UNIVERSITY OF ARKANSAS

Commissioning Standards

UNIVERSITY OF
ARKANSAS

September 20, 2013

UAF Commissioning Standards

Typical systems for which Commissioning is to be provided

August 6, 2012

1. Building Envelope System*
2. HVAC Systems*
3. Energy Management Control System*
4. Domestic Water Heating Systems*
5. Domestic Water Distribution Equipment
6. Renewable Energy Systems
7. Plumbing Fixtures and Piping Systems
8. Medical Gas / Laboratory Gas Systems
9. Electrical Distribution / Generation Systems
10. Lighting Control Systems*
11. Interior Lighting
12. Exterior Lighting
13. Fire Alarm System
14. Information Technology
15. Fire Protection System
16. Refrigeration
17. Vertical Transport
18. Smoke Removal System
19. Audio / Visual Systems

* - Indicates systems required for commissioning on all projects. Other items are optional and will be discussed on a project by project basis. The exact scope of work for the building envelope system should be discussed on a project by project basis.

UAF Commissioning Standards

Typical Commissioning Scopes of Work

Commissioning services are to be provided for all of the systems listed in the previous section. However, for those systems marked as required, the detailed scope of work below applies. For the remaining systems, a more abbreviated scope of work applies as a minimum level of service. The abbreviated scope of work is listed below. A more detailed scope of work for some or all of the remaining systems may be negotiated on a project by project basis.

Required Systems

August 6, 2012

1. Assist With Design
    a. Pre-Design Phase
        i. Partnering / Kickoff meeting
        ii. Commissioning Scope of Work and Contract
        iii. Owner's Project Requirements (OPR) development
        iv. Planning and programming charrettes
        v. Commissioning Kickoff Meeting
    b. Design Phase
        i. Review Basis of Design
        ii. Develop Preliminary Commissioning Plan
        iii. Develop Commissioning Specifications
        iv. Maintain Updated Owner's Project Requirements
        v. Attend Design Review Meetings
        vi. Energy Model Review
        vii. Measurement and Verification Plan Review
        viii. Review Design Development Drawings
        ix. Review Construction Documents
2. Project Observation
    a. Pre-Construction Phase
        i. Attend Pre-Construction Meeting
        ii. Develop Commissioning Activities Schedule
        iii. Commissioning Kickoff Meeting

b. Construction Phase
    i. Submittal Review
    ii. Develop Pre-Functional Checklists
    iii. Conduct Site Visits
    iv. Coordinate Completion of Pre-Functional Checklists
    v. Conduct Site Tours for Owner Staff
    vi. Pre-Functional Checklist Sampling
    vii. Maintain Commissioning Issues Log
    viii. Develop Functional Performance Tests

3. Operational and Functional Testing
    a. Post Construction Phase
        i. Review Test and Balance Report
        ii. Sample Test and Balance Report
        iii. Conduct Functional Performance Tests
        iv. Maintain Commissioning Issues Log
        v. Conduct Site Tours for Owner Staff
        vi. Coordinate Training Agenda and Curriculum
4. Training (Video)
    a. Operational Handover Phase
        i. Attend and Participate in Owner Training
        ii. Ensure Recording of Owner Training
        iii. Ensure delivery of Training Materials
        iv. Quantify and Assess Benefits of Owner Training
    b. Occupancy Phase
        i. Support Owner Staff
        ii. Custodial Group Training
        iii. Assist With Operational Issues
        iv. Update Commissioning Issues Log
5. Organization and Compilation of O&M Manuals
    a. Operations and Maintenance Closeout
        i. Review O&M Manuals
        ii. Ensure delivery of proper data for Maintenance Management System
        iii. Ensure Delivery of O&M Manuals
        iv. Ensure Delivery of Record Documents (As-built drawings, approved submittal sets, final project specification manual)

v. Ensure Delivery of Updated BIM Model
vi. Ensure Delivery of Updated Energy Model
vii. Ensure Delivery of M&V Plan

b. Commissioning Closeout
   i. Publish Commissioning Report
   ii. Review Commissioning Report With Owner Staff
   iii. Review Open Commissioning Issues with Owner Staff (Include GC and A/E representation at this meeting)

6. Warranty Period Commissioning
   a. Seasonal Commissioning Phase
      i. Meeting With Owner Staff
      ii. Review Measurement and Verification Data Results
      iii. Verify that project energy performance exceeds ASHRAE 90.1-2007 by at least 10%.
      iv. Conduct Seasonal Commissioning
      v. Update Commissioning Issues Log
   b. Warranty Inspection Phase (occurs within 10 months of building occupancy)
      i. Meet With Owner Staff
      ii. Review Measurement and Verification Data Results
      iii. Conduct Pre-Warranty Expiration Inspection
      iv. Update Commissioning Issues Log

Additional Systems Minimum Scope of Commissioning Services

August 6, 2012

1. Construction site observation during construction phase.
2. Integrated systems commissioning to verify interaction with required commissioned systems.
3. Verification of testing that is completed by others.
4. Verification of training that is completed by others.
5. Verification that close out documentation is provided to Owner.

UAF Commissioning Standards

Typical Commissioning Deliverables

August 6, 2012

1. Assist With Design
    a. Commissioning Contract
    b. Commissioning Meeting Notes
    c. Owner's Project Requirements
    d. Basis of Design Comments
    e. Commissioning Plan
    f. Commissioning Specifications
    g. Design Review Comments
2. Project Observation
    a. Commissioning Meeting Notes
    b. Commissioning Activities Schedule
    c. Submittal Review Comments
    d. Pre-Functional Checklists
    e. Site Observation Reports
    f. Completed Pre-Functional Checklists
    g. Commissioning Issues Log
    h. Functional Performance Tests
3. Operational and Functional Testing
    a. Test and Balance Review Comments
    b. Completed Functional Performance Tests
    c. Commissioning Issues Log
    d. Training Agenda
4. Training (Video)
    a. Owner Training Notes
    b. Owner Training Assessments
    c. Commissioning Issues Log
5. Organization and Compilation of O&M Manuals
    a. O&M Review Comments
    b. Maintenance Management System Data
    c. BIM Model Data

d. Commissioning Report (Electronic Media Preferred)

e. Commissioning Issues Log

6. Warranty Period Commissioning
    a. Commissioning Meeting Notes
    b. Measurement and Verification Review Comments
    c. Document project energy performance meets requirement to exceed ASHRAE 90.1-2007 by 10%.
    d. Seasonal Commissioning Report
    e. Commissioning Issues Log
    f. Warranty Inspection Report
7. Ensure delivery of the following operational documentation:
    a. Owners Project Requirements developed by the Owner and Commissioning Authority
    b. The Basis of Design / Programming Document (if applicable) developed by the design team
    c. The Commissioning Plan developed by the Commissioning Authority
    d. The IAQ Management Plan developed by the General Contractor and/or Construction Manager
    e. The Design Phase Energy Model developed by the design engineer
    f. The Construction Phase Energy Model (including all Value Engineering impacts) developed by the design engineer
    g. The Measurement and Verification Plan developed by the design engineer
    h. The Testing, Adjusting, and Balancing report developed by the General Contractor and/or Construction Manager
    i. The final Control Drawings and sequences of operation developed by the General Contractor and/or Construction Manager
    j. The Final Commissioning Report developed by the Commissioning Authority
    k. The LEED /GG Application /Filing documentation (if applicable) developed by the design team
    l. The as-built / calibrated Energy Model developed by the design engineer
    m. The Act 1494 Energy Report developed by the Commissioning Authority
    n. The Act 1494 Remediation Plan (if applicable) developed by the Commissioning Authority in conjunction with other project team members
    o. The Year 1 User IAQ Survey developed by the Owner

UAF Commissioning Standards

Typical OPR Outline

June 14, 2011

1. OPR Version History and Sign Off
    a. Version Number
    b. Date
    c. Initial Approval Signatures: Cx Agent, Designer, Construction Coordinator, and user group representative(s), and GC.
2. OPR Overview
3. General Project Information
    a. Name
    b. Budget
    c. Project Schedule
    d. Team Charter
    e. Team List and Contact Information
4. Energy and Sustainability Goals
    a. LEED/Green Globes Requirements
        i. LEED Silver / Two Green Globes
    b. Energy Efficiency Goals
        i. Minimum of 10% below ASHRAE 90.1-2007
        ii. Target 20% below ASHRAE 90.1 – 2007
        iii. Timing of energy model input into design
    c. Economic Considerations
        i. Energy modeling assumptions
        ii. Life Cycle Cost based decision
            1. Requires minimum lifecycle term of 50 years.
            2. Items to consider
                a. Utility escalation rates
                b. Term
                c. Cost of money (Discount Rate)
    d. Sustainability Dashboard Requirements
        i. Meters
        ii. Interval Data
        iii. Monthly Data
    e. M&V Requirements
        i. Design Engineer develops plan (reference attached template)
        ii. Design Engineer develops as-built energy model
        iii. Minimum compliance with LEED EA Credit 5
        iv. Separately meter building heating and cooling loads
5. Project Specific Requirements
    a. Occupancy Information
    b. Occupancy Schedules
    c. Building Envelope Performance

i. Component review
ii. Air barrier review
iii. Moisture control review
iv. Positive pressure buildings
v. Building envelope testing

d. IEQ Requirements
i. Temperature
ii. Humidity
iii. Prefer non-operable windows
iv. Demand controlled ventilation
v. CO_2 monitoring
vi. MERV 13 filtering requirements
vii. Glare control/shading
viii. Building flush out/testing

e. Lighting
i. Occupancy sensor in common and public areas
ii. Interlock occupancy sensors with HVAC
iii. Exterior lighting controls
1. Centralized photo sensor control
2. EMCS monitoring
iv. Preference for T8 lighting
v. Day-lighting controls
vi. Preference for generator backup power

f. Technical Requirements
i. Equipment/vendor preferences (reference IDIQ listing)
ii. Prefer not to have roof top equipment, piping, and ductwork
iii. Consult UAF Design Guide (coming soon)

g. Exceptional Codes and Standards
i. IDIQ Requirements
ii. Act 1494 Compliance
iii. LEED Rating System

6. Operations and Maintenance Requirements
a. O&M Organizational Chart
b. MEP Space Requirements (8% minimum of gross square footage)
c. Custodial Space Requirements
d. Construction period tours for maintenance personnel
e. Final O&M walk through coordinated by Cx at substantial completion

7. Training and Documentation
(italics show requirements for hard copy)
a. As-built energy model required
b. As-built BIM Model
c. Video recording by GC, verified by Cx
d. Systems manual content
i. As-built drawings
ii. Comprehensive submittals (product specific, not generic manuals)
iii. ASIs
iv. RFIs
v. Addenda

vi. Change Orders
vii. TAB Report
viii. Commissioning Report
ix. Warranty documentation

e. CMMS Information by GC
f. Building Energy Plan from designer

8. Post Construction Requirements
    a. Close out meeting
    b. M&V Requirements
        i. One month data review
        ii. Quarterly data review
        iii. 1st year report
    c. Thermal comfort survey
    d. Seasonal Commissioning
    e. 10-month warranty review
9. Appendix
    a. Team Charter
    b. M&V Plan template

Typical Commissioning Design Review / Comment Form

			UNIVERSITY OF ARKANSAS			PROJECT					Design/Submittal Review	
	DISCIPLINE	REFERENCE	REVIEWER	OFFICE SYMBOL	DATE	COMMENT	DESIGNER	DATE	RESPONSE (A=Accept; FS=Further Study; E=Exception)	COMMENT	STATUS (Open/ Closed)	COMMENT
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

Typical Commissioning Specifications

The highlighted sections are provided to indicate potential issues or details that need to be addressed on a project by project basis.

SECTION 01 91 13: GENERAL COMMISSIONING REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY: This section includes general requirements that apply to the implementation of the commissioning process without regard to specific systems, assemblies, and components.

1.2 ENVIRONMENTAL CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's environmental considerations and goals. These considerations and goals are to establish a facility which is environmentally responsible, profitable, and a healthy place to live and work. To guide this process, this project is pursuing LEED Certified level certification per the 2009 Green Building Design and Construction Reference Guide for New Construction. Compliance with all credits and prerequisites shown in the checklist attached to section 01 35 13 is required. All team members will be required to perform some amount of associated documentation. Refer to Sections listed below for environmental considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

1.3 RELATED Requirements

A. Section 01 35 13 - LEED Requirements

B. Section 01 79 00 - Commissioning Training Requirements

C. Section 01 92 00 – Measurement & Verification

D. Section 07 08 00 - Building Enclosure Commissioning

E. Section 07 27 00 - Air Barrier Requirements and Testing

F. Section 22 08 00 – Commissioning of Plumbing Systems

G. Section 23 08 00 – Commissioning of HVAC Systems

H. Section 26 08 00 – Commissioning of Electrical Systems

I. Other

1.4 DEFINITIONS

A. Acceptance Phase: Phase of construction after startup and initial checkout when functional performance tests, O&M documentation review and training occurs.

B. Commissioning Agent (CxA): An independent party, not otherwise associated with the A/E team members or the Contractor, oversees, though he/she may be hired as a subcontractor to them. The CxA directs the day-to-day commissioning activities.

C. Commissioning Plan: An overall plan that provides the structure, schedule, and coordination planning for the commissioning process.

D. Datalogging: Monitoring flows, currents, status, pressures, etc. of equipment using stand-alone data loggers separate from the control system.

E. Deferred Functional Tests: FPT's that are performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow the test from being performed.

F. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents (that is, does not perform properly or is not complying with the design intent).

G. Functional Completion: All TAB and commissioning responsibilities of the Contractor, (except for seasonal or approved deferred testing and controls training), must be completed.

H. Functional Performance Test (FPT): Test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems. 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 the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not functional testing. TAB's primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The CxA develops the functional test procedures in a sequential written form, coordinates, oversees, and documents the actual testing, which is usually performed by the installing contractor or vendor. FPT's are performed after prefunctional checklists, startup, T&B, controls are complete. The subcontractor is responsible for reviewing, understanding, and performing the FPT's.

I. Indirect Indicators: Indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed.

J. Issues log: A formal and ongoing record of problems or concerns and their resolution that have been raised by members of the Commissioning Team during the course of the commissioning Process.

K. Manual Test: Using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").

L. Monitoring: The recording of parameters (flow, current, status, pressure, etc.) of equipment operation using data loggers or the trending capabilities of control systems.

M. Over-written Value: Writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 50 F to 75 F to verify economizer operation). See also "Simulated Signal".

N. Phased Commissioning: Commissioning that is completed in phases due to the size of the structure or other scheduling issues, in order to minimize the total construction time.

O. Prefunctional Checklist (PFC): A list of items to inspect and elementary component tests to conduct to verify proper installation of equipment, provided by the CxA to the GC and Sub. Prefunctional checklists are primarily static inspections and procedures to prepare the equipment or system for initial operations (e.g., belt tension, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.).

P. Sampling: Functionally testing only a fraction of the total number of identical or near identical pieces of equipment.

Q. Seasonal Performance Tests: FPT that are deferred until the system(s) will experience conditions closer to their design conditions.

R. Simulated Condition: Condition that is created for the purpose of testing the response of a system.

S. Simulated Signal: Disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and DDC system to simulate a sensor value.

T. Startup: The initial starting or activating of dynamic equipment, including executing prefunctional checklists.

U. Test Procedures: The step-by-step process which must be executed to fulfill the test requirements. The test procedures are developed by the CxA with assistance and coordination from GC and subcontractors.

V. Test Requirements: Requirements specifying what modes and functions, etc. shall be tested. The test procedures are not the detailed test procedures. The test requirements are specified in the Contract Documents.

W. Trending: Monitoring using the building control system.

1.5 ABBREVIATIONS:

A. The following are common abbreviations used in the Specifications and in the Commissioning Plan.

1. A/E - Architect and Design Engineers
2. CxA - Commissioning Agent
3. CC - Controls Contractor
4. EC - Electrical Contractor
5. ES - Electronic Security Contractor
6. FPT - Functional Performance Test
7. GC - General Contractor (prime)
8. MC - Mechanical Contractor
9. PFC – Pre-functional Checklist
10. PM - Project Manager (of the Owner)
11. Subs - Subcontractors to General
12. TAB - Test and Balance Contractor

1.6 DESCRIPTION

A. Commissioning

1. This project will have selected building systems commissioned. The commissioning process will be implemented by the Contractor, monitored by the CxA.

2. Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the Owner's operational needs. This is achieved by actual verification of performance. The commissioning process encompasses and coordinates the functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents

a. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.

b. Verify and document proper performance of equipment and systems.

c. Verify that O&M documentation is complete.

d. Verify that the Owner's operating personnel are adequately trained.

B. The commissioning process does not reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product in accordance with the Contract Documents.

1.7 COMMISSIONING TEAM

A. Members appointed by contractor(s): Individuals, each having authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated actions. The commissioning team shall consist of, but not be limited to representatives of each contractor, including project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.

B. Members appointed by owner:

1. CxA - An entity identified by the owner who leads, plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the contracted commissioning agents under a separate contract.

2. Representatives of the facility user and operation and maintenance personnel.

3. Architect and engineering design professionals.

C. The Systems Commissioning Team shall include the following members

1. General Contractor Superintendent

2. General Contractor Project Manager

3. Contractor Quality Control Manager

4. Mechanical Subcontractor Representative

5. Electrical Subcontractor Representative

6. Testing, Balancing, and Adjusting Subcontractor Representative

7. Instrumentation and Controls Subcontractor Representative

8. Owner Furnished Equipment Manufacturer's Representatives

9. Owner’s Representative

D. Provision of a fully commissioned system of all materials required under the construction contract is the responsibility of the General Contractor. Therefore, Contractor Group members of the Systems Commissioning Team, through participation in the planning, management, and oversight of all construction activities related to equipment approvals, performance testing, and commissioning of the systems identified herein must be able to

assure the Owner that all systems have been properly tested and commissioned. The Owner is intended to participate fully as adjuncts to the Contractor Group Team members. It is intended that through this participation, the Contractor Group Team members will be provided timely access to all design information necessary to resolve questions as to intended performance of the systems specified. In addition, the Owner will be sufficiently involved in the development of commissioning and performance testing programs to assure timely review of plans and procedures submitted by the Contractor. The purpose of this process will be to provide fully functional systems which interact to meet all contract performance requirements. The participation of the Commissioning Team members shall not relieve the General Contractor of any responsibility for compliance with the requirements of the contract.

1.8 SCHEDULING

A. The CxA will work with GC according to established protocols to schedule the commissioning activities. The CxA will review the Construction Schedule and verify that prefunctional and functional testing is properly scheduled. The GC will integrate all commissioning activities into the master schedule.

B. Commissioning inspections and testing will be accomplished in the presence of a representative of the General Contractor, and the Owner with the CxA overseeing the process.

1.9 OVERVIEW OF THE COMMISSIONING PROCESS

A. Commissioning Plan: The CxA will develop the commissioning plan which shall be included in the project schedule. The commissioning plan provides guidance and further details the requirements in the execution of the commissioning process. The Specifications take precedence over the Commissioning Plan in the event of a conflict.

B. Commissioning Process: The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.

1. Commissioning during construction begins with a meeting conducted by the CxA where the commissioning process is reviewed with the commissioning team members during a scheduled monthly/biweekly contractors' meeting. This meeting will occur prior to the completion of the first Prefunctional Checklist.

2. Additional meetings will be required throughout construction, scheduled by the CxA with necessary parties attending, to plan, scope, coordinate, schedule future commissioning related activities, and resolve problems.

3. Equipment documentation, including: Shop Drawings, installation instructions, detailed start up procedures are submitted to the CxA during the normal submittals process.

4. In general, performance verification proceeds from component level to systems and intersystem levels with pre-functional checklists being completed before functional testing.

5. The Subs, under their own direction, execute and document the pre-functional checklists before and during the startup process with the GC and the CxA monitoring conformance.

6. Prior to commencement of functional testing, the Commissioning Team shall perform a systems activation inspection to ensure the systems are ready to be functionally tested.

a. The GC will ensure all Pre-functional Checklists are completed. The contractor shall identify any missing checklists and provide as necessary.

b. The CxA will verify all Pre-functional Checklists, TAB and startup are complete for systems to be Functionally Tested.

7. The CxA will prepare the Functional Testing protocols for execution by the GC and Subs.

8. The GC will schedule the Functional Testing after the Pre-Functional Checklists, TAB and startup are complete and the Functional Testing protocols have been reviewed by the GC and Subs.

9. The CxA will witness and document the Functional Testing process.

10. The GC will witness the Functional Testing process to insure completed by the Subs.

11. Items of non-compliance in material, installation or setup are noted for the Contractor to correct. Non-complying systems will then be retested and functional performance verified by the GC and the CxA.

12. All functional performance tests are completed before Substantial Completion Date.

13. The CxA will review the O&M documentation for completeness.

14. The GC will review the training plan provided by the Subs. The GC and CxA will witness training session(s) to verify that acceptable training was provided. The GC shall video all training for the Owner.

1.10 RESPONSIBILITIES

A. The general responsibilities of various parties in the commissioning process are provided in this subsection. The specific responsibilities will be included in the commissioning plan.

B. Owner's Responsibilities:

1. Provide the OPR documentation to the CxA for information and use.

2. Attend initial commissioning meeting and additional meetings as necessary.

3. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.

4. Assist the GC in coordinating the training of owner's personnel.

C. Architect/Engineer Responsibilities:

1. Provide the Basis of Design documents approved by the Owner to the CxA for use in developing the commissioning plan, operating and maintenance training plan, and final commissioning report.

2. Attend commissioning team meetings as needed.

3. Provide copies of all project documents including plans, specifications, addenda, ASI, PR's, etc.

4. Provide any design narrative and sequences documentation requested by the CxA. The designers shall assist in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

5. Coordinate resolution of system deficiencies identified during commissioning, according to the contract documents.

6. Participate in the resolution of system deficiencies identified during commissioning, according to the contract documents.

D. Contractors Responsibilities:

1. Facilitate the coordination of the commissioning and incorporate commissioning activities into the Master Project Schedule (MPS).

2. Ensure that all subcontractors and vendors execute their commissioning responsibilities according the contract documents and the MPS.

3. Provide copies of all submittals including all changes thereto to the CxA.

4. Provide RFI documents related to the commissioned systems to the CxA as needed.

5. Attend and participate in commissioning team meetings.

6. Cooperate with the CxA for timely resolution of issues recorded in the issues log.

7. Complete Prefunctional Checklist as work is completed and provide to the CxA for review and verification.

8. Schedule and conduct owners training.

E. Commissioning Authority (CxA) Responsibilities:

1. Organize and lead the commissioning team.

2. Coordinate the commissioning work and with the GC and owner, help integrate commissioning activities into the Master Project Schedule.

3. Plan and conduct commissioning team meetings.

4. Provide project-specific Prefunctional Checklist and Functional Performance Test procedures.

5. Review all completed Pre-Functional Checklist and verify a minimum of 10% in the field prior to Functional Performance Testing.

6. Prepare and maintain the commissioning issues log.

7. Witness all Functional Performance Testing of commissioned systems.

8. Verify the contractor has provided adequate training to the owner's personnel for the commissioned systems.

9. Develops and submits a final commissioning report at the end of project construction.

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

A. All testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the construction contractor for the equipment being tested.

B. Special equipment, tools, and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and shall be left on site for use by the Owner.

C. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerance specified in the Specifications.

2.2 UTILITIES AND ACCESSORIES

A. Provide utilities necessary to execute testing and commissioning, including water, fuels, chemicals, batteries, and other similar expendable items.

B. Provide any equipment or device required for access, such as ladders, and platforms.

PART 3 EXECUTION

3.1 MEETINGS: During commissioning meetings, the GC and CxA will be available to answer questions about the Commissioning process and assist subcontractors in the completion of pre-functional checklist and functional performance tests.

3.2 SUBMITTALS

A. Submittal Requirements for Commissioning: The CxA will review submittals during regular site visits. The GC will provide a copy of the commissioning related submittals to the CxA.

B. The CxA will review Contractor submittals applicable to systems being commissioned.

C. Data for Commissioning: Typically submittals should include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any OEM tests, fan and pump curves, full factory testing reports, if any, and full warranty information. In addition, copies of the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be maintained on site in the filing system set up and maintained by the GC. The CxA will review this data on site on a periodic basis.

3.3 START-UP AND PREFUNCTIONAL CHECKLISTS

A. General: Pre-Functional checklists ensure that the equipment and systems are properly installed and operational. They ensure that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full pre-functional checkout. The pre-functional testing for a given system must be successfully completed prior to formal functional performance testing of equipment of subsystems of the given system.

B. Execution of Pre-Functional Checklists

1. The Subs and vendors shall execute startup and provide the GC with the signed and dated copy of the completed start-up documentation and prefunctional checklist. The CxA will verify 10 percent of the pre-function checklist.

2. Only individuals that have direct knowledge and witnessed that a line item task on the pre-functional checklist was actually performed shall initial or check that item off.

3. The GC and CxA shall witness the Start-up.

C. Deficiencies: The subcontractor shall list any outstanding items of the initial start-up and pre-functional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies shall be provided to the GC and the CxA within 2 days of test completion. The GC and CxA will review and monitor outstanding deficiencies. The GC and the subcontractor shall correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

3.4 PHASED COMMISSIONING: When startup and initial checkout are required to be executed in phases, this phasing will be planned and scheduled in a coordination meeting of the CxA, mechanical, plumbing, TAB, and controls contractor, and the GC. The GC shall modify the construction schedule as needed, to reflect phased commissioning.

3.5 FUNCTIONAL TESTING

A. Objectives and Scope

1. The objective of functional testing is to demonstrate that each system is operating according to the Contract Documents. Functional testing facilitates bringing the systems to full dynamic operation. During the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.

2. In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze conditions, low oil pressure, no flow, equipment failure, etc. shall also be tested.

3. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CxA and GC. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre-functional checklists as soon as possible.

B. Documentation and Non-Conformance

1. Documentation: The GC and CxA will witness and the CxA will document the results of all functional performance tests using the specific procedural forms developed for that purpose.

2. Non-Conformance

a. The CxA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted.

b. Corrections of minor deficiencies identified may be made during the tests. In such cases, the deficiency and resolution will be documented on the procedure form.

c. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures.

d. All deficiencies or non-conformance issues identified during the functional testing shall be corrected and retested at no additional cost to the owner.

3.6 OPERATION AND MAINTENANCE MANUALS

A. O&M Manuals

1. The contractor shall compile O&M manuals for every piece of equipment and building operating or electrical system being commissioned with the following format:

a. Format: 8 ½" x 11" 3 ring loose-leaf binders, 3-inch maximum, and electronic format that is compatible with the owner's system. Each binder shall be clearly labeled on the spine. Use as many binders as required. Do not overload binders. Dividers with permanently marked tabs of card stock shall separate each section and sub section. Tab labels shall not be hand written. A separate manual or chapter shall be provided for each system.

2. Contractor shall submit two draft copies of the completed operating and maintenance manual to the architect/engineer and CxA for review within 60 calendar days after review of equipment shop drawings.

3. Contractor shall provide approved O&M manuals prior to Owner training sessions.

B. Commissioning Records

1. The GC shall compile, organize and index project commissioning data into labeled, indexed and tabbed, 3-ring binders and deliver to the CxA for review.

2. Final Commissioning Report Details

a. The Final Commissioning 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 shall contain

1) Completed Pre-Functional Checklists and Functional Test Reports.

2) Certified and approved factory start-up and testing reports.

3) Records of all required tests and inspections for code compliance and Contract Document compliance, and documentation of approved permits and licenses to operate components of the systems.

4) Final HVAC Test and Balance Report.

5) Training Plan, training procedure, and documentation used to support owners training.

b. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. shall be listed. Each non-compliance issue shall be referenced to the specific functional test, inspection, trend log, etc. where the deficiency is documented. The functional performance and

efficiency section for each piece of equipment shall include brief description of the verification method used (manual testing, BAS trend logs, data loggers, etc.) and include observations and conclusions from the testing.

3.7 TRAINING OF OWNERS PERSONNEL

A. The GC shall coordinate the operator training. Training requirements are shown in each Section specifying commissioning and in Sections specifying items or systems to be commissioned. GC shall video all training of personnel.

B. The GC will review the content of the training plan and adequacy of the training of Owner personnel for commissioned equipment.

1. Each Sub and vendor responsible for training shall submit a written training plan to the GC for review prior to training. The plan shall cover the following elements

a. Equipment included in training.

b. Intended audience

c. Location of training

d. Objectives

e. Subjects covered (description, duration of discussion, special methods, etc.)

f. Duration of training on each subject

g. Instructor for each subject

h. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)

i. Instructor and qualifications

2. For the primary HVAC equipment, the Controls Contractor shall provide a short discussion of the control of the equipment during the mechanical or electrical training conducted by others.

3. Video taping of the training sessions will be provided by the GC with tapes cataloged by the subcontractor and added to the O&M Manuals. The GC will witness the taped sessions.

C. See additional training information in section 01 79 00.

3.8 DEFERRED TESTING

A. Unforeseen Deferred Tests: If any check or test cannot be completed due to the building

structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the CxA.

3.9 PREREQUISITES TO SUBSTANTIAL COMPLETION: The commissioning must be completed, except for training, prior to Beneficial Occupancy Date, unless scheduled and approved by the Owner.

3.10 SCHEDULE OF SYSTEMS TO BE COMMISSIONED

A. The below systems will be commissioned.

1. HVAC Systems

a. Major and minor HVAC equipment items

b. Terminal Units

c. Automatic Temperature Control System

d. Building Automation System Integration

2. Plumbing System

a. Heating Water Systems

3. Electrical System

a. Lighting Controls other than manual switches

b. Building Automation System Integration

END OF SECTION 01 91 13

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SECTION 01 79 00: COMMISSIONING DEMONSTRATION AND TRAINING

PART 1 GENERAL

1.1 SUMMARY

A. Demonstration of products and systems to be commissioned and where indicated in specific specification sections.

B. Training of Owner personnel in operation and maintenance is required for:

1. All software-operated systems.

2. HVAC systems and equipment.

3. Plumbing equipment.

4. Electrical systems and equipment.

5. Landscape irrigation.

6. Items specified in individual product Sections.

1.2 ENVIRONMENTAL CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's environmental considerations and goals. These considerations and goals are to establish a facility which is environmentally responsible, profitable, and a healthy place to live and work. To guide this process, this project is pursuing LEED Certified level certification per the 2009 Green Building Design and Construction Reference Guide for New Construction. Compliance with all credits and prerequisites shown in the checklist attached to section 01 35 13 is required. All team members will be required to perform some amount of associated documentation. Refer to Sections listed below for environmental considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

1.3 RELATED REQUIREMENTS

J. Section 01 35 13 - LEED Requirements

K. Section 01 91 13 – General Commissioning Requirements

L. Section 01 92 00 – Measurement & Verification

M. Section 07 08 00 - Building Enclosure Commissioning

N. Section 07 27 00 - Air Barrier Requirements and Testing

O. Section 22 08 00 – Commissioning of Plumbing Systems

P. Section 23 08 00 – Commissioning of HVAC Systems

Q. Section 26 08 00 – Commissioning of Electrical Systems

R. Other

1.4 SUBMITTALS

A. Draft Training Plans: Owner will designate personnel to be trained; tailor training to needs and skill-level of attendees.

1. Submit to Architect for transmittal to Owner.

2. Submit to GC for review and inclusion in overall training plan.

3. Submit not less than four weeks prior to start of training.

4. Revise and resubmit until acceptable.

5. Provide an overall schedule showing all training sessions.

6. Include at least the following for each training session:

a. Identification, date, time, and duration.

b. Description of products and/or systems to be covered.

c. Name of firm and person conducting training; include qualifications.

d. Intended audience, such as job description.

e. Objectives of training and suggested methods of ensuring adequate training.

f. Methods to be used, such as classroom lecture, live demonstrations, hands-on, etc.

g. Media to be used, such as slides, hand-outs, etc.

h. Training equipment required, such as projector, projection screen, etc., to be provided by Contractor.

B. Training Manuals: Provide training manual for each attendee; allow for minimum of two attendees per training session.

1. Include applicable portion of O&M manuals.

2. Include copies of all hand-outs, slides, overheads, video presentations, etc., that is not included in O&M manuals.

3. Provide one extra copy of each training manual to be included with operation and maintenance data.

C. Training Reports:

1. Identification of each training session, date, time, and duration.

2. Sign-in sheet showing names and job titles of attendees.

3. List of attendee questions and written answers given, including copies of and references to supporting documentation required for clarification; include answers to questions that could not be answered in original training session.

D. Video Recordings: Submit digital video recording of each demonstration and training session for Owner's subsequent use.

1. Format: DVD Disc.

2. Label each disc and container with session identification and date.

1.5 QUALITY ASSURANCE

A. Instructor Qualifications: Familiar with design, operation, maintenance and troubleshooting of the relevant products and systems.

1. Provide as instructors the most qualified trainer of those contractors and/or installers who actually supplied and installed the systems and equipment.

2. Where a single person is not familiar with all aspects, provide specialists with necessary qualifications.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 DEMONSTRATION - GENERAL

A. Demonstrations conducted during system start-up do not qualify as demonstrations for the purposes of this section, unless approved in advance by Owner.

B. Demonstrations conducted during Functional Testing need not be repeated unless Owner personnel's training is specified.

C. Demonstration may be combined with Owner personnel training if applicable.

D. Operating Equipment and Systems: Demonstrate operation in all modes, including start-up, shut-down, seasonal changeover, emergency conditions, and troubleshooting, and maintenance procedures, including scheduled and preventive maintenance.

1. Perform demonstrations not less than two weeks prior to Substantial Completion.

2. For equipment or systems requiring seasonal operation, perform demonstration for other season within six months.

E. Non-Operating Products: Demonstrate cleaning, scheduled and preventive maintenance, and repair procedures.

1. Perform demonstrations not less than two weeks prior to Substantial Completion.

3.2 TRAINING - GENERAL

A. GC will prepare the Training Plan based on draft plans submitted.

B. Conduct training on-site unless otherwise indicated.

C. Owner will provide classroom and seating at no cost to Contractor.

D. Do not start training until Functional Testing is complete, unless otherwise specified or approved by the Commissioning Authority.

E. Provide training in minimum two hour segments.

F. The Commissioning Authority is responsible for determining that the training was satisfactorily completed.

G. Training schedule will be subject to availability of Owner's personnel to be trained; re-schedule training sessions as required by Owner; once schedule has been approved by Owner failure to conduct sessions according to schedule will be cause for Owner to charge Contractor for personnel "show-up" time.

H. Review of Facility Policy on Operation and Maintenance Data: During training discuss:

1. The location of the O&M manuals and procedures for use and preservation; backup copies.

2. Typical contents and organization of all manuals, including explanatory information, system narratives, and product specific information.

3. Typical uses of the O&M manuals.

I. Product- and System-Specific Training:

1. Review the applicable O&M manuals.

2. For systems, provide an overview of system operation, design parameters and constraints, and operational strategies.

3. Review instructions for proper operation in all modes, including start-up, shut-

down, seasonal changeover and emergency procedures, and for maintenance, including preventative maintenance.

4. Provide hands-on training on all operational modes possible and preventive maintenance.

5. Emphasize safe and proper operating requirements; discuss relevant health and safety issues and emergency procedures.

6. Discuss common troubleshooting problems and solutions.

7. Discuss any peculiarities of equipment installation or operation.

8. Discuss warranties and guarantees, including procedures necessary to avoid voiding coverage.

END OF SECTION 01 79 00

SECTION 07 08 00: BUILDING ENCLOSURE COMMISSIONING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 07 and Division 08.

B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned is specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIRMENTS. A Commissioning Agent (CxA) appointed by the Owner will manage the commissioning process.

1.2 RELATED WORK

A. Section 01 00 00 GENERAL REQUIREMENTS.

B. Section 01 91 13 GENERAL COMMISSIONING REQUIREMENTS.

C. Section 07 27 00 AIR BARRIER REQUIREMENTS, THIRD PARTY TESTING

1.3 SUMMARY

A. This Section includes requirements for commissioning the Facility exterior closure, related subsystems and related equipment. This Section supplements the general requirements specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

B. The Building Enclosure Commissioning Agent (BECxA) has been contracted with the owner directly. All building testing associated with the building enclosure, underfloor plenum, water resistance of exterior assemblies, etc., are the responsibility of the contractor unless otherwise noted in the contract documents.

B. The commissioning activities have been developed to support the OWNER requirements and to meet the enclosure commissioning requirements of the LEED (Leadership in Energy and Environmental Design) Rating System.

1.4 DEFINITIONS

A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in Division 07 and Division 08 is part of the construction process. Documentation and testing of these systems, as well as training of the OWNER's Operation and Maintenance personnel, is required in cooperation with the OWNER and the Commissioning Agent.

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B. The following Facility exterior closure systems will be commissioned:
   1. Roofs (Asphalt shingles, slate shingles, wood shingles, clay roof tiles, built-up bituminous, modified bituminous, EPDM, PVC, fluid-applied, sprayed polyurethane, flashing & sheet metal, metal roofing, roof specialties, and roof accessories)
   2. Exterior Insulation and Finish Systems (EIFS)
   3. Curtain Wall Systems (Mullions, glazing, and sealing)
   4. Exterior Doors (Revolving, glass leaf, emergency exit, and service)
   5. Exterior Windows (Aluminum, steel, glazing, storm)
   6. Louvers and Vents
   7. Sealants (Caulking, mechanical seals, and wind and vapor barriers)

1.6 SUBMITTALS

A. The commissioning process requires review of selected Submittals. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will forwarded to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.

B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-CONSTRUCTION COORDINATION

A. The Commissioning Agent shall coordinate and schedule a building enclosure pre-construction meeting. The enclosure architectural details, enclosure components, sequencing of trades, and testing requirements will be covered in the meeting. Any

potential changes to the construction details or materials will be identified in this meeting. The meeting should be scheduled before installation of any of the building enclosure components and after the construction of the mock-up.

3.1 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 07 (07 27 00) or Division 08 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. The Commissioning Agent will have the option to witness selected Contractor tests.

3.2 TRAINING OF OWNER PERSONNEL

A. Training of the OWNER operation and maintenance personnel is required in cooperation with the Architect and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Owner after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 01 Sections for additional Contractor training requirements.

END OF SECTION 07 08 00

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SECTION 07 27 00: AIR BARRIER REQUIREMENTS AND TESTING

PART 1 GENERAL

1.1 CONTRACTOR RESPONSIBILITY: The Contractor is responsible for the construction of an air/vapor barrier system that is contiguous and connected across the six surfaces of the building envelope meeting the performance requirements as outlined in this specification.

A third party testing technician (not hired by the air barrier installer, waterproofer, etc.) shall be contracted to perform a building air tightness test and thermography test to demonstrate that the building envelope is properly sealed and insulated. The testing shall be performed in accordance with the procedures outlined in this specification.

1.2 ENVIRONMENTAL CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's environmental considerations and goals. These considerations and goals are to establish a facility which is environmentally responsible, profitable, and a healthy place to live and work. To guide this process, this project is pursuing LEED Certified level certification per the 2009 Green Building Design and Construction Reference Guide for New Construction. Compliance with all credits and prerequisites shown in the checklist attached to section 01 35 13 is required. All team members will be required to perform some amount of associated documentation. Refer to Sections listed below for environmental considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

1.3 REFERENCES: The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 1060	(90; R 2003) Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings
ASTM E 779	(2003) Standard Test Method for Determining Air Leakage Rate by Fan Pressurization
ASTM E 1677	(2005) Standard Specification for an Air Barrier (AB) Material or System for

	Low-Rise Framed Building Walls
ASTM E 1827	(96; R 2002) Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door
ASTM E 2178	(2003) Standard Test Method for Air Permeance of Building Materials
ASTM D 4541	(2002) Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

1.4 SUBMITTALS

Building Air Tightness Test Procedures;

The third party testing technician shall submit detailed test procedures indicating the test apparatus, the test methods and procedures, and the analysis methods to be employed for the Building Air Tightness Test to the Owner's Building Enclosure Commissioning Agent (BECxA). The Building Air Tightness Test Procedures shall be submitted not later than 60 days after Notice to Proceed.

The third party testing technician shall submit detailed test procedures indicating the test apparatus, the test methods and procedures, and the analysis methods to be employed for the Thermography Test.

Test Reports;

The inspection and testing agency will submit a certified written report, in duplicate, of each inspection, test, or similar service to the Contractor with duplicate copies to the Commissioning Agent no later than 15 days after each test.

Report Data: Written reports of each inspection, test, or similar service include, but are not limited to, the following

a. Date of Issue
b. Project title and number
c. Name, address, and telephone number of testing agency
d. Dates and locations of samples and tests or inspections
e. Names of individuals making the inspection or test
f. Identification of product and specification section
g. Complete inspection or test data
h. Test results and an interpretation of test results

i. Ambient conditions at the time of sample taking and testing
j. Comments or professional opinion on whether inspected or tested work complies with Contract Document requirements
k. Name and signature of inspector
l. Recommendations on retesting

Building Air Tightness Test Reports;

The Building Air Tightness Test analysis and report shall be submitted not later than 15 days after the test.

Thermography Test Reports;

The Thermography Test analysis and report shall be submitted not later than 15 days after the test.

1.5 ADMINISTRATIVE AND PROCEDURAL REQUIREMENTS

This section includes administrative and procedural requirements for accomplishing an airtight building enclosure that controls infiltration or exfiltration of air.

1. The airtight components of the building enclosure and the joints, junctures and transitions between materials, products, and assemblies forming the airtightness of the building enclosure are called "the air barrier system".
2. The Contractor is responsible for the coordination between the trades, the proper scheduling and sequencing of the work, preconstruction meetings, inspections, tests, and related actions including reports by independent inspection and testing agencies.
3. The Contractor shall ensure that the intent of constructing the building enclosure with a continuous air barrier system to control air leakage into or out of the conditioned space is achieved. The air barrier system shall have the following characteristics:
    a. It must be continuous with all joints sealed.
    b. It must be structurally supported to withstand positive and negative air pressures applied to the building enclosure.
    c. Connection shall be made between:
        i. Foundation and walls
        ii. Walls and windows
        iii. Walls and doors
        iv. Different wall systems
        v. Walls and roof
        vi. Walls and roof over unconditioned space

vii. Walls, floors, and roofs across construction, control, and expansion joints.

viii. Walls, floors, and roofs to utility, pipe and duct penetrations.

4. It is the Contractor's responsibility to ensure that all penetrations through the air/vapor barrier system, and all paths of air infiltration or exfiltration, are sealed airtight.
5. Inspection and testing services are required to verify compliance with requirements specified or indicated.
6. The Contractor is required to coordinate between subcontractors required to provide an airtight building enclosure, customized fabrication and installation procedures and the following:
    a. Continuity of the air/vapor barrier materials and products with joints to provide assemblies. Continuity of all the enclosure assemblies with joints and transition materials to provide a whole building air barrier system.
    b. Specific quality control requirements for individual construction activities are specified in the sections of the specifications. Requirements in those sections may also cover production of standard products. It is the Contractor's responsibility to ensure that each subcontractor is adequately and satisfactorily performing the quality assurance documentation, tests, and procedures required by each section.
    c. Specified inspections, tests, and related actions do not limit the Contractor's quality control procedures that facilitate compliance with Contract Document requirements.

1.6 THIRD PARTY BUILDING AIR TIGHTNESS TEST TECHNICIAN

1. Responsibilities
    a. Describe the test procedures, test apparatus, and analysis method.
    b. Perform the Building Air Tightness Test.
    c. Perform the Thermography Test.
    d. Participate in identifying deficiencies in the building construction utilizing smoke testing.
    e. Submit a report of each air tightness test whether successful or not.
    f. Submit a report of each thermography test identifying problem areas.

1.7 QUALITY CONTROL

1. On-Site Quality Control: The Installers are required to undertake quality control measures on a daily basis. They shall have completed air barrier training and shall utilize equipment to inspect and test the quality of their work.

2. Documentation and Reporting: Installers shall document the entire installation process on daily job site reports. These reports include information on the Installer, substrates, substrate preparation, products used, ambient and substrate temperature, the location of the air barrier installation, the results of the quality control procedures, and testing results. Every job site report is data based and reviewed by the Contractors Quality Assurance Manager.

1.8 CONTRACTOR RESPONSIBILITIES

1. Coordination of Sub-Contractor(s): The Contractor shall provide coordination between the Sub-Contractors involved in the construction of the air barrier system; coordinate the sequence of construction to ensure continuity of the air barrier system joints, junctures, and transitions between materials and assemblies of materials and products from substructure to walls to roof. The Contractor shall provide quality assurance procedures, testing and verification as specified herein. The Contractor shall facilitate inspections, tests, and other quality control services specified elsewhere in the Contract Documents and required by the Architect. These coordination efforts are critical to avoid costly removal and replacement of construction materials to accommodate inspections and tests. The cost of all tear out and rework shall be at the Contractors expense.
2. Pre-Construction Conferences: The Contractor shall organize pre-construction conferences between the sub-contractors involved in the construction of the air/vapor/water control systems to discuss where each sub-contractor begins and ends, the sequence of installation, and each sub-contractor's responsibility to ensure airtight joints, junctures, and transitions between materials, products, and assemblies of products specified in the different sections to be installed by the different sub-contractors.
3. Construction Mock-Up: The Contractor shall build a construction mock-up of every joint, juncture, and transition between materials, products, and assemblies of products specified in the different sections to be installed. Work will not begin until the mock-up is satisfactory to the Architect.

1.10 AIR/VAPOR BARRIER SYSTEM PERFORMANCE REQUIREMENTS

The air barrier system performance requirements shall comply with this section as follows:

1. Materials: materials used for the air barrier system in the opaque envelope shall have an air permeance not to exceed 0.004 cfm/sqft under a pressure differential of 0.3-inches water gage (1.57psf) (0.02L/s.m2@75Pa) when tested in accordance with ASTM E 2178.
2. Assemblies: assemblies of materials and components shall have an air permeance not to exceed 0.03 cfm/sqft under a pressure differential of 0.3-inches water gage(1.57psf)(0.15L/s.m2@75Pa) when tested in accordance with ASTM E 1677.

PART 2 PRODUCTS

2.1 AIR/VAPOR BARRIER MEMBRANE SYSTEM

1. Membrane

   Liquid applied, 40 mil thick, 100 percent rubber copolymer membrane.

2. Transition Strip

   Self-adhering SBS smooth surfaced 40 mil modified bitumen membrane with primer as recommended by the manufacturer.

3. Substrate Filler and Mastic

   As recommended by membrane manufacturer.

PART 3 EXECUTION

3.1 REPAIR AND PROTECTION

Repair and protection is the Contractor's responsibility, regardless of the assignment of responsibility for inspection, testing, or sample taking and similar services. Upon completion of inspection, testing, or sample taking and similar services, the Contractor shall repair damaged construction and restore substrates and finishes, protect construction exposed by or for quality control service activities, and protect repaired construction.

3.2 TESTING AND INSPECTION

The following qualitative and quantitative tests and inspections shall be conducted by the Contractor during installation of the air/vapor barrier system.

1. Qualitative Testing and Inspection:

   a. Ensure continuity of the air/vapor barrier system throughout the building enclosure and that all gaps are covered, the covering is structurally sound, and all penetrations are sealed allowing for no infiltration or exfiltration through the air barrier system.

   b. Ensure structural support of the air/vapor barrier system to withstand design air pressures.

   c. Ensure masonry and concrete surfaces are smooth, clean, and free of cavities, protrusions and mortar droppings, with mortar joints struck flush or as required by the manufacturer of the air barrier material.

   d. Ensure site conditions for application temperature and dryness of substrates are within guidelines.

   e. Ensure substrate surfaces are properly primed.

f. Ensure laps in materials are at least a 2-inch minimum, shingled in the correct direction or mastic applied on exposed edges with no fishmouths.

g. Ensure that mastic is applied on cut edges.

h. Ensure that a roller has been used to enhance adhesion.

i. Measure application thickness of liquid applied materials to manufacturer's specifications for the specific substrate.

j. Ensure that the correct materials are installed for compatibility.

k. Ensure proper transitions for change in direction and structural support at gaps.

l. Ensure proper connection between assemblies (membrane and sealants) for cleaning, preparation and priming of surfaces, structural support, integrity and continuity of seal.

2. Quantitative Tests:

a. Provide written test reports of all tests performed with a copy to the Commissioning Agent and Architect.

3.3 THIRD PARTY BUILDING AIR TIGHTNESS TEST

Test the building for air tightness. This test is intended to demonstrate that the building construction has produced an effective air barrier so that air infiltration and exfiltration are minimized. An adequate air barrier demands close attention to construction and installation of the building envelope components. For example, close attention must be paid to all seals, to caulking around window, door, and louver frames, to sealing of joints between panels, to sealing the wall-to-floor interface and especially to sealing the wall-to-roof interface.

a. The test shall be performed when the building envelope is enclosed and prior to the installation of the finished ceilings.

b. The contractor shall notify the Architect and BECxA at least 48 hours prior to the Building Air Tightness Test. A representative of the architect may witness the test and record test readings.

c. Prior to the test, the third party testing technician shall submit evidence that the test equipment has been calibrated within the past year.

d. The measuring instruments used in the tests shall be digital meters, not analog gages. Tests shall be performed when the wind speed is less than 10 mph, and no rain unless biases can be accounted for in the software and test procedures.

e. The fans used in the testing procedure shall have a minimum of 8,000 CFM capacity at 75 Pa pressure.

f. The following conditions and Building Air Tightness Test Procedures will be provided by the contractor before the testing:

i. All exterior doors and windows shall be closed with the exception of the mechanical room door to the outside which shall be open;

ii. All interior doorways including stairway doors shall be open with the exception of any mechanical room doors to the inside which shall be closed;

iii. All HVAC systems shall be de-energized;

iv. All appliances shall be de-energized;

v. All plumbing traps shall be full;

vi. The contractor shall follow the Recommended Test Envelope Conditions in ASTM E 1827, Table 1, for the Closed Envelope condition.

g. The third party testing technician shall first test the building by pressurizing the building positively relative to outdoors at multiple pressures up to at least 0.30 in.w.g. (inches water gauge). From the positive pressure test, the building leakage rate shall be measured in accordance with ASTM E 1827 or ASTM E 779.

h. The third party testing technician shall then perform a negative pressure test at multiple pressures up to at least 0.30 in.w.g. and compare the results to the positive test. Where differences of 10% exist between the tests, the contractor shall investigate the causes and resolve the reasons for the differences. The contractor shall retest the building.

i. The acceptable leakage in cubic feet per minute maximum at a differential pressure of 0.3 in. w.g. is as follows:

i. Main building excluding loading docks and maintenance areas: 0.25 cfm per s.f. of Building,

j. Use techniques described in ASTM E 1186 to locate the leak sources, then correct the significant deficiencies in the building construction, then retest. Fog/smoke agents used to identify leaks shall be the non-toxic type. Smoke generators shall have a minimum output capacity of 11,000 cubic feet per minute to reduce testing time.

k. For each test, the third party testing technician shall take a minimum of 5 readings at various pressures and air flows within the range of the calibrated equipment. In the test report, test points shall be shown in graphical form on a log-log scale with pressure in inches water column displayed on the horizontal axis and flow in cfm displayed on the vertical axis.

l. A report shall be submitted for each leak test whether successful or not.

3.4 THERMOGRAPHY TEST

The building envelope shall be tested using Infrared Thermography technology. The thermography testing shall be completed in accordance with the requirements of ASTM C 1060. The Commissioning Agent shall be notified two days in advance of the testing. The third party testing technician shall note any areas of compromise in the building envelope, and shall note all actions taken to correct those areas. The thermography shall be used to demonstrate the problem areas have been corrected.

3.5 TEST REPORTS

Submit all Building Air Tightness Test Reports and Thermography Test Reports to the Commissioning Agent.

END OF SECTION 07 27 00

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SECTION 22 08 00: COMMISSIONING OF PLUMBING

PART 1 GENERAL

1.1 SUMMARY:

A. Section includes

1. Commissioning of Plumbing Systems

1.2 ENVIRONMENTAL CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's environmental considerations and goals. These considerations and goals are to establish a facility which is environmentally responsible, profitable, and a healthy place to live and work. To guide this process, this project is pursuing LEED Certified level certification per the 2009 Green Building Design and Construction Reference Guide for New Construction. Compliance with all credits and prerequisites shown in the checklist attached to section 01 35 13 is required. All team members will be required to perform some amount of associated documentation. Refer to Sections listed below for environmental considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

1.3 RELATED REQUIREMENTS

A. Section 01 35 13 - LEED Requirements

B. Section 07 25 00 - Building Envelope Testing

C. Section 01 91 13 – General Commissioning Requirements

D. Section 01 79 00 - Commissioning Training Requirements

E. Section 01 92 10– Measurement & Verification

F. Section 23 08 00 – Commissioning of HVAC Systems

G. Section 26 08 00 – Commissioning of Electrical Systems

1.4 DEFINITIONS:

A. CxA: Commissioning Agent.

B. GC: Contractor; General Contractor, not a Subcontractor.

C. O&M: Operations and Maintenance.

1.5 DESCRIPTION

A. This section describes commissioning requirements applicable to commissioned items and systems specified in CSI Masterformat 2004 Edition Division 22 to ensure that all systems are operating in a manner consistent with the Contract Documents.

B. Conform to commissioning requirements and the commissioning plan.

1.6 RESPONSIBILITIES

A. General Requirements

1. Construction and Acceptance Phases

a. Include the cost of participating in commissioning in the contract price. Commissioned equipment is defined in section 01 91 13.

b. In each purchase order or subcontract written, include requirements for submittal data, completion of commissioning documentation, O&M data and training.

c. Attend and actively participate in a commissioning scope meeting and other meetings necessary to facilitate the Commissioning process.

d. Provide requested documentation to the CxA for development of the functional testing procedures.

e. Complete CxA furnished functional performance tests and procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection, and provide necessary written alarm limits to be used during the tests.

f. Complete a start-up and initial checkout plan, as required in the related section, using manufacturer's start-up procedures and the CxA furnished Prefunctional checklists for all commissioned equipment. Submit to GC for review prior to startup. CxA will verify plan for compliance. Refer to Section 01 91 13 for further details related to start-up.

g. During the startup and initial checkout process, execute the plumbing-related portions of the prefunctional checklists for all commissioned equipment.

h. Correct system deficiencies before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air-or water-related systems.

i. Perform and clearly document all completed startup and system operational

checkout procedures, providing a copy to the GC.

j. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments, and problem-solving.

k. Provide all test equipment necessary to fulfill specified testing requirements.

l. Perform functional performance testing under the direction of the CxA for specified equipment. Assist the CxA in interpreting the monitored data, as necessary.

m. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA and A/E, and retest the equipment.

n. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions. O&M's to be consistent with the final tested condition of all installed systems.

o. During construction, maintain as-built mark-ups for all drawings. Update as needed following functional testing. Furnish final copy to CxA for inclusion in final report.

p. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Operation Manuals shall include (need to coordinate with OPR requirements):

a. A table of all setpoints and implications when changing them.

b. Schedules.

c. Instructions for operation of each piece of equipment for emergencies.

d. Startup and shutdown procedures.

e. First year maintenance requirements.

3. Warranty Period

a. Participate in deferred functional performance testing, organized by the CxA, according to the specifications.

b. Correct deficiencies and make necessary adjustments to O&M Manuals and as-built drawings for applicable issues identified in any seasonal testing.

c. Participate in the 10-month post-occupancy walk-through, as required.

B. Plumbing Contractor: The commissioning responsibilities of the plumbing contractor, during construction and acceptance phases in addition to those listed in Paragraph A, above, are:

1. Participate in the Commission the plumbing systems listed in Section 01 91 13 and the Commission Plan.

2. Provide submittals as required by A/E and those listed on the pre-functional test sheets.

3. During the startup and initial checkout process, execute the plumbing-related portions of the pre-functional checklists for all commissioned equipment.

4. Provide all test equipment necessary to fulfill specified testing requirements (Testing per this section is a section requirement. Include all documentation and scheduling to the CxA).

5. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.

6. Prepare a preliminary schedule for pipe system testing, flushing and cleaning, and equipment start-up for use by the CxA. Update the schedule as appropriate.

7. Notify the GC when pipe system testing, flushing, cleaning, and startup of each piece of equipment will occur. Be responsible to notify the GC ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CxA has the scheduling information needed to efficiently execute the commissioning process.

8. Refer to Section 01 91 13 for specific details on non-conformance issues relating to pre-functional checklists and tests and for issues relating to functional performance tests.

9. The training shall consist of a review of the O&M manuals and hands-on training. Hands-on training shall include start-up, operation in all-modes possible, including manual, shut-down, and any emergency procedures and preventative maintenance for all pieces of equipment. The plumbing contractor shall fully explain and demonstrate the operation, function, and overrides of any local package controls, not controlled by the central control system. Training shall occur after functional testing is complete, unless approved otherwise by the GC. Contractor and vendor training will be as specified for the product or system. Training will be scheduled by the GC and monitored by the GC and CxA.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 STARTUP

A. The plumbing contractor shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 13. CSI Masterformat 2004 Edition Division 22 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the Commissioning Agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the GC. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.2 TRAINING OF OWNER PERSONNEL (need to coordinate with the training section of the specifications)

A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.

B. The GC shall be responsible for reviewing the content and adequacy of the training of Owner personnel for commissioned equipment or systems. CxA will verify compliance.

C. Mechanical and Plumbing Contractor: The mechanical and plumbing contractors shall have the following training responsibilities for their commissioned systems

1. Provide the GC with a training plan 4 weeks before the planned training.

2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of commissioned equipment.

3. Training shall start with classroom sessions followed by hands on training on each piece of equipment.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M Manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than 1 party may be required to execute the training.

6. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M Manuals for reference.

8. Training shall include

   a. Use the printed installation, operation, and maintenance instruction material included in the O&M Manuals.

   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.

   c. Discussion of relevant health and safety issues and concerns.

   d. Discussion of warranties and guarantees.

   e. Common troubleshooting problems and solutions.

   f. Explanation of information included in the O&M Manuals.

   g. Discussion of any peculiarities of equipment installation or operation.

   h. Classroom sessions shall include the use of overhead projections, slides, video/audio taped material as might be appropriate.

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and maintenance of all pieces of equipment.

10. Fully explain and demonstrate the operation, function, and overrides of any local packaged controls, not controlled by the central control system.

D. See additional training requirements in section 01 79 00.

END OF SECTION 22 08 00

SECTION 23 08 00: COMMISSIONING OF HVAC SYSTEMS

PART 1 GENERAL

1.1 SUMMARY:

A. Section includes

1. Commissioning HVAC Systems

2. Commissioning Building HVAC Systems Automation Controls

3. Commissioning Testing, Adjusting and Balancing (TAB)

1.2 ENVIRONMENTAL CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's environmental considerations and goals. These considerations and goals are to establish a facility which is environmentally responsible, profitable, and a healthy place to live and work. To guide this process, this project is pursuing LEED Certified level certification per the 2009 Green Building Design and Construction Reference Guide for New Construction. Compliance with all credits and prerequisites shown in the checklist attached to section 01 35 13 is required. All team members will be required to perform some amount of associated documentation. Refer to Sections listed below for environmental considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

1.3 RELATED REQUIREMENTS

A. Section 01 35 13 - LEED Requirements

B. Section 01 79 00 - Commissioning Training Requirements

C. Section 01 91 13 – General Commissioning Requirements

D. Section 01 92 00 – Measurement & Verification

E. Section 07 08 00 - Building Enclosure Commissioning

F. Section 07 27 00 - Air Barrier Requirements and Testing

G. Section 22 08 00 – Commissioning of Plumbing Systems

H. Section 26 08 00 – Commissioning of Electrical Systems

I. Other

1.4 DEFINITIONS:

A. CxA: Commissioning Agent.

B. GC: Contractor; General Contractor, not a Subcontractor.

C. O&M: operations and Maintenance.

1.5 DESCRIPTION

A. Conform to commissioning requirements and the commissioning plan.

1.6 RESPONSIBILITIES

A. Mechanical, Plumbing, Controls, and TAB Contractors: The commissioning responsibilities applicable to each of the mechanical, controls, and TAB contractors of CSI Master format Division 23 (all references apply to commissioned equipment only):

1. Construction and Acceptance Phases

a. Include the cost of participating in commissioning in the contract price. Commissioned equipment is defined in section 01 91 13.

b. In each purchase order or subcontract written, include requirements for submittal data, completion of commissioning documentation, O&M data and training.

c. Attend and actively participate in a commissioning scope meeting and other meetings necessary to facilitate the Commissioning process.

d. Provide requested documentation to the CxA for development of the functional testing procedures.

e. Complete CxA furnished functional performance tests and procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection, and provide necessary written alarm limits to be used during the tests.

f. Complete a start-up and initial checkout plan using manufacturer's start-up procedures and the CxA furnished Prefunctional checklists for all commissioned equipment. Submit to GC for review prior to startup. CxA will verify plan for compliance. Refer to Section 01 91 13 for further details related to start-up.

g. During the startup and initial checkout process, execute the mechanical-related portions of the prefunctional checklists for all commissioned equipment.

h. Correct system deficiencies before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air-or water-related systems.

i. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the GC.

j. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments, and problem-solving.

k. Provide all test equipment necessary to fulfill specified testing requirements.

l. Perform functional performance testing under the direction of the CxA for specified equipment. Assist the CxA in interpreting the monitored data, as necessary

m. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA and A/E, and retest the equipment.

n. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions. O&M's to be consistent with the final tested condition of all installed systems.

o. During construction, maintain as-built red-line mark-ups for all drawings. Update as needed following functional testing. Furnish final copy to CxA for inclusion in final report.

p. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Operation Manuals shall include:

a. A table of all setpoints and implications when changing them.

b. Schedules.

c. Instructions for operation of each piece of equipment for emergencies.

d. Startup and shutdown procedures.

e. Recommendations for re-commissioning frequency by equipment type.

3. Warranty Period

a. Participate in deferred functional performance testing, organized by the CxA, according to the specifications.

b. Correct deficiencies and make necessary adjustments to O&M Manuals and as-built drawings for applicable issues identified in any seasonal testing.

B. Mechanical Contractor: The commissioning responsibilities of the HVAC mechanical contractor, during construction and acceptance phases, in addition to those listed in Paragraph A, above, are:

1. Participate in the Commissioning of the mechanical systems listed in Section 01 91 13 and the Commissioning Plan.

2. Provide submittals as required by A/E and those listed on the Prefunctional checklist.

3. Provide startup for all HVAC equipment, except for the building automation control system. Clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.

4. Provide all test equipment necessary to fulfill specified testing requirements. Data Loggers and test equipment not specified in equipment or system sections excluded.

5. Assist and cooperate with the TAB contractor and CxA by:

   a. Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.

   b. Including cost of sheaves and belts that may be required by TAB.

   c. Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Providing an approved plug.

   d. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.

6. Install a P/T plug at water sensors which is an input point to the control system.

7. List and clearly identify on the as-built drawings the location of all air-flow stations (if applicable).

8. Prepare a preliminary schedule for CSI Masterformat Division 23 pipe and duct system testing, flushing and cleaning, equipment start-up, and TAB start and completion for use by the CxA. Update the schedule as appropriate.

9. Notify the GC when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment, and TAB will occur. Be responsible to notify the GC ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CxA has the scheduling information needed to efficiently execute the commissioning process.

10. Refer to Section 01 91 13 for specific details on non-conformance issues relating to prefunctional checklists and tests and for issues relating to functional performance tests.

11. The training shall consist of a review of the O&M manuals and hands-on training. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment. The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packages controls, not controlled by the central control system. Training shall occur after functional testing is complete, unless approved otherwise by the GC. Contractor and vendor training will be as specified for the product of system. Training will be scheduled by the GC and monitored by the GC and CxA.

C. Controls Contractor: The commissioning responsibilities of the controls contractor, during construction and acceptance phases in addition to those listed in Paragraph A, above, are:

1. Sequences of Operation Submittals: The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include

   a. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components, and function.

   b. All interactions and interlocks with other systems.

   c. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.

   d. Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).

   e. Start-up sequences.

   f. Warm-up mode sequences.

   g. Normal operating mode sequences.

   h. Unoccupied mode sequences.

   i. Shutdown sequences.

   j. Capacity control sequences and equipment staging.

   k. Temperature and pressure control: setbacks, setups, resets, etc.

l. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.

m. Effects of power or equipment failure with all standby component functions.

n. Sequences for all alarms and emergency shut downs.

o. Seasonal operational differences and recommendations.

p. Initial and recommended values for all adjustable settings, setpoints, and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.

q. Schedules, if known.

r. To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. For a given system, numbers shall not repeat for different sequence sections, unless the sections are numbered.

2. Control Drawings Submittal

a. The control drawings shall have a key to all abbreviations.

b. The control drawings shall contain graphic schematic depictions of the systems and each component.

c. The schematics shall include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment if primarily controlled by packaged or integral controls.

3. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M Manual submittal.

4. Assist and cooperate with TAB contractor in the following manner

a. Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB contractor any unique instruments needed for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).

b. For a given area, have all required prefunctional checklists, calibration, startup, and selected functional tests of the system completed prior to TAB.

c. Provide a qualified technician to operate the controls to assist the TAB contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.

5. Assist and cooperate with the CxA in the following manner.

   a. Using a skilled technician who is familiar with the installed systems in this building, execute the functional testing of the controls system. Assist in the functional testing of all equipment. Provide 2-way radios during the testing.

   b. Execute all control system trend logs.

6. Provide a signed and dated certification to the GC upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.

7. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control, and virtual points.

8. List and clearly identify on the as-built duct and piping drawings the locations of all monitoring and control sensors.

9. Provide all test equipment necessary to fulfill specified testing requirements.

D. TAB Contractor: The duties of the TAB contractor, in addition to those listed in Paragraph A, above, are

   1. Submit the outline of the TAB plan and approach for each system and component to the CxA, QC, and the controls contractor 6 weeks prior to starting the TAB. This plan shall be developed after the TAB has met with the GC and become familiar with the control system.

   2. The submitted plan shall include:

      a. Certification that the TAB contractor has reviewed the construction documents and the systems with the design engineers and contractors to sufficiently understand the design intent for each system.

      b. An explanation of the intended use of the building control system. The controls contractor shall comment on feasibility of the plan.

      c. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted, and balanced with the data cells to be gathered for each.

      d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.

      e. Final test report forms to be used.

      f. Submit NEBB or AABC procedural standards or provide detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration

(for each terminal type), diffuser proportioning, branch/sub-main proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using air flow straighteners or relocating flow stations and sensors shall be discussed. Provide the analogous explanations for the waterside.

g. List of all airflow, water flow, system capacity, and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.

h. Details of how total flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.). (Describe in Narrative and submit in final reports).

i. The identification and types of measurement instruments to be used and their most recent calibration date.

j. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.

k. Confirmation that TAB understands the outside air ventilation criteria under all conditions.

l. Details of whether and how minimum outside air cfm will be verified and set, and for what level (total building, zone, etc.).

m. Details of how building static and exhaust fan/relief damper capacity will be checked.

n. Details of methods for making any specified coil or other system plant capacity measurements.

o. Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.

p. Details regarding specified deferred or seasonal TAB work.

q. Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.

r. Details of any required interstitial cavity differential pressure measurements and calculations.

s. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).

t. Plan for formal progress reports (scope and frequency).

u. Plan for formal deficiency reports (scope, frequency, and distribution).

3. The TAB field technicians shall keep a running log of events and issues. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CA and GC at least twice a week.

4. Communicate in writing to the controls contractor all setpoint and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.

5. Provide a draft copy of the TAB report to the CxA within 2 weeks of completion. The report shall contain a full explanation of the methodology, assumptions, and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB, or ASHRAE Standard 111.

6. Provide the CxA with any updates as a result of A/E review.

7. Provide all test equipment necessary to fulfill specified testing requirements.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 STARTUP

A. The mechanical and controls contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 13. CSI Masterformat Division 23 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the Commissioning Agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the GC. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.2 OPERATIONS AND MAINTENACE (O&M) MANUALS

A. The following O&M Manual requirements do not replace O&M Manual documentation requirements elsewhere in these specifications.

B. Special Control System O&M Manual Requirements: In addition to documentation that

may be specified elsewhere, the controls contractor shall compile and organize at a minimum the following data on the control system in a labeled 3-ring binders with indexed tabs.

1. 3 copies of the controls training manuals in a separate manual from the O&M Manuals.

2. Operation and Maintenance Manuals containing

   a. Specific instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. These instructions shall be step-by-step. Indexes and clear tables of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included.

   b. Full as-built set of control drawings.

   c. Full as-built sequence of operations for each piece of equipment.

   d. Full print out of all schedules and set points after testing and acceptance of the system.

   e. Full as-built print out of any custom software programs.

   f. Electronic copy on disk of the entire program for this facility.

   g. Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.

   h. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.

   i. Control equipment component submittals, parts lists, etc.

   j. Warranty requirements.

   k. Copies of all checkout tests, other than commissioning tests, and calibrations performed by the Contractor.

3. Field checkout sheets and trend logs should be provided to the GC for inclusion in the on-site Commissioning filing system.

C. Special TAB Documentation requirements: The TAB contractor shall compile and submit the following with other documentation that may be specified elsewhere in the Specifications.

1. The TAB contractor shall mark on the drawings where all traverse and other critical measurements were taken and cross reference the location in the TAB report.

3.3 TRAINING OF OWNER PERSONNEL

A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.

B. The GC shall be responsible for reviewing the content and adequacy of the training of Owner personnel for commissioned equipment or systems. CxA will verify compliance.

C. Mechanical and Plumbing Contractor: The mechanical and plumbing contractors shall have the following training responsibilities for their commissioned systems

1. Provide the GC with a training plan 4 weeks before the planned training.

2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of commissioned equipment.

3. Training shall start with classroom sessions followed by hands on training on each piece of equipment.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M Manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than 1 party may be required to execute the training.

6. The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M Manuals for reference.

8. Training shall include

a. Use the printed installation, operation, and maintenance instruction material included in the O&M Manuals.

b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any

emergency procedures.

c. Discussion of relevant health and safety issues and concerns.

d. Discussion of warranties and guarantees.

e. Common troubleshooting problems and solutions.

f. Explanation of information included in the O&M Manuals.

g. Discussion of any peculiarities of equipment installation or operation.

h. Classroom sessions shall include the use of overhead projections, slides, video/audio taped material as might be appropriate.

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and maintenance of all pieces of equipment.

10. Fully explain and demonstrate the operation, function, and overrides of any local packaged controls, not controlled by the central control system.

11. Training shall occur after functional testing is complete, unless approved otherwise by the GC.

D. Controls Contractor: The controls contractor shall have the following training responsibilities for their commissioned systems

1. Provide the GC with a training plan 4 weeks before the planned training.

2. The controls contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.

3. Training manuals: The standard operating manual for the system and any special training manuals shall be provided for each trainee. In addition, copies of the system technical manual shall be demonstrated during training. Manuals shall include detailed description of the subject matter for each session. The manuals shall cover all control sequences and have a definitions section that fully describes all relevant words used in the manuals and in all software displays. Copies of audiovisuals shall be delivered to the Owner.

4. The training sessions shall be tailored to the needs and skill-level of the trainees.

5. The trainers shall be knowledgeable on the system and its use in buildings.

6. Provide 2 training sessions structured as follows:

a. Building Systems: The first session shall be held on-site and consist of two (2) 4-hour sessions of actual hands-on training after the completion of system

commissioning. The session shall include instruction on

1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.

2) Security levels, alarms, system start-up, shut-down, power outage, and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.

3) All trending and monitoring features (values, change of state, totalization, etc.) including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees shall actually set-up trends in the presence of the trainer.

4) Every screen shall be completely discussed, allowing time for questions.

5) Use of keypad or plug-in laptop computer via phone lines or networks.

6) Use of remote access to the system via phone lines or networks.

7) Setting up and changing an air terminal unit controller.

8) Graphics generation.

9) Point database entry and modifications.

10) Understanding DDC field panel operating programming (when applicable).

b. The second training will be conducted on-site 6 months after occupancy and will consist of 4 hours of training. The session shall be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.

E. The TAB contractor shall have the following training responsibilities

1. TAB shall meet for 2 hours with facility staff after completion of TAB and instruct them on the following

a. Go over the final TAB report, explaining the layout and meanings of each data type.

b. Discuss any outstanding deficient items in control, ducting, or design that

may affect the proper delivery of air or water.

c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans, and pumps that are close to or are not meeting their design capacity.

d. Discuss any temporary settings and steps to finalize them for any areas that are not finished.

e. Other salient information that may be useful for facility operations, relative to TAB.

F. See additional training information in section 01 79 00.

END OF SECTION 23 08 00

UNIVERSITY OF ARKANSAS

SECTION 26 08 00: COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

1. Commissioning Lighting Control Systems

1.2 ENVIRONMENTAL CONSIDERATIONS: This project is designed and constructed with practices and procedures to meet the project's environmental considerations and goals. These considerations and goals are to establish a facility which is environmentally responsible, profitable, and a healthy place to live and work. To guide this process, this project is pursuing LEED Certified level certification per the 2009 Green Building Design and Construction Reference Guide for New Construction. Compliance with all credits and prerequisites shown in the checklist attached to section 01 35 13 is required. All team members will be required to perform some amount of associated documentation. Refer to Sections listed below for environmental considerations and goals, and applicable paragraphs of this specification section. The Contractor shall ensure that the requirements related to these considerations and goals, as defined in the Contract Documents, are implemented to the fullest extent.

1.3 RELATED REQUIREMENTS

J. Section 01 35 13 - LEED Requirements

K. Section 01 79 00 - Commissioning Training Requirements

L. Section 01 91 13 – General Commissioning Requirements

M. Section 01 92 00 – Measurement & Verification

N. Section 07 08 00 - Building Enclosure Commissioning

O. Section 07 27 00 - Air Barrier Requirements and Testing

P. Section 22 08 00 – Commissioning of Plumbing Systems

Q. Section 23 08 00 – Commissioning of HVAC Systems

R. Other

1.1 DEFINITIONS

A. CxA: Commissioning Agent

B. GC: Contractor; General Contractor, not a Subcontractor

C. O&M: Operations and Maintenance

1.2 DESCRIPTION

A. This Section describes commissioning requirements applicable to commissioned items and systems specified in CSI Masterformat Division 26 to ensure that all systems are operating in a manner consistent with the Contract Documents.

B. Conform to commissioning requirements and the commissioning plan.

1.3 RESPONSIBILITIES

A. Construction and Acceptance Phases

1. Include the cost of commissioning in the contract price. Commissioned equipment is defined in section 01 91 13.

2. In each purchase order or subcontract written, include requirements for submittal data, O&M data and training.

3. Conduct a commissioning scoping meeting and other meetings necessary to facilitate the Commissioning process.

4. Provide requested documentation to the CxA, developed for functional testing procedures.

5. Assist in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

6. Provide functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

7. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists for all commissioned equipment. Submit to GC for review prior to startup. CxA will verify plan for compliance. Refer to Section 01 91 13 for further details related to start-up.

8. During the startup and initial checkout process, execute and document the electrical-related portions of the prefunctional checklists provided by the CxA for all commissioned equipment.

9. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the GC.

10. Address current A/E punch list items before functional testing. Systems shall be

completed with discrepancies and problems remedied before functional testing of the respective systems.

11. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

12. Provide all test equipment necessary to fulfill specified testing requirements.

13. Perform functional performance testing under the direction of the CxA for specified equipment. Assist the CxA in interpreting the monitoring data, as necessary.

14. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA and A/E, and retest the equipment.

15. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

16. During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line as-built drawings for all drawings and final as-builts for contractor-generated coordination drawings.

17. Provide training of the Owner's operating personnel as specified.

18. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

B. Operation Manuals shall include:

1. A table of all set-points and implications when changing them.

2. Schedules.

3. Instructions for operation of each piece of equipment for emergencies.

4. Startup and shutdown.

5. Recommendations for re-commissioning frequency by equipment type.

C. Warranty Period

1. Execute deferred functional performance testing, witnessed by the CxA, according to the specifications.

2. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

1.4 SUBMITTALS

A. Provide submittal documentation relative to commissioning as required in this Section, Section 01 91 13 and other specified requirements.

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.1 STARTUP

A. The electrical contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01 91 13. CSI Masterformat Division 26 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the Commissioning Agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems, or sub-systems at the discretion of the CxA and GC. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.2 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. See Section 01 91 13 for documentation requirements.

3.3 TRAINING OF OWNER PERSONNEL

A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.

B. The GC shall be responsible for reviewing the content and adequacy of the training of Owner personnel for commissioned equipment or systems. CxA will verify compliance.

C. Electrical Contractor. The electrical contractor shall have the following training responsibilities:

1. Provide the GC with a training plan four weeks before the planned training.

2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.

3. Training shall start with classroom sessions, if necessary, followed by hands on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, power failure, etc.

4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

6. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

7. Training shall include:

   a. Use the printed installation, operation and maintenance instruction material included in the O&M manuals.

   b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.

   c. Discussion of relevant health and safety issues and concerns.

   d. Discussion of warranties and guarantees.

   e. Common troubleshooting problems and solutions.

   f. Explanation of information included in the O&M manuals.

   g. Discussion of any peculiarities of equipment installation or operation.

   h. Classroom sessions shall include the use of overhead projections, slides, video and audio taped material as might be appropriate.

8. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and maintenance of all pieces of equipment.

9 Training shall occur after functional testing is complete, unless approved otherwise by the GC.

10. Minimum Duration of Training: The electrical contractor shall provide training on each piece of equipment according to the periods indicated in the individual CSI Masterformat Division 26. Provide a 4 hour training session to cover, As-builts,

O&M's, and systems installed.

D. See additional training information in section 01 79 00.

END OF SECTION 26 08 00

Typical M&V Plan Template

All items is *Red Italics* will require project-specific revisions.

Measurement & Verification Plan

LEED-2009

Overview

1.1 Project Background

The *UAF PROJECT NAME* has been designed and constructed according to LEED 2009 criteria. The project building is a new construction, *?????? SF, ???????? facility*.

For addition information about the project design, please reference the following:

- Owner's Project Requirements
- Mechanical Systems Narrative and Basis of Design

1.2 M&V Objectives

This Measurement and Verification (M&V) plan is based on Option D: Calibrated Simulation of the *International Performance Measurement & Verification Protocol (IPMVP) Volume III: Concepts and Options for Determining Energy Savings in New Construction, April, 2003.* The plan is intended to verify the cost savings associated with energy efficiency measures incorporated into the design, and to provide a recalibrated energy model that will serve as a tool for building operators in identifying and remedying causes of underperformance.

The plan describes the process and responsible parties for:

- Predicting energy use by end use in the project building
- Measuring energy use by end use in the project building
- Calculating actual cost savings
- Corrective action when underperformance occurs
- Calibration of Building Simulation Model

1.2 Baseline and Expected Energy Savings

Anticipated annual savings are based on energy modeling performed during the design process using *ENERGY MODELING SOFTWARE*, which showed a building-wide reduction in energy costs of *????%* compared to ASHRAE 90.1-*2007* efficiency levels. This projection was developed based on the Building Performance Rating Method in Appendix G of ASHRAE 90.1-*2007*.

1.3 M&V Plan Summary

Through the use of utility invoices, building automation system (BAS) permanently installed sub-metering and spot measurements, the facility's operations staff will work with the mechanical engineering design and commissioning firm to measure the actual utility usage of the building and key end uses for two years of post-occupancy consumption.

Collected data will be used to verify the predicted energy performance of energy conservation measures (ECMs) integrated into the design as part of the LEED effort.

Table 2: M&V Plan Summary

ECM	***Description***	***M&V Methods and Equipment***
Lighting	*Optimize activation using scheduling and occupancy sensors*	*Monitor lighting electricity usage through use of sub meters*
Exterior Lighting	*Optimize activation using scheduling through time clocks and photocell*	*Monitor lighting electricity usage through use of sub meters*
Space Heating	*Optimize activation using scheduling and remote thermostats*	*Monitor space heating electricity and gas usage through use of sub meters and BAS data logging.*
Space Cooling	*Optimize cooling through electronic thermostats CO2 sensors, and air flow measuring stations to minimize ventilation air*	*Monitor space cooling electricity usage through use of sub meters and BAS data logging.*
Water Heating	*Reduce hot water storage temperature*	*Monitor gas usage through sub meters*

1.4 Equipment Commissioning

Commissioning activities occurred in the project building for the following energy-related systems prior to occupancy.

- Heating
- Ventilation
- Air conditioning
- Refrigeration
- Lighting
- Domestic hot water
- Controls

Commissioning was performed by *CxA NAME HERE*, in accordance to LEED EA Prerequisite 1, Fundamental Commissioning of the Building Energy Systems. The Commissioning Report is included in the LEED Certification Application, and records of deficiencies and their remediation of kept by efficient. Throughout the M&V period, minor additional commissioning activities will be performed as necessary by the CxA and the building operations staff.

1.5 M&V Period

The M&V period is the timeframe during which monthly readings of energy consumption will occur. This period shall be at least two years in length, and is anticipated to commence approximately on *MONTH, DAY, 20??*.

1.6 Expected M&V Accuracy

Permanent metering equipment will have Utility Grade Metering Accuracy and meet ANSI National Accuracy Standards.

Within the M&V program, it is expected that data collected during the period will be highly accurate. Limitations of the modeling program are expected to be the greatest potential source of inaccuracy. Adherence to ASHRAE 90.1- *2007* Appendix G protocols will be used to minimize this potential. The project is setting a goal of *10% error (based on ASHRAE Guideline 14 MBE Method) in the calibrated energy models*.

1.7 Quality Assurance

The M&V strategy will be reviewed following the first month of implementation to ensure that procedures and processes are effective for capturing the required data. Monthly data recordings will be reviewed promptly for anomalous values that could signal data errors or underperforming equipment.

1.8 Budget and Resources

UAF PROJECT NAME is financially responsible for executing the M&V program costs. Materials and labor budgets are outlined below. These do not reflect soft costs associated with data recording on the part of operations staff.

Item	Budget
Submetering Equipment	*$15,000-$25,000*
M&V Labor	*$15,000*
Corrective Action	*As needed*

2.0 Data and Assumptions

2.1 Energy Rate Data

Electricity costs will be calculated using UAF campus utility rates for Fayetteville, AR.

Natural gas usage costs will be calculated using UAF campus utility rates for Fayetteville, AR.

2.1 Energy Savings Calculations

Energy savings will be determined by comparing measured energy use to the projected based on the following equation:

Energy Savings = Projected Baseline Energy Use – Measured Post-Construction Energy Use

Measured Post-Construction Energy Use is the energy use of the as-built facility. This is in accordance with the Method 2, Option D: Savings Estimation protocol in the IPMVP standard.

2.2 Reporting Requirements

The M&V report shall be provided to UAF within 45 days of the completion of the first and second years of M&V period. The owner or owner's representative shall then review the report with a subsequent 30 days. The report will include summaries of logged information for each ECM, log deviations from expected savings, provide recommendations for corrective actions and future savings, and record any significant O&M work performed on equipment associated with ECMs.

2.3 Responsible Parties

MECHANICAL / ENERGY ENGINEER NAME is the entity primarily responsible for the M&V Plan's development, coordination and implementation. The project owner and building operations staff will support implementation of the plan.

Table 3: M&V Responsibilities

M&V Activity	Responsible Party
Baseline energy model	Mechanical / Energy Engineer
Recalibrate baseline energy model to reflect as-built and post-occupancy conditions	Mechanical / Energy Engineer
Identification of ECMs for inclusion in the M&V plan	CxA / Mechanical / Energy Engineer
Development of M&V plan	Mechanical / Energy Engineer
Compilation of all occupancy, controls, BAS data, and scheduling information during the M&V period	UAF
Spot metering during M&V period	UAF
Installation of required sub-metering equipment	UAF
M&V Report	CxA / UAF
Corrective Action	UAF

3.0 Electricity M&V Plan

3.1 Electricity Baseline Simulation

IPMVP Option D has been selected for the M&V plan because a) the integrated design process yielded efficiency strategies intended to work in concert with each other, making isolation of ECMs inappropriate, and b) a computer simulation was used during the design phase to predict whole building energy usage. The computer simulation was performed using Energy Pro to demonstrate achievement with LEED-2009 EA Credit 1: Optimize Energy Performance. Model inputs are recorded in the LEED Certification Application materials. The Energy Pro energy model files have been supplied to UAF and are available for calibration.

The energy analysis used climatic data for DOE Climate Zone 4 which is proximate and climatically similar to Fayetteville, AR.

Building occupancy and operating schedules will be estimated by occupant interviews.

3.2 Electricity Baseline and Expected Usage Projections

The projected baseline is based on the minimum requirements of ASHRAE 90.1- *2007* for buildings with similar mechanical systems.

Projections reflect annual electricity consumption, and are summarized by end use in the table below.

Table 4: Baseline, Expected, and Actual Electricity Usage Projects by End Use

End Use	Baseline Annual Electricity (kWh)	Expected Annual Electricity (kWh)	Actual Annual Electricity (kWh)
Interior Lighting			
Exterior Lighting			
Space Heating			
Space Cooling			
Fans – Interior			
Plug Loads			

3.3 Post-Installation Equipment Monitoring

Following installation and before occupancy, commissioning activities were used to verify the proper fundamental operations of the building systems. Should a component of an ECM fail to work in the designed manner, maintenance will be performed to restore the equipment to its designed operation. Permanent and spot metering will be used to measure electrical

consumption. Operation staff will use metered trend data and spot checks to identify underperforming systems so that corrective action can be taken.

The method of metering will be through sealed electronic sub meters, these meters will record the electrical loads indicated within this plan. These meters are intended to validate the anticipated energy savings previously indicated in LEED EAc1 and as indicated below. Recalibration of the meters can be done by sending these meters back to the factory, contacts with these vendors have indicated that this is typically done every five years. The table below shows the metering strategy that will be used to monitor electrical loads.

Table 5: Electrical Metering Equipment

Meter	***Location***	***Metered Panels/Loads***	***Load Type***	***Loads***
E1	*ELECTRICAL ROOM 137 - MSB*	*PANEL SL*	*Electric - Exterior Lighting*	*OUTDOOR LIGHTING*
E2a	*ELECTRICAL ROOM 137 - MSB*	*PANEL EL-1*	*Electric - Interior LIGHTING*	*INTERIOR LIGHTING*
E2b	*ELECTRICAL ROOM 137 - MSB*	*PANEL WL-1*	*Electric - Interior LIGHTING*	*INTERIOR LIGHTING*
E2c	*ELECTRICAL ROOM 137 - MSB*	*PANEL AL-1*	*Electric - Interior LIGHTING*	*INTERIOR LIGHTING*
E3a	*ELECTRICAL ROOM 137 - MSB*	*PANEL EH-1*	*Electric - Space HVAC*	*ROOF TOP UNITS AND SPLIT SYSTEMS*
E3b	*ELECTRICAL ROOM 137 - MSB*	*PANEL WH-1*	*Electric - Space HVAC*	*ROOF TOP UNITS AND SPLIT SYSTEMS*
E3c	*ELECTRICAL ROOM 137 - MSB*	*PANEL PS*	*PV Panels*	*General*
E3d	*ELECTRICAL ROOM 137 - MSB*	*PANEL PS*	*PV Panels*	*General*
E4	*Virtual*	*Virtual*	*Plug/Misc*	*Subtract all sub meters from Main meter.*

The BAS includes data logging functions that will also be used to provide ongoing measurement and verification data pertaining to certain mechanical systems. BAS data will be used in conjunction with metered electricity to track equipment performance, identify underperforming systems. This data will also be used to assist the baseline energy model recalibration. The table below shows the metering strategy that will be used to monitor mechanical systems that use electricity.

Table 6: BAS Monitoring Summary – Electrical

Item	***Meter Type***	***Description/Intended Use***
ACU Fans	*Run Time*	*The BAS provides start/stop contacts and calculates run time to all constant load HVAC motors. Power consumption can be calculated from run time and power measured during balancing.*
ACU Cooling	*Run time and Cooling Load*	*The BAS provides start/stop contacts and calculates run time for each stage of cooling. Power consumption can be calculated from run time and power measured during balancing.*
ACU Heating (split systems with heat pump)	*Run time and heating load*	*The BAS provides start/stop contacts and calculates run time for each stage of heating. Power consumption can be calculated from run time and power measured during balancing.*

Please note that the exhaust fans run continuously (due to fire life safety codes); spot checking will occur on a monthly basis to validate energy usage. The usage of the fans is independent of the environment or guest room occupancy.

Building occupancy and operating schedules will be estimated by occupant interviews and Building Automation System data.

3.4 M&V Period Verification Activities-Process for Corrective Action

On a monthly basis, operations staff shall record the energy consumption of loads associated with ECMs. Also record any significant O&M activities performed on the systems during that time period, including any associated costs. At the end of the two-year M&V period, summarize the electrical consumption data for comparison with the recalibrated baseline and expected

consumption. The metered equipment shall be inspected at the conclusion of the M&V period and as needed to verify proper operation. All collected information and comparison results will be included in the M&V report.

All efforts will be made to prevent the omission or loss of metered data. In the event that data is missing or lost, existing data from before and after the missing portion will be used to extrapolate if appropriate. Extension of the M&V period is also an option for mitigating the effect of lost data.

Table 7: Electrical Monthly Consumption Reporting Form

Measurements Recorded By:			
Date of Measurements:			
Occupancy Levels:			
Meter	***Location***	***Electric Consumption (kWh)***	***O&M Activities / Costs / Comments***
E1	*ELECTRICAL ROOM 137 - MSB*		
E2a	*ELECTRICAL ROOM 137 - MSB*		
E2b	*ELECTRICAL ROOM 137 - MSB*		
E2c	*ELECTRICAL ROOM 137 - MSB*		
E3a	*ELECTRICAL ROOM 137 - MSB*		
E3b	*ELECTRICAL ROOM 137 - MSB*		
E3c	*ELECTRICAL ROOM 137 - MSB*		
E3d	*ELECTRICAL ROOM 137 - MSB*		
E4	*Virtual*		

4.0 Natural Gas M&V Plan

4.1 Natural Gas Baseline Simulation

IPMVP Option D has been selected for the M&V plan because a) the integrated design process yielded efficiency strategies intended to work in concert with each other, making isolation of ECMs inappropriate, and b) a computer simulation was used during the design phase to predict whole building energy usage. The computer simulation was performed using *ENERGY MODELING SOFTWARE* to demonstrate achievement with LEED-2009v3 EA Credit 1: Optimize Energy Performance. Model inputs are recorded in the LEED Certification Application materials.

The energy analysis used climatic data for DOE Climate Zone 4 which is proximate and climatically similar to Fayetteville, AR.

Building occupancy during the M&V period will be tracked based on occupancy schedules.

4.2 Natural Gas Baseline and Expected Usage Projections

The projected baseline is based on the minimum requirements of ASHRAE 90.1- *2007* for buildings with similar mechanical systems.

Projections reflect annual natural gas consumption, and are summarized by end use in the table below.

Table 8: Baseline, Expected, and Actual Energy Usage Projects by End Use

End Use	Baseline Annual Natural Gas (kBtu)	Expected Annual Natural Gas (kBtu)	Actual Annual Natural Gas (kBtu)
Space Heating			
Space Cooling			
Lighting			
Fans			
Service Water Heating – Domestic			
Plug Loads			

4.3 Post-Installation Equipment Monitoring

Following installation and before occupancy, commissioning activities were used to verify the proper fundamental operations of the building systems. Should a component of an ECM fail to work in the design manner, maintenance will be performed to restore the equipment to its designed operation. Permanent and spot metering will be used to measure electrical consumption. Operation staff will use metered trend data and spot checks to identify underperforming systems so that corrective action can be taken.

Gas meters will be turbine style. Recalibration of the meters can be done by sending these meters back to the factory, contacts with these vendors have indicated that this is typically done every five years. The table below shows the metering strategy that will be used to monitor natural gas loads.

Table 9: Natural Gas Metering Equipment

Meter	***Location***	***Metered Loads***	***Load Type***	***Loads***
G1	*Roof Top Equipment*	*ACU-1thru 28; RH-1 thru 4: Space Heating*	*Gas*	*Roof Top Equipment and Radiant Heaters*
G2	*Mechanical Room*	*Service Water Heating - Domestic*	*Gas*	*Hot Water and Dryer*

The BAS includes data logging functions that will also be used to provide ongoing measurement and verification data pertaining to certain mechanical systems. BAS data will be used in conjunction with metered electricity to track equipment performance, identify underperforming systems. This data will also be used to assist the baseline energy model recalibration. The table below shows the metering strategy that will be used to monitor mechanical systems that use natural gas.

Table 10: BAS Monitoring Summary – Gas

Item	***Meter Type***	***Description/Intended Use***
G1	*Building gas load -Gas flow meter*	*Overall building gas load is continuously metered by the BAS via the gas meter.*
G2	*ACU-Heating Load Relay*	*Status of gas valve for each ACU is monitored by the BAS (All Stages).*
G3	*Radiant Heating Load Relay*	*Status of gas valve for each RH is monitored by the BAS.*

Building occupancy and operating schedules will be estimated by occupant interviews and Building Automation System data.

4.4 M&V Period Verification Activities

On a monthly basis, operations staff shall record the energy consumption of loads associated with ECMs. Also record any significant O&M activities performed on the systems during that time period, including any associated costs. At the end of the two-year M&V period, summarize the natural gas consumption data for comparison with the recalibrated baseline and expected consumption. The metered equipment shall be inspected at the conclusion of the M&V period and as needed to verify proper operation. All collected information and comparison results will be included in the M&V report.

All efforts will be made to prevent the omission or loss of metered data. In the event that data is missing or lost, existing data from before and after the missing portion will be used to extrapolate if appropriate. Extension of the M&V period is also an option for mitigating the effect of lost data.

Table 11: Natural Gas Monthly Consumption Reporting Form

Measurements Recorded By:			
Date of Measurements:			
Occupancy Levels:			
Meter	**Location**	**Natural Gas Consumption (kBta)**	**O&M Activities / Costs / Comments**
G1			
G2			

5.0 M&V Calibration of Building Energy Model

Based on Method 2 from IMVP Volume III (2003)

At the end of the first full year of operation the building energy model will be calibrated using the following steps:

- Obtain actual historical weather data for the M&V period and input into the building energy model.

- Adjust inputs and parameters in the model to reflect the actual conditions of operation. The comparison should include the following calibration parameters from the building sub meters and Building Automation System:

    - *Actual building operating schedules.*
    - *Gas usage to HVAC equipment.*
    - *Gas usage to Domestic water equipment.*
    - *Gas usage to all other loads.*
    - *Electric usage to interior lighting.*
    - *Electric usage to exterior lighting.*
    - *Electric usage to HVAC.*
    - *Electric usage to plug and miscellaneous load circuits.*
    - *Fan energy for each ACU.*
    - *Fan energy for each exhaust fan.*
    - *Cooling energy for each ACU.*
    - *Heating energy for each ACU.*
    - *Space actual temperatures.*
    - *ACU discharge air temperatures.*
    - *Radiant heater energy.*

- Adjust and reconcile the As-built model to within 5% of the actual utility bills.

- Rerun the baseline model with adjustments. These results will be compared to the utility meter readings to obtain the actual savings.

UNIVERSITY OF ARKANSAS

Commissioning Standards Meeting Notes

Attendance: Bob Beeler, Scott Turley – UAF; Tim Staley, Steve Williams, Jay Holstead – CSUSA Energy Services; Chris Ladner – Viridian; Jason Whittaker - TLC (via phone).

May 25, 2011

OPR Requirements

1. Supplemental to the planning document and issued as a separate document.
2. Cx agent to coordinate separate OPR meeting.
3. Clearly stated energy goals for the project.
4. Ownership of energy model to be retained by UAF. Needs to be stated in OPR.
5. Specifically listed requirements for building dashboards.
6. Require M&V plan to be developed on the project by the design firm.
7. Require M&V plan to address LEED Silver requirements.
8. Include standard M&V plan components and overall approach in the OPR document.
9. A standard or sample M&V template should be included in the OPR document.
10. OPR should state requirement for contractor to provide information necessary for CMMS.
11. OPR needs to state requirement for GC to provide a disk of all RFI, ASI, change order logs, and addenda as a standard delivery to UAF.
12. Any OPR requirements regarding BIM need to be discussed further.
13. Some form of building envelope commissioning to be included in all major projects.

Action Items

1. Bob Beeler to schedule follow-up meeting to discuss OPR standardization.
2. Chris Ladner to draft a paragraph for design firm contract requiring commissioning (Cx) firm to review energy model.
3. Tim Staley to contact TME about using the Vol Walker M&V Plan as a standard OPR template.
4. Scott Turley to distribute a list of standard forms and information to be provided for CMMS at the end of the project.

Notes

1. OPR developed in parallel with Planning Document. Design intent responds to programming document and OPR document.

2. Cx agent needs to coordinate a separate OPR meeting (separate from planning meetings) to be led by Cx agent.
3. Table discussion and action item for including requirement of Cx review of energy model in design firm professional services contract. Chris will draft paragraph and route for review.
4. Good discussion of when Cx plan needs to be issued. Scope will continue to include the issuance of a preliminary commissioning plan during the design phase.
5. UAF believes they should own the energy model for future data comparison. Needs to be addressed in OPR.
6. Building dashboards will show consumption by utility, by month. Will have capability to break out by system components (lighting, heating, cooling, etc.).
7. Have had trouble breaking out plug loads vs. lighting loads. Other systems have been easier to segregate.
8. M&V plan needs to be developed to meet LEED Silver requirements.
9. Include M&V plan major components and approach in the OPR document.
10. LEED M&V requirements: Lighting (exterior and interior), plug loads, HVAC, renewable energy, and domestic heating water.
11. M&V template should be referenced in the OPR document.
12. TME to issue IDS based M&V plan on Vol Walker. CSUSA will distribute to team for review and comment in hopes of developing a largely standard document.
13. Bobby Harris has recently scheduled a FAMA design review meeting to compile a consensus set of review comments from FAMA. This meeting needs to include Cx.
14. Cx plan and specifications need to require contractor to provide data for CMMS system (completion of standard forms). Scott will distribute sample forms and list of equipment for which information is to be provided.
15. Bob has no objection to contractor providing video services for the training. Training is to be coordinated by Cx agent.
16. Pre and post testing of UAF operational staff should be required for more complicated projects, not for every project.
17. There is consensus that a more creative approach to training is required to increase effectiveness.
18. There is consensus that some standard language regarding training needs to be included in the OPR document.
19. Scott indicated a desire to get approved submittals earlier in the construction process. OK to receive information in a piecemeal fashion, but a complete comprehensive set still needs to be delivered at the end of the project.
20. GC should be expected to provide a disk of all RFI, ASI, change order logs, and addenda as a standard delivery to UAF.
21. UAF now has ability to access BIM models. They have purchased all the required software.
22. Need to coordinate some additional discussion as to what a complete BIM model looks like.
23. Updated energy model also needs to be added to design firm professional services contract.

24. Need to include the GC in the final meeting when you review any open commissioning issues with the Owner. Could have an impact on retainage payment.
25. Mike Johnson emphasizes the importance and value of building envelope commissioning.
26. The expectations regarding building envelope commissioning and total commissioning budget on the project need to be reconciled. All agree some level of effort is required for OPR, infiltration specifications, design review, and construction review. Additional discussion and timing needed for testing requirements.
27. Bob Beeler to schedule a follow up meeting to discuss OPR standardization.

UNIVERSITY OF ARKANSAS

Commissioning Standards Meeting Notes

Attendance: Bob Beeler, Scott Turley – UAF; Tim Staley, Steve Williams, Jay Holstead – CSUSA Energy Services; Chris Ladner – Viridian; Dave Horton - TLC.

June 14, 2011

1. Review UAF commissioning standard documentation with Mike Johnson. Bob Beeler will coordinate the meeting.
2. Review UAF commissioning standard documentation with Construction Coordinators. Bob Beeler to coordinate meeting.
3. UAF is committed to commissioning, does not matter if it is a LEED requirement or not.
4. Jay Honeycutt handles all contracts with design firms.
5. Is there going to be requirement for a standard energy model software at UAF? ESG has developed EQuest models for a number of buildings as well as Dr. Nutter in his efforts.
6. OPR document needs to encourage, emphasize a strong preference by UAF for the use of EQuest as a standard energy modeling software.
7. OPR and contract for design firm needs to require the design engineer to update the energy model at the end of the project.
8. Design firm will require submittal of energy model by design engineer at end of design phase and end of construction phase.
9. Commissioning agent will be responsible for calibrating the energy model and checking results at the end of the warranty period.
10. Calibration effort of energy model will need to be coordinated with the campus energy engineer.
11. Calibration and model verification becomes part of the corrective plan of action (if needed) as required by Act 1494.
12. Do contractors need to install the equipment tags? The FAMIS tag number is different than the project tag number. The project tag number is a “dumb” number with no content associated.
13. Internally, UAF needs to decide to what level equipment will get tagged. Electrically, all secondary panels. They do not typically get light fixtures, VAV terminals, fan coils, etc. Focus needs to be on what will receive a PM.
14. For equipment that is not requiring PM, Cx agent can provide a generic list of the type of equipment that is in the building.
15. Dave Horton will provide standard spreadsheet for simplistic listing of building equipment and systems reference for the team to review.
16. OPR to require the Cx agent to facilitate the provision of equipment and system data for UAF FAMIS software.

17. Cx workgroup team to review TLC spreadsheet and comment.
18. Cx workgroup team to continue dialog on this issue and further evolve the OPR over time.
19. Scott Turley will work to define more details of UAF specific needs regarding FAMIS data entry.
20. OPR shall include a requirement for a design intent document that as a minimum meets the requirements defined by LEED EA prerequisites and credits.
21. Ideas for skeleton documents was brought up and discussed. This effort will be deferred until the next phase of commissioning discussion. For now, we will focus on OPR content and requirements, not skeletal documents.
22. Once UAF Cx standards and OPR standard is flushed out, we need to have a review/training session with the Project Coordinators.
23. Construction Coordinator will be the single point of signature/approval for the Cx agent. Construction Coordinator will coordinate with user group on approval of OPR changes.
24. Additional OPR requirements:
    a. Need to include specific details for training program, as a minimum require video recording. Needs to include construction tours with maintenance staff to be coordinated by Cx agent. Needs to address some follow up training requirements during the warranty period.
    b. Need to require a construction close out meeting to review commissioning items that are still open and assign responsibilities. This needs to be formally required by OPR and design documents. User group owner representatives need to be present.
    c. Need to require a warranty period follow up with commissioning agent and other team members.
25. Standard OPR Outline:
    a. OPR Version History and Sign Off
        A. Version Number
        B. Date
        C. Initial Approval Signatures: Cx Agent, Designer, Construction Coordinator, and user group representative(s), and GC.
    b. OPR Overview
    c. General Project Information
        A. Name
        B. Budget
        C. Project Schedule
        D. Team Charter
        E. Team List and Contact Information
    d. Energy and Sustainability Goals
        A. LEED/Green Globes Requirements
            1. LEED Silver / Two Green Globes

B. Energy Efficiency Goals
   1. Minimum of 10% below ASHRAE 90.1-2007
   2. Target 20% below ASHRAE 90.1 – 2007
   3. Timing of energy model input into design

C. Economic Considerations
   1. Energy modeling assumptions
   2. Life Cycle Cost based decision
      a. Requires minimum lifecycle term of 50 years.
      b. Items to consider
         i. Utility escalation rates
         ii. Term
         iii. Cost of money (Discount Rate)

D. Sustainability Dashboard Requirements
   1. Meters
   2. Interval Data
   3. Monthly Data

E. M&V Requirements
   1. Design Engineer develops plan (reference attached template)
   2. Design Engineer develops as-built energy model
   3. Minimum compliance with LEED EA Credit 5
   4. Separately meter building heating and cooling loads

e. Project Specific Requirements

A. Occupancy Information

B. Occupancy Schedules

C. Building Envelope Performance
   1. Component review
   2. Air barrier review
   3. Moisture control review
   4. Positive pressure buildings
   5. Building envelope testing

D. IEQ Requirements
   1. Temperature
   2. Humidity
   3. Prefer non-operable windows
   4. Demand controlled ventilation

5. CO_2 monitoring
6. MERV 13 filtering requirements
7. Glare control/shading
8. Building flush out/testing

E. Lighting
1. Occupancy sensor in common and public areas
2. Interlock occupancy sensors with HVAC
3. Exterior lighting controls
    a. Centralized photo sensor control
    b. EMCS monitoring
4. Preference for T8 lighting
5. Day-lighting controls
6. Preference for generator backup power

F. Technical Requirements
1. Equipment/vendor preferences (reference IDIQ listing)
2. Prefer not to have roof top equipment, piping, and ductwork
3. Consult UAF Design Guide (coming soon)

G. Exceptional Codes and Standards
1. IDIQ Requirements
2. Act 1494 Compliance
3. LEED Rating System

f. Operations and Maintenance Requirements

A. O&M Organizational Chart
B. MEP Space Requirements (8% minimum of gross square footage)
C. Custodial Space Requirements
D. Construction period tours for maintenance personnel
E. Final O&M walk through coordinated by Cx at substantial completion

g. Training and Documentation

(italics show requirements for hard copy)

A. As-built energy model required
B. As-built BIM Model
C. Video recording by GC, verified by Cx
D. Systems manual content
1. *As-built drawings*
2. *Comprehensive submittals (product specific, not generic manuals)*

3. ASIs
4. RFIs
5. Addenda
6. Change Orders
7. *TAB Report*
8. *Commissioning Report*
9. *Warranty documentation*

E. CMMS Information by GC

F. Building Energy Plan from designer

h. Post Construction Requirements

A. Close out meeting

B. M&V Requirements

1. One month data review
2. Quarterly data review
3. 1st year report

C. Thermal comfort survey

D. Seasonal Commissioning

E. 10-month warranty review

i. Appendix

A. Team Charter

B. M&V Plan template

UNIVERSITY OF ARKANSAS

Commissioning Standards Meeting Notes

Attendance: Bob Beeler, Rick Gragg, Kevin Shackleford, James Ezell, Scott Turley, Wayne – UAF; Tim Staley, Steve Williams, Jay Holstead – CSUSA Energy Services; Chris Ladner, Rick Vance, Corey Keen – Viridian; Todd Kuhn, Mike Sanders – Cromwell Architects | Engineers; Ryan McClain, Shane Lanning – Pinnacle Energy Services

August 6, 2012

1. We are meeting to ensure everyone is on the same page, doing the right thing, and continuity.
2. Smoke removal systems should be a required system to be commissioned.
3. Bob considers the entire list as required. The issues are wants versus needs.
4. The commissioning agent needs to address, as a matter of course, all items on the list.
5. Add electrical generation to the list.
6. Need to add asterisk to lighting control systems.
7. Need to add smoke removal/ejector systems (if applicable) to the required list.
8. We need to delete others from the list.
9. We need to add A/V to the list.
10. Killian is the new A/V provider out of Springfield.
11. At the end of the day, this commissioning group is absolutely responsible for the commissioning of the building envelope enclosure.
12. NIBS guideline has been further developed since last meeting.
13. General approach is commissioning agent is responsible for envelope commissioning and specifying the testing to be completed by outside testing agency to work for the contractor.
14. Building Envelop Approach and Scope of Work:
    a. Standard approach is the design documents will include a building envelope testing specification to be contracted and managed by GC.
    b. Commissioning authority will provide design phase and construction phase building envelope commissioning activities that will include the witness of building envelop testing.
    c. Included components: vapor barrier, thermal barrier, moisture/water vapor
    d. Design phase design review for constructability and sequencing.
    e. Pre-construction coordination meeting.
    f. Site observation.
    g. Testing of specifications and performance.

i. Air pressure testing

ii. Water testing

h. Chris to develop and publish a standard building envelope testing specification to distribute to the group for review and comment.

15. Johnson Controls is the IDIQ controls provider.
16. Trane is the current IDIQ provider for fan coil units.
17. Bob Beeler to provide a current IDIQ list.
18. Commissioning scope for ancillary systems:
    a. Construction site observation
    b. Interaction with commissioned systems
    c. Verification of testing
    d. Verification of training
    e. Verification of close out documentation.
19. Alternate delivery method is the preferred method of contracting at UAF.
    a. Typically starts with a partnering session in the morning for half a day.
    b. In the afternoon go into early programming session.
    c. Then move into the OPR.
    d. Basis of design document should be developed in response to the OPR.
20. Bob to require the schematic design deliverable for the design firms to include BOD document. The schematic design presentation should include the OPR, the BOD, and they all sign off on the OPR at the meeting.
21. Rick Gragg indicated that the standard energy dashboards are not developed yet, but they are coming. This should hopefully address the issues associated with Act 1494.
22. If the project will pursue LEED M&V, then additional discussion will be required for the project as part of the OPR process.
23. Standard commissioning deliverable is the commissioning agent will provide confirmation of 10% below the 90.1 2007 baseline. This needs to be in the standard scope of work.
24. Commissioning agent is no longer responsible for calibrating the energy model. This corrects item #9 on the June 14, 2011 meeting notes.
25. Commissioning major deliverables are typically handled through the listserv. UAF has adopted Submittal Exchange for documenting activity on the project. The Submittal Exchange will be the standard practice going forward. Alternatively, if the GC has standard software they use, the project will use the GC software package.
26. Design review comments, site observation reports, and issues logs need to be organized in an orderly manner and published to the appropriate team members during construction to help protect the contractor relationship. The final list of items needs to be included in the final commissioning report for archival purposes.
27. A formal submittal review process is included in all projects. This will comply with LEED enhanced commissioning.

28. Todd Kuhn to put together a design feedback form for designers to use as a means of responding to commissioning submittal review comments.
29. Construction coordinator has been coordinating construction site tours. This needs to change to Rick Gragg. Future construction site tours need to be coordinated with Rick Gragg. Rick will handle coordination with construction group and zone maintenance coordinator.
30. Commissioning authority should be responsible for reaching out to utilities and zone maintenance and requesting their presence for a construction period tour.
31. Rick would also like to observe the functional performance tests on projects. Commissioning authority to make the request, but it is harder for personnel to attend. They will make every effort to observe for a couple of hours for each system.
32. Close out package needs to include a video or DVD of training.
33. Rick indicated that large formal training can be congested and is not effective. Sometimes JCI training is not effective. He has a small group of 3 or 4 people that need real time interacting with the JCI personnel.
34. Some additional discussion needs to occur during construction tours and after design on the exact level of training needed for the utilities group.
35. Zone maintenance personnel need to see where equipment is located and the maintenance requirements for on-going maintenance.
36. Design intent training is needed to ensure that the designer, commissioning agent, and operations personnel are all on the same page in terms of the intent for the building and systems. Design intent training is required.
37. Bob likes the interactive CD approach for close out documentation. The electronic media needs to include:
    a. OPR
    b. BOD
    c. Cx report
    d. Warranties
    e. Training videos
    f. Current issues log and outstanding issues.
    g. Blank commissioning forms to support on-going commissioning.
    h. FAMIS data that is included in the PFCs.
    i. O&M manuals
    j. Reference list on notes from 05/25/12.
    k. Need to include a list of first year maintenance requirements to the list.
38. Commissioning agent needs to be included in the 10-month inspection prior to warranty expiration. The construction coordinator is charged with coordinating these walk through.
39. Bob would also like the commissioning agents to track the timing of when the 10-month inspections are needed and remind UAF when possible to make sure they occur.

40. Tim to update the commissioning standards document and send to the commissioning providers for review and comment.
41. Chris will send out a general specification and section 07 building commissioning section for review by the commissioning team.
42. Viridian will send out the section specific commissioning specifications for review and approval by the commissioning team. Once reviewed, they will be accepted as the commissioning specification standard for UAF.
43. The UAF standard for commissioning specifications is that the commissioning agent will produce the commissioning specifications and the design team will review and incorporate into the project manual.
44. Bob would like to have some schedule of values in the commissioning proposal that breaks down the different levels of service. This will allow Bob to reduce the fee as needed when he faces budget constraints.
45. Bob is good with a fixed fee approach. He has no objection to this approach.
46. Bob desires to get together once per year with the commissioning agents for a similar discussion.