

## R. Energy and Commissioning

### Energy Conservation – Mechanical Requirements

1. All new mechanical systems shall be designed to conserve energy and shall conform to the University of Chicago's Energy Policy Guidelines. Forms of energy recovery or conservation shall be investigated to maximize energy efficiency on each project.
2. Proposed systems shall meet or exceed the requirements set forth in the City of Chicago's Energy Conservation Code.
3. Proposed systems shall have life cycle and energy cost analysis comparison. Base systems shall be a VAV Air Handling System as described in ASHRAE 90.1. Analysis shall be submitted to the University at the SD, DD and CD project phases.
4. All air conditioning systems shall have full economizer cycles.
5. Night set back schedules for space unoccupied times shall be incorporated into design.
6. Demand control ventilation shall be incorporated unless specifically demonstrated not to be feasible.
7. Design systems for spaces that need 24 hours per day operations separate from spaces that can utilize night set back. Example, data centers shall be design separate from the building HVAC system.
8. All incoming utilities shall be metered. Refer to Building Automation Standards for metering requirements.
9. Perform energy modeling at each phase of the design to include building activities and operation hours for use in setting up building utility budget.
10. Establish energy use benchmark such as btu/SF/year and compare with similar buildings on campus and elsewhere.

### Commissioning Standard for Capital Projects

#### **Program Overview:**

The commissioning process is a quality-oriented process for achieving, verifying and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria. The fundamental benefits of the commissioning process are:

- Reduction of change orders and additional claims
- Fewer project delays
- Managed start-up requirements
- Quicker and more effective building turn-over to operations
- Less post-occupancy corrective work and vendor/contractor call backs
- Minimized effects from design changes
- Improved indoor air quality and reduction of occupant/client complaints
- Better operation, maintenance and reliability
- Lower energy and operational costs

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

- Complete and useful system documentation and O&M manuals
- Fully trained operations staff

Although the commissioning process requires an investment of time and money in the early stages of planning, a study conducted by the Lawrence Berkley Laboratories recently estimated the average payback period of commissioning new buildings to be 4.8 years. With the University owning and operating a majority of its buildings over 40 years, this offers a significant savings opportunity over time. In addition, commissioning can lessen the risks to critical operations and occupant safety and health by verifying proper installation and operations of systems such as emergency power, life safety systems, and elevators.

The commissioning process will be utilized on all university projects involving major mechanical, electrical or plumbing (MEP) work. For smaller projects the scope may be tailored to an individual project's needs. The University Project Manager (PM) shall engage the University Commissioning Manager during the planning phase of a project to determine the adequate scope for commissioning for each project. The PM shall consult with the Capital Projects Director to determine if non-MEP portions of the work should be commissioned.

It is the goal of the University that projects with a construction value equal to or exceeding \$5 million will pursue LEED® Silver certification. This standard meets and exceeds the requirements established in LEED® NC v2009 EA prerequisite 1 “Fundamental Commissioning” as well as EA credit 3 “Enhanced Commissioning” and also incorporates many aspects of the BCA, ACG and ASHRAE guidelines.

The Building Systems and Equipment to be commissioned includes but is not limited to the following:

- Mechanical Systems
  - Heating, ventilating, and air conditioning systems, with all mechanical equipment forming a part of these systems (including, but not limited to piping, air handler units, fan coil units, exhaust fans, variable frequency drives, ductwork, etc.)
  - Building chilled water systems, and all equipment forming a part of these systems (including, but not limited to piping, chillers, cooling towers, pumps, etc.)
  - Heating hot water systems (including PRV stations, heat exchangers, pumps, etc.)
  - Fuel pumping systems
  - Smoke exhaust and evacuation systems
  - Air curtains
  - Geothermal systems
  - Vertical transport
  - Air compressors
- Plumbing Systems

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

- Domestic water systems
  - Natural gas systems
  - Water treatment systems
  - Landscape irrigation Systems
  - Lab gas system
  - Sump pumps and ejector pumps
  - Thermostatic mixing valves (sampling may be deemed acceptable)
  - Fixtures (sampling may be deemed acceptable)
  - Acid neutralization
- Electrical Power Systems
  - Electrical supply and distribution systems including common and clean power systems.
  - Main electrical gear systems
  - Backup power systems
  - Fire alarm systems
  - Interfaces to automated temperature/building automation control systems
  - Grounding systems
  - Lighting control systems (including but not limited to occupancy sensors, daylight sensors and dimming controls.)
  - Renewable energy systems including passive and active systems
  - Access controls
  - CCTV and security system
- Life Safety Systems
  - Life safety systems, and all equipment forming a part of these systems (This testing will be in addition to any code required safety verifications performed on qualified life safety system specialists.)
- Building Automation, Controls and Metering
  - Central building automation and controls systems, and all equipment forming a part of these systems (including, but not limited to linkages to remote monitoring and control sites, etc.)
  - Instrumentation and sensors (with a sampling of operational range and calibration)
  - Utility monitoring, meters and metering system.

### **Pre-design Phase**

The following activities are to be conducted during the pre-design phase:

- Commissioning scoping and planning – during project programming the University PM should engage the University Commissioning Manager to participate in the process. At this point the Commissioning Manager will be the team's liaison for commissioning requirements. The PM and Commissioning Manager will collectively determine the level of

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

commissioning required for all projects involving MEP work and whether the commissioning authority (CxA) will be an internal resource or if an outside consultant will be hired. Factors such as project size and current workload will determine if commissioning activities can be handled internally. The Commissioning Manager should be consulted in the solicitation and selection of the Commissioning Consultant. The University Commissioning Manager can also assist in estimating commissioning costs for the project budget during the programming phase.

- Cx selection – Once the commissioning scope has been determined by the project manager and the University commissioning manager, the CxA can be brought on to the project. The University Commissioning Manager should be consulted to determine when involvement of the Cx will be most beneficial. The commissioning authority should be typically be brought on after the OPR is developed.
- Owner's Project Requirements (OPR) – The OPR is to be completed by the design team with input from the Owner and Commissioning Manager. The CxA shall conduct at least one review of the OPR. The OPR shall address the following issues at a minimum:
  - Owner and user requirements – Describe the primary purpose, program and use of the proposed project and any pertinent project history. Provide any overachieving goals relative to the program needs, future expansion, flexibility, quality of materials, and construction and operational costs.
  - Environmental and sustainability goals – Describe any specific environmental or sustainability goals.
  - Energy Efficiency goals – Describe overall project efficiency goals relative to the local energy code, ASHRAE standard or LEED. Describe any goals or requirements for building orientation, landscaping, façade, fenestration, envelope and roof features that will affect energy use.
  - For each program or area, describe the intended use, anticipated occupancy schedules, space environmental requirements (including lighting, temperature, humidity, acoustics, air quality, and ventilation), desired adjustability of systems controls, and accommodations for after-hour use.
  - Equipment and system expectations – Describe the desired level of quality, reliability, type, automation, flexibility and maintenance requirements for the building equipment. When known provide specific efficiency targets, desired technologies or preferred manufacturers for building systems.
  - Building occupant and O&M personnel requirements – Describe how the facility will be operated and by whom. Describe the desired level of training and orientation required for the building occupants to understand and use the building systems.

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

- Basis of Design (BOD). The Architect / Engineer (A/E) is responsible for drafting the basis of design. The BOD describes the building systems and outlines any design assumptions that are not otherwise included in the design documents. This document should be updated throughout the design and construction process. The BOD must have the following elements at a minimum:
  - Primary Design Assumptions – Including space use, redundancy, diversity, climatic design conditions, space zoning, occupancy, operations, and space environmental requirements.
  - Standards – Include applicable codes, guidelines, regulations, and other references that will be put into practice.
  - Narrative descriptions - Include performance criteria for the HVAC&R systems, lighting systems, hot water systems, on-site power systems, and other systems to be commissioned.

### **Design Phase**

The following activities are to be conducted during the design phase:

- The Cx shall conduct a review of the BOD prior to beginning of the design development phase. The review shall include the following elements:
  - BOD is thorough, complete and reflects the OPR.
  - BOD satisfies LEED® requirements (if applicable).
  - A review of the LEED® scorecard (if applicable) as it pertains to the equipment to be commissioned and any potential issues/ concerns.
- Design Review –Although the engineer of record is ultimately responsible for the design of building systems, the Cx shall perform an independent review of the plans and specifications. This design review shall exceed what is required by LEED® but will be less extensive than a full formal peer review. Particular attention should be paid attention to the performance, operation and maintenance of equipment. The Cx shall review the plans and specification for final DD's, and major CD milestones. The following issues at a minimum shall be considered while performing the design reviews:
  - Adequate access is given in order to perform Test and Balance as well as functional testing.
  - Access for equipment maintenance and replacement.
  - Equipment locations and capabilities vs. occupancy needs
  - Building Automation System (BAS) layout and system integration.
  - Complete and unambiguous sequence descriptions.
  - Sequences optimized for equipment performance and system efficiency.
  - Ability of achieving the owners project requirements and basis of design and coordination of commissioned systems.

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

- Coordination between disciplines
- Develop the Commissioning Specification – The Cx shall generate a commissioning specification for inclusion in the general conditions of the construction specifications no later than the 50% CD milestone. This specification shall be all encompassing for commissioning activities. It is the responsibility of the Cx to coordinate with the design team on other sections of the specifications that mention functional testing or commissioning-related activities so they are consistent with the formal commissioning sections. Care should be taken to cross reference between sections. The commissioning specification shall contain the following sections at a minimum:
  - Commissioning team involvement
  - Roles and responsibility
  - A list of equipment and systems to be commissioned
  - Incorporation of start-up and commissioning activities into construction schedule (list what need to be completed (system components, equipment, related systems and controls, etc) prior to starting commissioning of each system)
  - Submittal review procedure
  - Operations and Maintenance documentation requirements
  - Project commissioning meeting overview
  - Pre-functional checklist verification process
  - Start-up plan development and implementation
  - Issue log process
  - TAB verification
  - Functional performance testing requirements and process
  - Acceptability and Closeout - Include how completion of commissioning activities relates to occupancy permits and project closeout.
  - Training requirements
  - Peak seasonal testing
  - Warranty review
  - System manual requirements
  - Language assigning financial responsibility for failed tests to the appropriate parties.
  - Include sample pre-functional checklist and functional test procedures.
- Initial Commissioning Plan – The initial commissioning plan lays the groundwork for a successful commissioning process. The commissioning plan is intended to be a “living” document as details within the document will change as the project evolves. The initial commissioning plan should be submitted to the owner and design team for review prior to the 50% CD milestone. The initial commissioning plan should be drafted after the commissioning specification and include at a minimum the following elements:
  - The scope of commissioning

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

- The commissioning team roles and responsibilities and lines of communication
- Reference documents
- Systems to be commissioned
- Commissioning meeting overview
- Sample pre-functional checklists (PFCs) – although the specific details for all equipment may not yet be determined, sample checklist for each type of equipment should be provided.
- Sample functional performance tests (FPTs) - although the specific details for all equipment may not yet be determined, sample checklist for each type of equipment should be provided.
- Commissioning schedule
- O&M documentation requirements
- Training requirements
- Design Phase Acceptance – The Cx should sign off that all issues have been resolved at the conclusion of the design phase. The intent of this step is to verify that all commissioning related concerns have been addressed prior to initiating the bid phase. In the event that the Cx and the EOR are not in agreement about a particular issue the University will work with all parties to resolve any differences of opinion.

### **Construction Phase**

The following activities are to be conducted during the construction phase:

- Commissioning meetings – Open communication between the commissioning team is integral to a successful project. Commissioning meetings are not meant to burden the team members but rather to proactively discuss ongoing issues and potential concerns. The frequency and length of meetings should be sufficient enough to facilitate a commissioning process that is seamless with construction. The following commissioning meetings should be conducted during the construction phase:
  - Commissioning kick-off meeting - The Cx shall conduct a kick-off meeting to review the commissioning process with the commissioning team. Attendees required at the kick-off meeting include the architect, engineer, construction manager/ general contractor, and all appropriate sub-contractors (including the TAB contractor). The Cx shall prepare the meeting agenda and issue meeting minutes.
  - Construction meetings - The Cx should participate regularly in construction meetings. The expectation is that the Cx will attend sufficient meetings in order to be well informed of project status and developments. The Cx should also attend all pre-bid meetings associated with portions of the work to be commissioned .
  - Commissioning meetings – The Cx should conduct regular commissioning meetings with the construction team. These meetings may not be regular during the initial phases of construction but as the project progresses the meetings shall be held more regularly. The frequency of these meetings should be agreed upon by the University

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

- and Cx. The Cx shall prepare the meeting agenda and issue minutes. Meeting minutes shall be prepared and distributed to all meeting participants within 48 hours of the meeting.
- Controls integration meeting –the Cx should facilitate a controls integration meeting. A controls integration meeting between the Cx, the designers, the controls contractor, and the building operator is held after the controls submittal review and prior to submittal approval. The goal of this meeting is to facilitate resolution of review comments, and verify that the control system and system sequences are complete, verifiable, coordinated and meet the OPR.
  - Construction submittal reviews – The Cx shall review all construction submittals for the systems to be commissioned. Commissioning review of the submittals should be conducted concurrently with the design team. All review comments should be submitted to the architect/engineer for incorporation. The architect/engineer has the final authority to accept or reject the submittals. The Cx should specifically evaluate the submittals for the following:
    - Conformance with the owner project requirements and basis of design.
    - Acceptability of factory testing and pump/fan curves
    - Fulfilling operation and maintenance requirements.
    - Facilitating TAB and performance testing.
    - Optimization of efficient equipment and systems
  - Update commissioning plan – The initial commissioning plan should be updated with the project design details after the 100% CDs are released. A master list of commissioned equipment shall be created. Pre-functional checklist (PFC) as well as functional performance tests (FPTs) should be completed utilizing the approved construction submittals and installation manuals to make the checklists specific to the installed equipment. The commissioning plan shall be updated throughout the construction phase to reflect any changes due to submittals, RFIs, ASIs, etc. PFCs and FPTs shall be project specific. Generic “canned” forms are not acceptable. Generally, 100% of equipment shall be tested. In the case that 100% testing is not feasible or financially prudent, sampling plans should be pre-approved by the University Commissioning Manager.
  - Commissioning Status Reports – The Cx shall issue a commissioning status report monthly. The report should compile a list of deliverables and current status of each item.
  - Integration of commissioning activities in the construction schedule – The Cx shall work with the general contractor/construction manager to incorporate the various start-up and commissioning activities into the project schedule. Ample time should be given to perform TAB and functional testing in the schedule. Functional testing should be tied to its pre-

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.



requisites such as system start-up, TAB and point to point testing. Construction schedule and commissioning schedule shall be integrated with all detailed tasks and activities shown in a sequential manner. This will provide realistic intermediate milestone dates. Project scheduler shall update the scheduled dates and actual dates bi-weekly and distribute to everyone in the construction team.

- Site visits – The Cx shall verify the contractor progress of pre-functional checklists. Equipment, systems and assemblies in the commissioning scope should be examined. The PFCs should be audited during each site visit to assure that contractors are completing the PFCs correctly and in a timely manner. PFCs shall be updated by the contractors routinely as the project progresses, not all at the end of a project. Only contractors having direct knowledge of the activity should sign off on each line item. The Cx should submit a site visit report to the University within no later than the following working day and identify any concerns or deficiencies. When possible a digital photo should be taken of any deficiencies or observations and included in the report. The University prefers that construction phase communications are automated and timely. The use of software tools during the construction phase (i.e. Vela, Latista, or proprietary systems) increase the project team's ability to automate the deficiency resolution process. Although this technology is not required by the University at this time it has been deemed advantageous on large projects. The use of such software tools will be considered when evaluating qualifications of providers.
- System start-up – The general contractor/construction manager shall submit a start-up plan (including vendor/contractor start-up procedures and forms) to the Cx for review. A minimum two week notice should be provided to the Cx and the University for participation in system start-up and/or testing if the dates differ from those included in the construction schedule. Valves should not be opened, motors bumped or equipment energized prior to having the proper documentation submitted and appropriate people present. This is crucial so that the process is handled safely, activities are properly documented and warranties are appropriately kept. The Cx should attend an adequate number of start-ups in order to confirm proper procedures and documentation are followed. All completed start-up forms should be submitted to the Cx for review and become part of the final commissioning report. Start-up testing includes flushing, pressure testing as well as official equipment start-up.
- Maintain and distribute a commissioning deficiency list – The commissioning authority shall maintain a log of all project issues encountered during the commissioning process. While the commissioning authority may not have the ability to correct the issues, it is expected that they work closely with the general contractor / construction manager and design team to resolve any issues. A proactive and collaborative process of addressing project issues as they

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

arise is a vital part of a successful project. The University expects the Cx to exercise a great deal of leadership and perseverance in assisting the project team in resolving issues.

- **Test and Balance (TAB)** – The TAB contractor shall submit a test and balance plan to the Cx for review by the Cx prior to performing any TAB activities. TAB plans should contain the forms to be used during TAB. Only instruments calibrated within the last 12 months to an NIST traceable standard should be used during TAB. The TAB contractor shall submit calibration sheets to the Cx for all equipment to be used prior to starting TAB. The TAB contractor shall under the supervision of the Cx, repeat a portion (generally 10%) of the TAB readings sufficient enough to prove readings are repeatable. The Cx shall review the final TAB report (the completed field report is acceptable) prior to conducting functional performance testing.
- **System readiness** – The following activities shall be complete before functional testing: installation and PFCs (including end to end testing) complete, TAB complete and report reviewed. The general contractor / construction manager shall notify the University and the CxA in writing that functional testing requirements are met and system(s) are ready for functional testing.

### **Acceptance Phase**

- **Functional Testing** – The CxA shall direct, witness and document the results of the functional performance testing of all systems to be commissioned. Each functional test should have specific acceptance criteria on which the results will be evaluated. The construction schedule should be used to schedule functional testing and resources needed for testing. The general contractor / construction manager is responsible, with input from the CxA, for coordinating participation by the appropriate sub-contractors and vendors. The CxA should also notify the general contractor / construction manager in advance if special testing equipment is needed. Operations personnel from the University are encouraged to attend functional testing. Immediately after test and balance, trending should be performed and included in the commissioning report as additional documentation supporting the proper operations of the systems. Instrumentation should be verified to be accurate in the field, at the local controls and at the campus BAS. Any meter for campus utilities including (but not limited to steam, chilled water, and condensate) should be verified to be operational in the field, at the Ion system as well as the campus BAS. Meters should be checked at high flow, no flow and typical operating conditions. During functional testing graphics on the campus BAS should be verified. Any testing conducted at the local control level should be pre-approved by the University. System setpoints should always be recorded prior to initiating testing and returned to their pre-testing values at the conclusion of testing. Documentation that this procedure is followed should be part of FPTs. During testing it is

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

acceptable to override setpoints or process variables in order to simulate conditions. However, it is important to document the method of each test conducted in order to provide a level of repeatability to testing. If problems or incomplete work are discovered during functional performance tests, the responsible contractors must correct or complete the work and have it re-tested with satisfactory results before proceeding to the next stage of commissioning. If numerous problems indicate that the installation is not ready for FPTs, the commissioning authority should halt testing and immediately notify the general contractor / construction manager and University.

- Excessive retesting costs (more than 10% repeat) will be charged to the responsible contractor not to the University.
- Operations and Maintenance Manual review – The CxA shall review all O&M manual for equipment in the commissioning scope. The CxA shall receive a copy of each O&M document in its final form no later than 50% completion of construction. Partial or draft submissions will not be acceptable. The CxA will perform their commissioning review concurrently with the EOR. Comments will then be forwarded to the EOR for incorporation. O&M documents shall be finalized utilized during the training process.
- Training Review – The CxA will verify that all training requirements have been met. The general contractor/construction manager shall submit a training plan complete with an agenda for each session to the CxA no later than 50% completion of construction or 60 days prior to scheduling training activities whichever comes first. The CxA will attend a sufficient amount of training sessions enough to be confident that contractual requirements have been met. The CxA will review all training documentation including sign-in sheets and video (if applicable) to ensure all requirements have been met.
- Systems Manual – The Cx will assemble and distribute a systems manual for the project prior to training. Final versions of some documents may need to be updated after training. Although the Cx is not responsible for generating all the documents within the systems manual, they are responsible for attaining the documentation and collating it. The systems manual shall contain the following documents however the parties noted in parenthesis are responsible for providing:
  - Final Version of the BOD (A/E)
  - System single-line diagrams (A/E)
  - As-built sequences of operations, control drawings, and original setpoints (Controls Contractor)
  - Operating instructions for integrated building systems (sub-contractors)
  - Recommended schedule of maintenance requirements and frequency, if not already included in the project O&M manuals. (sub-contractors)

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

- Recommended schedule for retesting of commissioned systems with blank test forms from the original commissioning plan. (Cx)
  - Recommended schedule for calibrating sensors and actuators. (CC)
- Final Report – The Cx shall issue a final report within 30 days of functional testing. The final report shall include the following at a minimum:
  - Executive summary of the process and the results of the commissioning program by equipment and systems, including observations, conclusions and any outstanding items.
  - Deficiency list complete with closed items and any open items clearly identified with resolution recommendations and a cost benefit analysis.
  - Functional test results.
  - Confirmation from the Cx indicating whether individual equipment and systems meet the owner's project requirements, basis of design, and contract documents.
  - Summary of the design review process
  - Summary of the submittal review process.
  - Summary of the O&M documentation and training process.
- Peak Season Testing – The Cx shall conduct peak season testing during the first summer and winter seasons after occupancy. Peak season testing is not intended to be a complete repeat of functional performance testing but rather a repeat of the systems whose performance is greatly dependent on the conditions outside. (i.e chillers in summer and boilers in winter). During peak season testing trending should also be set-up and reviewed to verify that HVAC zones are able to operate as designed.
- Warranty Review – The Cx shall conduct a warranty review 10 months after substantial completion. The Cx should coordinate with the University a walk-through, and interview building operators and occupants. The Cx shall submit any suggestions to optimize operations in their warranty report. Any ongoing issues should be investigated and if necessary systems retested. A warranty review report should be issued 7 days after the visit and be an addendum to the commissioning final report.

The Facilities Services Facility Standards (FS)<sup>2</sup> is a living document which is subject to change.

Please refer to the latest version of the document in accordance with Exhibit C of the contract agreements.

## **References**

ACG Commissioning Guideline 2005

ASHRAE Guideline 0-2005 - The Commissioning Process

New Construction Building Commissioning Best Practice - Building Commissioning Association, December 8, 2011

THE COST-EFFECTIVENESS OF COMMERCIAL-BUILDINGS COMMISSIONING A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States Lawrence Berkley Laboratories December 15, 2004

LEED Reference Guide for Green Building Design and Verification, 2009 Edition