

**Hawaii Preparatory Academy
Energy Lab
Kamuela, HI**

COMMISSIONING PLAN

Fundamental Building Commissioning
Enhanced Commissioning

December 2008

US Green Building Council (USGBC)
Leadership in Energy and Environmental Design (LEED)
For Schools



Hawaii Preparatory Academy

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1. Commissioning the Project

This Plan outlines the commissioning activities and deliverables. Project Team roles and responsibilities are established and described. This plan does not provide a detailed explanation of the required testing procedures. Additionally, this plan does not provide extensive narrative on all commissioning concepts, as may be provided in other commissioning guides.

1.1 Commissioning: Design Phase

Commissioning during design is intended to achieve the following specific objectives:

- a. Ensure that the Owner’s Project Requirements are clearly reflected in the engineer’s Basis of Design (BOD).
- b. Provide a commissioning focused design review of design development and construction documents.
- c. Ensure that all related commissioning activities for the construction phase are adequately reflected in the bid documents by incorporating commissioning specifications within project specifications.

1.2 Commissioning: Construction Phase and Acceptance Phase

Commissioning during construction is intended to achieve the following specific objectives:

- a. Review the contractor submittals
- b. Ensure that applicable equipment and systems are installed properly and receive adequate operational check by installing contractors.
- c. Verify and document proper performance of equipment and systems.
- d. Provide Owner with Summary Commissioning Report.
- e. Ensure that the Owner’s operating personnel are adequately trained.
- f. Develop a System’s Manual.
- g. Plan for building post-occupancy review within 10 months after substantial completion.

1.3 Abbreviations and Definitions

The following are common abbreviations used in this document.

A/E	Architect and Design Engineers	GC	General Contractor
CxA	Commissioning Agent	MEP	Mechanical, Electrical, Plumbing
CC	Controls Contractor	MC	Mechanical Contractor
CM	Construction Manager	PM	Owner’s Project Manager
Cx	Commissioning	Subs	Subcontractors to GC
EC	Electrical Contractor	TAB	Test and Balance Contractor
PFAT	Prefunctional Assurance Tests	FAT	Functional Assurance Tests

Owner’s Project Requirements:

The Owner’s Project Requirements (OPR) are developed by the owner’s representatives and design team and details the functional requirements of the project including expectations of how the Project will be used and operated. The OPR includes design goals, measurable performance criteria, success criteria, and supporting information.

Basis of Design (BOD):

The BOD is documentation of the primary thought processes, explanations and assumptions behind design decisions that were made to meet the owner's project requirements. The BOD describes the systems, components, conditions and methods chosen to meet the OPR and will be reviewed against the OPR. Some reiterating of the OPR may be included. The BOD will be updated by the design engineer as necessary.

Prefunctional Assurance Tests:

Prefunctional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., checking equipment assembly and installation, oil levels OK, fan belt tension, labels affixed, gages in place, sensor calibration, etc.). However, some prefunctional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase motor or verifying amp draw of a motor). Prefunctional checklists augment and are combined with the manufacturer's start-up checklist.

Functional Tests:

Functional testing is the dynamic testing of systems (rather than just components) under full operation. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all of the control system's sequences of operation and components are verified to be responding as the sequences state.

1.4 Goals and Objectives

Hawaii Preparatory Academy (HPA) is seeking LEED certification for their Energy Lab building located in the city of Kamuela. Green Building Services, Inc. is providing Fundamental Building Commissioning and Enhanced Commissioning, per the US Green Building Council, Leadership in Energy and Environmental Design (LEED) for Schools. The Academy's objective is to create a special innovative building which demonstrates energy efficiency and sustainable strategies. The goal of the project is to earn LEED Platinum certification.

The goal of the commissioning process is to provide the Hawaii Preparatory Academy with a high degree of assurance that equipment and systems have been installed in the prescribed manner and will operate according to the projects design. It is a cooperative effort that requires participation by the HPA, Flamsburgh Architects, Hakalau Engineering, Wallace Oki Electrical Engineer, Pa'ahana Enterprises, Buro Happold sustainable consultant, the general and installing contractors, and Green Building Services as the Commissioning Authority.

1.5 General Project Information

Project:	HPA Energy Lab
Location:	69-1692 Kohala Mountain Road Kamuela, Hawai'i
Project Type:	Education classrooms and labs
Square Footage:	6,000 Square Feet.
Number of stories:	1

Hawai'i Preparatory Academy's Energy Lab building is a new, stand-alone structure dedicated to the study of non-fossil fuel, alternative energies in the advancement of a sustainable energy future. Intended as an educational facility, the building will function as classroom and laboratory, where students can hypothesize, experiment, and theorize on sustainable energy systems.

The project has an ambitious sustainability agenda and aims to achieve LEED for Schools Platinum rating and Living Building Challenge Certification. The building will be mostly passively ventilated, it will use 100% renewable power from PVs and wind turbines, will integrate solar hot water, a demonstration radiant night cooling system and it will capture 100% of its water needs from rainwater.

1.6 Systems to be Commissioned

<u>System</u>	<u>Equipment</u>
Heating, Ventilating and Air Conditioning systems	AHU-1 & 2 split AC systems, FCU-1 Auxiliary cooling system and EF-1 to 8
HVAC Controls	24/7 programmable T stats/ H stats
Lighting and Day lighting system	Occupancy sensors and other automatic lighting controls
Renewable Energy Systems	Photo Voltaic (PV) electrical system

2. Commissioning Team Contacts

<p><u>FACILITY OWNER</u> Hawaii Preparatory Academy 69-1692 Kohala Mountain Road Kamuela, HI 96743 Office: 808-885-7321 Fax: 808-881-4003 Contacts: Lindsay Barnes Email: lbarnes@hpa.edu Gary Campbell Email: gcampbell@hpa.edu Bill Wiecking Email: bill@mail.hpa.edu</p>	<p><u>OWNER'S REPRESENTATIVE</u> Pa'ahana Enterprises LLC P.O. Box 109 Kealahou, HI 96750 Office: Fax: 808-323-2304 Contacts: Ken Melrose Cell: 808-345-0854 Email: melrosek001@hawaii.rr.com Ann Cobb Cell: 808-987-9985 Email: cobba001@hawaii.rr.com</p>
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<p><u>COMMISSIONING AUTHORITY</u> Green Building Services 133 SW Second Avenue, Suite 201 Portland, OR 97204 Office: 866-743-4277</p>	<p><u>SUSTAINABILITY</u> Buro Happold 100 Broadway, 23rd floor New York, NY 10005 Office: 212-616-0261</p>

<p>Fax: 503-467-4711 Contacts: Doug Crombie, PE, CxA Direct: 503-546-4605 Cell: 503-459-7136 Email: doug@greenbuildingservices.com</p>	<p>Fax: 212-334-5528 Contacts: Ana Serra Cell: 646-577-4068 Email: ana.serra@BuroHappold.com</p>
<p><u>GENERAL CONTRACTOR</u> Quality Builders, Inc. P.O. Box 2135 Kamuela, HI 96743 Office: 808-885-7233 Fax: 808-885-3440 Contacts: Harry Buscher, President Cell: 808-936-2978 Email: hbqbi@hawaiiintel.net John Hansen, Project Superintendent Cell: 808-936-9067 Email: jqhbi@hawaiiintel.net Elin Kalaniopio, LEED/LBC Specialist Cell: 808-987-5765 elinqbi@hawaiiintel.net</p>	<p><u>MECHANICAL CONTRACTOR</u> Kona Industries, Inc. 73-5563 Olowalu St. Kailua-Kona, HI 96740 Office: 808-329-7789 Fax: 808-329-8799 Contacts: Duke K. Kamaka Cell: 808-960-7231</p>
<p><u>ELECTRICAL CONTRACTOR</u> PA Harris Electric 75-5617 Maiiau Street, Suite 11 & 12 Kailua-Kona, HI 96740 Office: 808-327-0751 Fax: 808-329-9795 Contact: Phil Harris Cell: 808-896-8460</p>	<p><u>TAB CONTRACTOR</u> Kona Industries, Inc. 73-5563 Olowalu St. Kailua-Kona, HI 96740 Office: 808-329-7789 Fax: 808-329-8799 Contacts: Duke K. Kamaka Cell: 808-960-7231</p>
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<p><u>Photo Voltaic Contractor</u></p>	<p><u>Solar Domestic Hot Water</u></p>

3. Description of Commissioning Process Activities

Task description narratives are provided in Section 6.

Task Descriptions – HPA Energy Lab				Task Due	Task Status	LEED Credit	Cx Agent	Owner	Architect	GC	CC	MEP Designers	MEP Contractors	TAB	Documented Deliverable
Design Phase	1 Overall Coordination of the Cx during Design Phase														
	a. Plan and schedule meetings		Ongoing	Fundamental	x			x	x						
	b. See that all tasks are carried out		Ongoing	Fundamental	x			x	x						
	2 Develop Cx specifications for construction														
	a. Develop Cx specifications	6/4/07	Complete	Fundamental	x										Commissioning specifications
	b. Review and comment on specifications			Fundamental				x				x			Review commentary
	3 Focused review of design intent documentation														
	a. Document the Owner's Project Requirements (OPR)	6/30/07	Complete	Fundamental				x	x						Owner's Project Requirements
	b. Provide Basis of Design (BOD) format and assistance			Fundamental								x			Basis of Design Document
	c. Review Basis of Design			Enhanced	x										Design Intent Statement
	4 Focused design review														
	a. Review of the design development documents	7/20/07	BEA Consulting	Enhanced	x										Design Review document
	b. Review of the construction documents	7/20/07	BEA Consulting	Enhanced	x										Design Review document
	b. Provide response to Cx review of design documents			Fundamental					x	x			x		Response to Cx request
	5 Cx Plan														
a. Develop a Commissioning Plan	3/24/08	Distribute at Kick off meeting	Fundamental	x											
b. Review and comment on Cx plan in design phase		Provided for comment	Fundamental					x	x					Design Cx Plan	
c. Review and comment on Cx plan for construction phase		Provided for comment	Fundamental					x	x			x	x	Construction Cx Plan	
Construction Phase	1 Commissioning Kick-off Meeting														
	a. Attend meeting			Fundamental	x				x	x			x	x	
	b. Coordinate meeting and distribute minutes			Fundamental	x										Meeting minutes
	2 Initial Submittals and Documentation														
	a. CxA requests submittals for equipment/systems			Enhanced	x										List of equipment
	b. Provide equipment submittals to CxA			Fundamental					x	x			x	x	Equipment submittals
	c. Review and comment on submittals - Produce Issues Log			Enhanced											Review comments
	3 Prefunctional Checklist, Tests, and Startup														
	a. Develop prefunctional checklist for commissioned systems		Contractors to provide	Fundamental	x					x			x		Prefunctional checklists
	b. Approves checklists			Fundamental	x										Checklist approval
	c. Submit Startup Schedules		GC to provide	Fundamental						x	x			x	Startup Plan
	d. Outline of the TAB plan		TAB Contractor to provide	Fundamental										x	Outline of TAB plan
	e. Controls Checkout Plan		CC to provide	Fundamental							x				Controls checkout plan
	f. Execution of startup and completion of checklists		Per construction schedule	Fundamental						x	x		x	x	Completed checklists
	g. Provide completed checklists and deficiencies			Fundamental						x	x		x	x	Issues log & deficiency reports
	4 Development of Functional Test and Verification Procedures														
	a. Develop functional test procedures		GBS to provide	Fundamental	x										Functional test forms
	b. Review tests and provide equipment and controls updates			Fundamental						x	x		x	x	Comments/updated documents
	5 Execution of Functional Testing Procedures														
	a. Schedule tests		Coordinate with GC	Fundamental	x					x					Schedule
b. Execute tests			Fundamental							x			x	Functional test forms	
Post-Construction	1 Commissioning Report														
	a. Provide as-built sequences of operations, control drawings and original setpoints			Fundamental					x	x			x	x	Updated project documents
	b. Creates and delivers documents to GC			Fundamental	x										Final commissioning report
	2 Operation & Maintenance Manual & Systems Manual														
	a. Verify O&M documentation turned over to Owner		Coordinate with GC	Fundamental	x					x					
	b. Develop a systems manual			Enhanced	x										Systems Manual
	3 Training and Orientation of Owner Personnel														
	a. Provide training schedule to GC			Enhanced							x		x		Training schedule
	b. Review training schedule for completeness			Enhanced	x		x	x							Review
	c. Coordinate and verify equipment training			Enhanced					x	x			x		
4 Post Occupancy Review															
a. Complete Post Occupancy Review			Enhanced	x										Post-occupancy commentary	

4. Schedule of Key Deliverables

Product	Developed By	Timetable for Delivery
Owners Project Requirements	Owner, A/E with CxA	Revised and submitted with Conformed drawings within two weeks of Notice to Proceed (NTP).
Basis of Design Document	A/E with CxA	Revised and submitted with Conformed drawings within two weeks of NTP.
Commissioning Plan	CxA	Draft Plan and process presented at a regularly scheduled construction project meeting within a month after the Mechanical, Electrical and Controls subcontractors have been selected. Final Commissioning Plan reviewed at a regularly scheduled construction project meeting.
Commissioning schedules	CxA w/ GC	Test schedules shall be updated by the GC and finalized at a regular construction meeting two weeks prior to performing the any tests.
Equipment submittals & commissioning data	Subs	Should be received within 2 months of NTP and six weeks prior to any testing. CxA submittal review to be performed concurrently with the A/E review. Submittals to include contractor proposed test plans and checklists.
Prefunctional checklists	Subs	Should be part of the equipment submittal. Completed checklists submitted to CxA within one week after equipment/system start-up.
Startup Plan	Subs and GC	Submitted one month prior to startup.
Issues log (deficiencies)	CxA	Periodically during the project.
Site Visit reports	CxA	Periodically during construction.
Functional Test forms	Subs & CxA	At least one week prior to any functional test.
Functional test approval	CxA w/ Subs	Prior to testing.
Filled out functional tests	CxA	Within a week after functional testing is complete.
O&M manuals	Subs	Draft O&M with the submittal Revised O&M manual one month prior to any scheduled training.
Final commissioning report	CxA	Draft within a month after substantial completion with any deferred or seasonal tests completed. Report updated as required.
Miscellaneous approvals	Owner's Rep	As required within 10 days if possible.
Meeting minutes	GC, CxA	Distributed within five working days of meeting.
Air Balance report	TAB	Within two weeks of testing.
Change orders (that affect Commissioned equipment)	GC	Send with the revised submittal at least 10 days prior to any testing and acceptance.

5. Summary of Cx Documents Reviewed and Distributed To Date

Document	Date
Project Specifications	12-18-08
Basis of Design (BOD)	12-22-08
Owner's Project Requirements (OPR)	12-18-08
Drawings – 50% CD Set	12-17-08
Commissioning Specifications	12-17-08
A/E Review Comments	

6. Task Description Narratives

6.1 Design Phase Tasks

6.1.1. Coordination of Commissioning During Design

- a. The commissioning agent will be the coordinator of the commissioning activities during design. The beginning of this task consists of holding a kick-off meeting with the design team at the beginning of Construction Documents Phase. The meeting includes reviewing the process and outlining each party's responsibilities.
- b. The commissioning agent will ensure that commissioning issues are relayed to the design team and that each party understands their responsibilities and executes them. The commissioning agent makes any necessary changes to the Design Phase Commissioning Plan provided to the A/E team. The commissioning agent reports to the architect and to the Project Manger.

6.1.2. Review of Design Intent Documentation

- a. The owner's representatives are responsible for identifying and developing the Owner's Project Requirements (OPR). This includes performance criteria (efficiency standards, energy consumption, and tolerances of the IEQ objectives, etc.) and restrictions and limitations of system or facility.
- b. The MEP firms are responsible for the development of the Basis of Design (BOD). The basis of design is the documentation of the primary thought processes and assumptions behind design decisions that were made to meet the design intent. The basis of design describes the systems, components, conditions and methods chosen to meet the intent. Some reiterating of the design intent may be included.
- c. The CxA reviews the design intent for clarity and completeness. 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 design intent is updated to reflect changes in design and construction.

6.1.3. Focused Design Review

- a. In the design phase, prior to mid-construction documents, the commissioning agent reviews the design documents along with the other design team members. The commissioning agent compares the design with the stated interests and

needs of the Owner. The commissioning agent is not responsible for design concept, design criteria or compliance with codes.

- b. The architect and design team provides a written response to the CxA and GC as to how the comments will be reflected in the final bid documents.

6.1.4. Develop Cx Specifications for Construction

- a. Commissioning specifications for inclusion in the construction bid documents are developed by CxA as part of the commissioning process during design. The specifications provide detail so that those bidding on the project can clearly understand how the commissioning process works and specifically what role they have in the process. They provide the requirements and process for properly executing the commissioning work. Specification content - The commissioning specifications shall provide the bidders a clear description of the extent of the verification testing required, including what components and systems will be tested and the documentation, reporting and scheduling requirements. Details of the extent of testing and who is responsible for writing tests, executing tests, witnessing and signing-off on tests shall be included. The relationship between and requirements for start-up, prefunctional checklists, manual functional performance tests, control system trend logs and stand-alone data logging shall also be given. The specifications shall also detail the operator training and the O&M documentation and any O&M plan requirements. Any specific program of tasks focusing on indoor air quality should be included in the specifications.
- b. Architect and MEP designers review and comment on Cx specifications.

6.1.5. Commissioning Plan

- a. Develop the Commissioning Plan
- b. The commissioning agent submits the Commissioning Plan to the architect and Project Manager in the design phase for approval. This plan guides the commissioning work during design. All design team members receive a copy of the plan from the architect.
- c. The commissioning agent updates the Commissioning Plan for the construction phase and submits to the architect and PM for approval. This plan guides the commissioning work during the construction phase. All construction parties receive a copy of the plan from the PM.

6.2 Construction Phase Tasks

6.2.1. Commissioning Scope Meeting

- a. A commissioning scope meeting is planned and conducted by the CxA. In attendance are the Design/Construction Team representatives. At the meeting the commissioning process is reviewed, management and reporting lines are determined. The flow of documents, how much submittal data the CxA will receive, and communication logistics are discussed. The outcome of the meeting is increased understanding by all parties of the commissioning process and their respective responsibilities. The meeting provides the CxA additional information needed to finalize the Cx Plan, including the commissioning schedule. Prior to this meeting the CxA is given, by the GC, all drawings and specifications and the construction schedule by trade. The CxA keeps notes from the meeting and distributes them to each team member.

6.2.2. Initial Submittals and Documentation

- a. Standard Submittals - The CxA provides all subcontractors responsible for commissioned equipment with commissioning documentation requirements for their respective equipment and systems through the GC. This data request typically coincides with the normal A/E submittal process. At minimum, this equipment data includes installation and start-up procedures, O&M data, performance data and control drawings. The CxA reviews and approves submissions relative to commissioning issues expressed in the contract documents, not for general contract compliance (which is the A/E's responsibility), unless specifically directed by the owner to do so.
- b. Special Submittals, Notifications and Clarifications - The 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 equipment or systems. The controls contractor provides the CxA a full points list and any details requested by the CxA. Thirty (30) days prior to performing owner-contracted tests, the Subs provide the CxA full details of the procedures. As the phases of the TAB are completed, the draft TAB report is provided to the CxA with full explanations of approach, methods, results, data table legends, etc. The final TAB report is provided to the CxA upon completion.
- c. These submittals to the CxA do not constitute compliance for submittals for the O&M manuals. The CxA may request additional design narrative from the A/E and from the controls contractor depending on the completeness of the documentation provided with the bid documents.

6.2.3. Prefunctional Checklists, Tests and Startup

- a. Prefunctional Assurance Tests (PFAT), are important to ensure that the equipment and systems are installed and operational and that functional performance testing may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout by the installing contractor. No sampling strategies are used. In general, the prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems.
- b. Installing contractor submits prefunctional checklist to CxA for review/approval.
- c. Prefunctional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., checking equipment assembly and installation, oil levels OK, fan belt tension, labels affixed, gages in place, sensor calibration, etc.). However, some prefunctional checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase motor or verifying amp draw of a motor). Prefunctional checklists augment and are combined with the manufacturer's start-up checklist.
- d. Contractors typically already perform some, if not many, of the prefunctional checklist items the commissioning agent will recommend. However, few contractors document in writing the execution of these checklist items. This project requires that the procedures be documented in writing by the installing technician. The CxA does not witness much of the prefunctional testing, except for testing of larger or more critical pieces of equipment and some spot-checking.
- e. Start-up Plan - The CxA assists the commissioning team members responsible for startup in developing detailed start-up plans for all equipment. The parties responsible for each part of startup and initial checkout are identified on the prefunctional checklists.

- f. Execution of Checklists and Startup - Four weeks prior to startup, the Subs and vendors schedule startup and initial checkout with the GC and CxA. The startup and initial checkout are directed and executed by the Sub or vendor. The CxA, and CM if necessary, observe, at minimum, the procedures for each piece of primary equipment. For components of equipment, (e.g., Air diffusers), the CxA observes a sampling of the prefunctional and start-up procedures. To document the process of startup and checkout, the site technician performing the line item task initials and dates each paragraph of procedures in the “Startup Plan” and checks off items on the prefunctional and manufacturer field checkout sheets, as they are completed. Only individuals having direct knowledge of a line item being completed shall check or initial the forms.
- g. Deficiencies and Non-Conformance - The subcontractors clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully at the bottom of the procedures form or on an attached notes sheet. The procedures form and deficiencies are provided to the CxA and CM within two days of test completion. The CxA and CM work with the Subs and vendors to correct and retest deficiencies or uncompleted items. The installing Subs or vendors correct all areas that are deficient or incomplete according to the checklists and tests. The CxA recommends approval of the startup and initial checkout of each system to the CM.
- h. Testing and Balancing (TAB) - The TAB contractor submits the outline of the TAB plan and approach to the CxA and the controls contractor four weeks prior to starting the TAB. Included in the approach, is an explanation of the intended use of the building control system. The CxA reviews the plan and approach for understanding and coordination issues and may comment. The controls contractor reviews the feasibility of using the building control system for assistance in the TAB work. The TAB submits weekly written reports of discrepancies, contract interpretation requests and lists of completed tests to the CxA and GC. This facilitates quicker resolution of problems and will result in a more complete TAB before functional testing begins.
- i. Controls Checkout Plan - The controls contractor develops and submits a written step-by-step plan to the CxA which describes the process they intend to follow in checking out the control system and the forms on which they will document the process. The controls contractor will 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 controls contractor will provide the TAB with any necessary unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.). The controls contractor shall also provide a technician qualified to operate the controls to assist the TAB contractor in performing TAB. Additional details are found in the Controls Specifications.
- j. All CxA required controls prefunctional checklists, calibrations, start-up and selected functional tests of the system shall be completed and approved by the CxA prior to TAB.

6.2.4. Development of Functional Test and Verification Procedures

- a. Overview - Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are

run through all of the control system's sequences of operation and components are verified to be responding as the sequences state. The commissioning agent develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is performed by the installing contractor, vendor, and/or TAB.

- b. Development Process - Before test procedures are written, the CxA obtains all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, control sequences and setpoints.

6.2.5. Execution of Functional Testing Procedures

- a. The CxA schedules functional tests through the GC and affected Subs. For any given system, prior to performing functional testing, the CxA waits until the prefunctional checklist has been submitted with the necessary signatures, confirming that the system is ready for functional testing. The CxA oversees, witnesses and documents the functional testing of all equipment and systems according to the Specifications and the Cx Plan. The Subs execute the tests, with oversight by the CxA. The control system is tested before it is used to verify performance of other components or systems. The air and water balancing is completed with any issues resolved before functional testing of air-related or water-related equipment or systems. Testing proceeds from components to subsystems to systems and finally to interlocks and connections between systems.
- b. Deficiencies and Retesting: The CxA documents the results of the test. Corrections of minor deficiencies identified are made during the tests at the discretion of the CxA. The CxA records the results of the test on the procedure or test form. The GC and CxA will schedule retesting if necessary. Decisions regarding deficiencies and corrections are made at as low a level as possible, preferably between CxA or GC and the Sub. For areas in dispute, final authority, besides the Owner's, resides with the A/E. The CxA recommends acceptance of each test to the A/E and PM. The A/E and PM gives final approval in each test.

6.3 Post Construction Phase Tasks

6.3.1. O&M Manuals and Systems Manual

- a. The CxA reviews the O&M manuals, documentation and redline as-built drawings for systems that were commissioned to verify compliance with the Specifications. The CxA recommends approval and acceptance of these sections of the O&M manuals to the GC. The CxA also reviews each equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated.
- b. The CxA develops a systems manual that provides future operating staff the information needed to understand and optimally operate the commissioned systems. The systems manual generally focuses on operating, rather than maintaining the equipment, particularly the interactions between equipment.

6.3.2. Written Work Products

- a. A final summary report by the CxA will be provided to the PM. The report shall include an executive summary, list of participants and roles, brief building description, overview of commissioning and testing scope and a general description of testing and verification methods. For each piece of commissioned equipment, the report will contain the disposition of the CxA regarding the adequacy of the equipment, documentation and training in meeting the contract

documents. The following areas will be considered: 1) Equipment installation, 2) Functional performance, 3) Equipment documentation and design intent, and 4) Operator training. All outstanding non-compliance items shall be specifically listed. Each non-compliance issue shall be referenced to the specific functional test, inspection, etc. where the deficiency is documented. The functional performance section for each piece of equipment shall include observations and conclusions from the testing.

- b. Appendices shall contain acquired sequence documentation, prefunctional checklists, logs, meeting minutes, progress reports, deficiency lists, site visit reports, findings, unresolved issues, communications, the commissioning plan, etc.

6.3.3. Operator Training and Orientation of Owner Personnel

- a. The installing contractor provides a list of equipment and schedule for training. After reviewing the specifications, and after interviewing facility staff, if necessary, the Owner and Commissioning Agent (CxA) review the equipment for which operator training or orientation will be provided.
 - a). Special Training and Orientation – Necessity of special orientation and trainings will be determined by the CxA and A/E:
 - 1). Recommissioning. The commissioning agent will provide instruction on the use of blank functional test forms for periodic recommissioning of equipment and systems, per the specification.
 - 2). Mechanical Contractor. The mechanical contractor will provide an overview of the major systems and equipment in the facility, including for each system: an overview of its operation, and interactions with other systems, any special areas to be aware of and issues regarding future expansion and remodeling.
 - 3). Electrical Contractor. The electrical contractor will provide an overview of the major electrical systems and equipment in the facility, particularly the lighting control systems, fire alarm, security and emergency power, focusing on the design intent, an overview of its operation, and interactions with other systems, any special areas to be aware of and issues regarding future expansion and remodeling.

6.3.4. Post Occupancy Review

- a. The CxA will review the building operation within 10 months after substantial completion with O&M staff and occupants. Any outstanding construction deficiencies or deficiencies identified in this post-occupancy review can be documented and corrected under manufacturer or contractor warranties. Any other problems in operating the building as originally intended are identified.

END OF PLAN