction progress and to update parties involved in commissioning. The GC provides the CxA with information regarding substitutions or change orders that may affect commissioned equipment or the commissioning schedule.

All issues found from site visits and functional performance testing will be documented in a Issues Log. The report will include all details of the components or systems found to be non-compliant with the parameters of the functional performance test plans and design documents. The Issues Log will be furnished to the GC, A/E and GRN, and will *ultimately become part of the A/E's punch list*. The report will detail the adjustments or alterations required to correct the system operation, and identify the responsible party. The Issues Log will be continuously updated. The CxA schedules any required retesting through the GC. Resolutions and corrections are made at as low a level as possible, preferably between CxA, sub-contractor and GC.

A sample Issues Log is provided in Section 10 below..

5.9 Operations and Maintenance Training

Manuals: The operation and maintenance manuals prepared by the contractors for the owner's maintenance personnel are reviewed for completeness. The contractors are encouraged to submit O&M manuals at the earliest possible date. Materials may be added, or requested from the contractors, to stress and enhance the importance of system interactions, troubleshooting, and long-term preventative maintenance and operation.

Record Documents: CxA will review record Drawings for accuracy.

Training: Effective training of O&M Staff is critical to the long term performance of the new building. The CxA will develop and present to O&M Staff a "Systems Training" which will undertake to describe the sequence of operations for all commissioned equipment in terms of their interactions with other equipment. The training will seek to clarify the design intent of the commissioned systems in terms that highlight key O&M-related features.

5.10 Develop Recommissioning Manual

A Recommissioning Manual will be prepared which includes all information required to effectively maintain the building at optimal performance. This manual will serve as be the handed out during the "Systems Training".

- Final version of the Owner's project requirements and basis of design.
- As-built sequences of operations for all equipment as provided by the design professionals and contractors, including time-of-day schedules and schedule frequency, and detailed point listings with ranges and initial setpoints.

- Ongoing operation instructions for all energy- and water-saving features and strategies.
- Functional performance test results, blank test forms, and recommended schedule for ongoing benchmarking. Seasonal operational guidelines.
- Recommendations for recalibration frequency of sensors and actuators by type and use.
- Single line diagrams of each commissioned system. Troubleshooting table for ongoing achievement of the owner's project requirements.
- Guidelines for continuous maintenance of the owner's project requirements (operational requirements) and basis of design (basis of operation).

5.11 Final Commissioning Report and LEED Documentation

Final Commissioning Report: A final Commissioning Report will be compiled which summarizes all of the tasks, findings, and documentation of the commissioning process. The report will address the actual performance of the building systems in reference to the design documents. All test reports by various sub-contractors, manufacturers and controlling authorities will be incorporated into the final report.

The commissioning report includes:

- An evaluation of the operating condition of the systems at the time of functional test completion,
- Issues that were identified and the measures taken to resolve them,
- Functional test procedures and results,
- Reports that document all commissioning field activities as they progressed, and
- A description and estimated schedule of required deferred testing.

LEED Documentation: LEED documentation will be compiled. Documentation will address the LEED section on "Energy and Atmosphere" prerequisite of "Fundamental Building Systems Commissioning" and the LEED section on "Best Practice Commissioning."

5.12 Conduct Post-Occupancy Review

The commissioning provider will return to the site before the end of the warranty period to review the current building operation with the facility maintenance staff. The review will also include any outstanding issues from original or seasonal testing. The commissioning provider will interview facility staff to identify concerns with building operation and provide suggestions for improvements. In addition, the commissioning provider may help identify issues that relate to the original warranty and assist staff in developing reports or documentation to remedy any problems.

6. Deliverables

The deliverables to be prepared over the course of the commissioning effort are as follows:

- Commissioning Design Reviews - Design Development and mid-phase Construction Documents
- Commissioning Plan - Revised / updated during construction, acceptance, and warranty phases of the project.
- Commissioning Specifications - As appropriate, revise commissioning specifications of the construction documents.
- Design Intent and Basis of Design Reports for all building systems being commissioned.
- Submittal reviews
- Prefunctional Checklist Binder to include all startup and prefunctional checklists and forms related to building systems being commissioned.
- Functional Performance Tests.
- Issues Log - Updated throughout the course of the commissioning process.
- Recommissioning Manual
- Systems Training
- Final Commissioning Report, prepared at the completion of the Acceptance Phase commissioning effort, and updated during the post-occupancy commissioning activity.
- Post-Occupancy Review Report.

7. Scheduling

7.1 General Issues

1. The scheduling of HVAC commissioning activities will be coordinated to coincide with the completion of HVAC systems. Commissioning activities that address the interaction between systems will occur upon completion of all HVAC related construction in a given area. During these tests, TAB flows will be verified while the systems are operating in various modes.
2. Scheduling of lighting control commissioning testing will occur once the lighting control contractor has completed the pre-functional checklists and has performed their own tests, and the system is said to be ready to be turned over to the owner.

7.2 Special Notes

1. Equipment is not “temporarily” started (for heating or cooling), until pre-start checklist items and all manufacturer’s pre-start procedures are completed and moisture, dust and other environmental and building integrity issues have been addressed.
2. Manufacturer’s startup procedures will be followed and documented on manufacturer provided documentation. This information will be turned over to AEC with the pre-functional checklists. Startup of equipment should be done by a manufacturer’s startup technician, not a third party company.
3. HVAC Cx: Functional performance testing does not begin until pre-functional, start-up and TAB is completed for a given system.
4. HVAC and Lighting Cx: The controls system and equipment it controls are not functionally tested until all points have been calibrated and pre-functional checklists are completed.
5. For HVAC systems: The functional performance tests will involve the general contractor, mechanical contractor, TAB contractor, controls contractor, school maintenance personnel. The mechanical engineer is encouraged to attend to verify the systems meet the design and to provide quick resolution to questions that arise.

7.3 Commissioning Activities Integrated into Construction Schedule

1. Mechanical and Electrical Equipment Startup (insert manufacturer’s and/or contractor’s completed startup documentation into the “Commissioning Prefunctional Binder” located in job trailer)
2. Complete Pre-punch (fill out commissioning “Prefunctional Checklists” and insert into the “Commissioning Prefunctional Binder” located in job trailer)
3. Create and Perform Architect’s Punchlist/ Final Cleaning (conduct commissioning “Functional Testing” with contractors and owners O&M staff; incorporate resulting commissioning issues into Architect’s Punchlist)

4. Owner Training and Turnover (include commissioning “Systems Training” to be provided by Commissioning Agent).Milestones outlined in section **Error! Reference source not found.** should be sequenced in such a way as to coincide with completion of “Finishes” described in Construction Schedule.

8. Sample Prefunctional Checklists

Prefunctional Checklists are developed and completed for all mechanical equipment being commissioned. The checklist captures equipment nameplate and characteristics data, and confirms the as-built status of the equipment or system. The checklists ensure that the installation is complete and the equipment is operational.

The checklists are prepared by AEC from manufacturer's data, drawings and specifications to include the required installation, checkout, and start up procedures. The installing Subs date and initial the checklists as the construction and start-up is completed. AEC reviews and verifies the completed checklists before scheduling the Functional Performance Tests

Prefunctional checklists will be created for all equipment identified for commissioning in section 1.5, and are to be completed by the installing contractors prior to functional performance testing. The GC will aid in supervising this process by managing the pre-functional checklist books, either by keeping them in their trailer, or by giving them to the appropriate contractor for completing. The GC will at least bi-weekly fax a copy of the summary sheet "Pre-functional Test Verification Form" to AEC in order to keep AEC apprised of progress and to aid in scheduling the Functional Performance Tests.

On the following page is a sample pre-functional checklist developed and used by Architectural Energy Corporation.

Pre-functional Test Verification Form: Mechanical

Facility Name: **Pikes Peak Regional Center**

<i>Equipment Name</i>	<i>Location</i>	<i>Area Served</i>	<i>Drawing No</i>	<i>Manufacturer</i>	<i>Model No</i>
CH-01	Chiller S020	CHW System	M1.3	YORK	YCWS0120SB46 YA

General: To be filled out by installing contractor, and kept onsite during project. The checklist will be completed and turned in prior to Functional Performance Testing.

Instruction: Fill in Unit Information as listed below, then check the appropriate box as items are verified and deemed acceptable. Add comments if needed and explain any exceptions taken.

<i>Installation Checks</i>	<i>Contractor</i>			<i>Comment</i>
	<i>Yes</i>	<i>No</i>	<i>N/A</i>	
Permanent labels attached and documented (valves, chiller, piping, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Electrical power complete (main, branch circuit breakers, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Chilled water system piping complete	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Chilled Water pumps P-6 and P-7 mechanical pre-functional checklist complete	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Condenser water pumps P-8 and P-9 mechanical pre-functional checklist complete	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Ice Build pumps P-4 and P-5 mechanical pre-functional checklist complete	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Heat Exchanger mechanical pre-functional checklist complete	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Refrigerant Gas Monitor installed and calibrated per IOM, documented in attached checklist	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Cooling Tower mechanical pre-functional checklist complete	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Chiller control pre-functional checklist complete	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Chiller installation and start-up is complete per manufacturer's recommended procedures in IOM manual.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Chiller installation and start-up is documented in attached manufacturer's start-up checklist.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Chiller Test Adjust and Balance Complete, with deficiencies corrected	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
Chiller signed as complete on CX FPT Readiness checklist (mechanical entry)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____

Notes _____

****By signing, I have verified that the above equipment is installed per the manufacturer's instructions, and the design documents, and is ready for final testing by the commissioning agent.**

Signature**	Date
Mechanical Contractor _____	_____
General Contractor _____	_____

15170 MECHANICAL PUMP COMMISSIONING CHECKLIST

9. Sample Functional Performance Tests

Functional performance testing verifies the intended operation of individual components and system interactions under various conditions and modes of operation. The systems are run through all of the sequences of operation and the response of components is verified. Testing proceeds from components to subsystems to systems, and finally to interlocks and connections between systems.

AEC prepares functional performance test plans so that the complete sequence of operations is included. AEC obtains all documentation, including an updated points list, control sequences, and setpoints. If necessary, AEC may request clarifications from contractors and the design team regarding sequences and operation. Prior to execution, AEC provides a copy of the primary equipment tests to the installing Subs and GC who can review the tests for feasibility, safety, warranty and equipment protection.

AEC schedules functional tests through the GC and Subs. Under the supervision of AEC, the installing Subs performs the hardware and/or software manipulations required for the testing. Owner maintenance staff may also be present in order to assist in system observations. AEC witnesses and records the results of functional performance testing. Functional testing will occur on all systems identified for commissioning in section 1.5.

On the following page is a sample functional performance test developed and used by Architectural Energy Corporation.

<u>Functional Performance Testing Procedure</u>		
	AHU-1	
Title:	Engineered air heat wheel VAV unit with VFD	
Equipment Tag:	AHU-1	
Participants:	Name	Organization
Date: 5/5/04	Mike Willie	Long
	Erik Jeannette	AEC
Comments:	<p>A user adjustable occupied / unoccupied time schedule controls the unit mode of operation. OA and exhaust air dampers close whenever the supply/exhaust fans stop under any condition. OA dampers are slow opening to prevent nuisance tripping of low temperature detection thermostat. Discharge air temperature alarm to trip when DAT drops below 45 deg F for 10 minutes. The DDC Modulates the exhaust fan to maintain space pressure of 0.05" w.c. DDC monitors DAT,exhaust air humidity, and exhaust air temperatures. DDC monitors status of heat wheel via current switch. Minimum speed on exhaust fan is 40 % less than supply fan speed. DDC monitors unit temp, exhaust air temp and evaporative cooler pump status.</p> <p>Warm up /cool down handled by each zones blower coils. AHU operates between 7:00 and 3:00 pm. Occupied cycle: DDC enables supply and exhaust fan VFD's,modulates the VFD's to minimum speed and opens the outside / exhaust damper's 100%. DDC modulates supply fan VFD to maintain a minimum of 0.05" w.c. to the inlet of the last blower coil. Should either fan fail to start or fail during operation for any reason, alarm indicated at DDC. Evaporative cooling of exhaust is enabled by DDC in cooling mode. DDC enables engineered air factory provided w-trac total energy wheel controller. The controller then operates in conjunction with a variable speed control system to slow the rotation of the heat wheel to satisfy supply air temperature demands. An adjustable set point on the face of the W-trac allows a selection of 52 deg F to 74 deg F discharge air temp. In the heating mode, as the discharge air temperature nears the setpoint, the speed of rotation of the wheel is slowed to maintain setpoint. When minimum speed is reached, and there is cooling demand, wheel will stop completely.</p> <p>The wheel will remain off until the outdoor air temp exceeds the exhaust air temperature at which point the wheel will resume full speed. In unoccupied mode: The DDC disables both fans and closes all dampers.</p>	
Sequence:	Event #1 Occupied Mode Event #2 Communication and Power loss Event #3 Unoccupied Mode Event #4 Saffties and Alarms	
<u>Functional Performance Testing Procedure</u>		
System:	AHU-1	
Title:	Engineered air heat wheel VAV unit with VFD	
Equipment Tag:	AHU-1	

Commissioning Plan for the Laramie County Library in Cheyenne, Wyoming

Equipment Schedule		AHU-1		
Record time-of-day and setpoints and note any deviation from DESIGN.				
	SCHEDULE		NOTES	
Monday	Occupied from 7 AM to 3 PM		7-5PM temp schedule	
Tuesday	Occupied from 7 AM to 3 PM		7-5PM temp schedule	
Wednesday	Occupied from 7 AM to 3 PM		7-5PM temp schedule	
Thursday	Occupied from 7 AM to 3 PM		7-5PM temp schedule	
Friday	Occupied from 7 AM to 3 PM		7-5PM temp schedule	
Saturday	Unoccupied		Unoccupied	
Sunday	Unoccupied		Unoccupied	
Holiday	Unoccupied		Unoccupied	
DDC Parameters		AHU-1		
Record values for current setpoints, control parameters, limits, delays, lockouts, etc. and note any deviation from design ().				
	Parameter		Value programmed in BAS	
	Cool Setpnt		55/54 with 10 min delay on make	
Sensor Location Checks		AHU-1		
Verify that sensors are adequately located and not effected by other elements of the system.				
Sensor	Plan Location	Actual Location	Notes	
exhaust air temp after evap	in exhaust duct	Per Plans		
smoke detector	in supply duct	Per Plans		
return air temp and humidity	return duct	Per Plans, in RA duct	between RA filters and Evap	
Return air temp and humidity	return duct	Per Plans, in RA duct		
freeze protection	after energy wheel in SA airstream	per plans, in unit		
Duct High Limit pressure sensor	in Supply air stream	in control panel		
last BC pressure sensor	in duct at last BCU	per plans	may need to be moved to different duct	
DAT	at AHU discharge air duct	Per Plans, in DA duct	sensor is currently failed	
Actuator Stroke Checks		AHU-1		
Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop, inadequate sealing and excessive stroke time.				
Component	Fully Open	Fully Closed	Fail Position	Notes
OA Damper	open	closed	Closed	Eng Air controler opens whenever unit is enabled
EA Damper	open	closed	Closed	

Functional Performance Test					
System:		AHU-1			
Title:		Engineered air heat wheel VAV unit with VFD			
Tag:		AHU-1			
Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
x		1a	Set time to occupied time. Set	SF runs. Static pressure at furthest	Static pressure not met (-.02" w/ SF @
x		1b	Set time to occupied time. Set OA temp lower than 54	SF runs. Static pressure at furthest blower coil is above 0.05"w.c.. Evaporative cooler turns off and heat wheel stops rotation.	
	x	2b	With unit in occupied mode, disconnect power, observe and reconnect power.	AHU shuts down, (observe damper fail position) then returns to occupied mode sequence after power is regained.	Disconnect does not turn off VFDs
x		3a	Override time-of-day to an unoccupied time.	AHU shuts down, SF and exhaust fan are disabled, OSA and exhaust air dampers close.	
x		4a	With unit in occupied mode turn off fan at HOA switch.	AHU SF turns off. OA and EA dampers close. Alarm generated at DDC.	Once alarm is generated, unit shuts down which resets alarm status. Then after 14 min delay, the unit restarts.
x		4b	Activate smoke alarm.	AHU SF turns off. OA damper closes. Alarm generated at DDC	
x		4c	Trip the low temperature thermostat.	Alarm generated at DDC	
	x	4d	Open door to fan compartment while unit is running	AHU supply and return fans stop. Alarm generated at DDC.	No door switches
x		4e	Set duct high limit setpoint lower than current duct pressure.	AHU turns off supply and return fans. Alarm at DDC	

10. Sample Issues Log

The issues report provides a summary of items found during the commissioning process which did not meet the design intent (construction documents) or the operational requirements. The table includes a reference number, the equipment name and location, a code for how the deficiency was identified, a description of the deficiency, a cause code, the date identified, action to be taken, date resolved, a responsibility code and a comment field.

On the following page is a sample Issues Log report used by Architectural Energy Corporation.

No.	Equipment	Test Type	Description	Cause Code	Date Identified	Action Required	Expected Date Resolution	Date Received	Responsibility	Notes
624	AHU-01-07	PF	Electrical "closet" with VFDs has high-voltage power exposed	Manufacturer	6/10/04	install electrical equipment in an enclosure, or add disconnect capability to VFD "closet" doors	6/30/04		MC	electrical device located below VFD cabinet doors need to have a disconnect to turn off power when the VFD doors are open. NOT YET RESOLVED AS OF 7/12/04
532	AHU-02	FPT	1 of 2 E.A. damper do not function	Manufacturer	5/7/04	one of the damper arms is missing a c-clip, therefore the damper does not function	6/30/04		MC	Simpson to add C-clip to damper arm
533	AHU-02,03	FPT	Unit names are backwards	Manufacturer	5/7/04	re-label unit, and swap nameplate data on Engineered Air control cabinet	6/30/04		MC	NOT RESOLVED AS OF 7/12/04
585	AHU-07	PF	exterior evap section door handle missing	Installation	5/24/04	replace door handle	6/30/04		MC	handle broke off during construction or in transit. Replace broken handle with new.
650	AHU-08	PF	Exhaust discharges directly to CRAC-2 intake	Design	7/3/04	consider relocating intake hood			CX	
651	AHU-08	PF	Cabinet Interior Lighting not functional	Installation	7/3/04	Ensure lighting is functional			EC	
648	AHU-08	FPT	Freezeostat installed downstream of CC	Installation	7/1/04	Relocate between CC and HC			CC	
657	AHU-08	PF	AHU-8 serving Auditorium shares "Technology Room D142" ceiling return plenum with AHU-4	Installation	7/3/04	monitor building and exhaust pressure control to see if this causes problems			CX	
652	AHU-08	PF	Supply Fan cabinet drain tailpiece torn off	Installation	7/3/04	ensure this is patched/repaired as needed			MC	
653	AHU-08	FPT	Outside Air Damper fails to fully close	Installation	7/3/04	adjust lin bags			CC	
654	AHU-08	FPT	Exhaust Damper shows no difference between 0 and 10% command	Installation	7/3/04	adjust lin bags			CC	