Higher Value Commissioning

Presented by:

Erik Jeannette, PE

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Commissioning – What is it?

• Commissioning (Cx) is a comprehensive and systematic process to verify and document the systems of a facility function completely as designed to meet the owner’s requirements.
Why Commission Your Building...??
Erik Jeannette, PE

• BS and MS degree in Building Systems Engineering
• 18 years experience in building systems
  • ASHRAE University HVAC Research (CU Boulder)
  • Controls Engineer, programmer
  • Cx Engineer, Team Leader
• More than 50 Cx projects completed
• Mechanical and Controls optimization
• Specialty Systems:
  • Chilled Beams, Radiant heating and cooling, GeoExchange, Energy Recovery, energy metering, microturbines, solar PV & DHW, 2-stage evaporative, Coolerado, digital scroll compressors
**Commissioning – Types of Cx**

- **Commissioning:** Process applied to new construction or major building renovation
- **Retro-commissioning:** Performed on facilities that have been in service and never commissioned
- **Re-commissioning:** Facility has previously been commissioned and is in need of a “tune-up”
- **Continuous commissioning:** On-going program of structured commissioning throughout the lifetime of a building
Why Commission Your Building?

- Because LEED says so?
- Why does LEED require it....?
- Do non-LEED projects get commissioned?
- Will my project benefit from commissioning?
- What will it cost?
- Should I include commissioning on every project?
- What should I expect from commissioning?
How do you Get the Most out of the Cx Process?

• Commissioning should help every project team member
  • Reduced mistakes/ change orders
  • Better design team coordination
  • Reduced RFIs
  • Better trade coordination
  • Reduced schedule delays
  • Reduced warranty call-backs

Happy Client, designers, contractors
Commissioning – Low Value

- Quality control as the main priority
- Minimal design input
- A Cx agent that doesn’t know their clients’ desires/ requirements
- Few jobsite observations
- Minimal coordination with design team or contractors
- Big books of redundant checkout forms
- 0 to few commissioning coordination meetings
- No assistance in developing project closeout schedule
- Functional testing without re-testing
- Quick to “cry” CHANGE ORDER for additional testing
- No or minimal follow-through with issues log resolution
- Adversarial with contractors, not a “Team Player”
Commissioning - Value

Low Value

• “Seagull Commissioning”
  • Fly real high,
    • then swoop down and cra@ all over everyone
    • and then quickly fly away
Commissioning – Ok Value

• Quality control as a main priority
• Some design input – Cx specs
• Understands clients’ desires/ requirements
• Just enough jobsite observations
• Some coordination with design team or contractors
• Big books of checkout forms
• A few commissioning coordination meetings
• Minor assistance in developing project closeout schedule
• Functional testing with 1 retest
• Quick to “cry” CHANGE ORDER for additional testing
• Minimal follow-through with issues log resolution
Commissioning – High Value

- Quality control, energy efficiency, building operation as priorities
- Lots of great design input
- A Cx agent that knows their clients’ desires/requirements
- Many helpful jobsite observations – WITH FOLLOW-THROUGH
- Regular coordination with entire commissioning team
- Moderate books of checkout forms, or PDA or online versions
- 6-10 commissioning coordination meetings
- Lots of assistance in developing project closeout schedule
- Dry-run testing at controls shop
- Staged Functional testing with some re-testing
- Complete follow-through with issues log resolution – Cx meetings
- Team Player working towards delivering a project on time, and fully operational
Design through Warranty
Continuous Participation

Planning
- Review Design Intent, Cx Plan, and Specifications

Design
- Design Meetings and Reviews

Construction
- Review Submittals, Prepare Checklists and Testing Plans, Jobsite Obs, Witness Start-Up

Acceptance
- Perform Functional Testing, Resolve Issues, Review O&M

Occupancy
- Staff Training, Seasonal Testing, Warranty Review
Commissioning - Design

• Know Your Client
  • Interview Facilities Staff
  • Understand their likes and dislikes for the Cx systems
    • Occ sensors
    • CO₂ sensors
    • Equipment manufacturers
    • 2-pipe / 4-pipe
  • Learn their “hot-buttons”
  • Learn their energy targets
  • Develop the OPR together (Owner’s Project Requirements)
Commissioning - Design

- Assist with system selection brainstorming
  - Cx agents have many lessons learned
  - Cx agents get to work with many design teams
  - System selection based on energy targets (EUI)
- Review SD, DD, CD Energy Model
  - Engage modeling firm EARLY!
  - Model indirect evap efficiency with degradation included
  - Model setpoints and sequences per design
  - Evaluate Energy Model “work-arounds”
Commissioning - Design

- Design reviews – Plans and Specs
  - Owner’s project requirements
  - Basis of Design
  - Schematic Design
  - Design Development
  - 50% CD
  - 90% CD
  - Close the Loop!
    - Get feedback to the Cx engineer so they know what was incorporated
WebCx – Design Review

### Electrical

<table>
<thead>
<tr>
<th>No.</th>
<th>Per.</th>
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<th>Reference</th>
<th>Comment</th>
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<td>Electrical</td>
<td>E-101</td>
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### Mechanical

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</table>

Please provide details showing connection between lighting control panel and lighting power panel. Comment by KM of EMC on 2009-04-22.

Recommend adding occupancy sensors to control lighting in all restrooms, storage closets, conference rooms and offices. Example: small restrooms between 1st grade and Kindergarten class rooms, storage closets at each classroom and offices and conference rooms in administration area and kitchen area. (typical) Spaces that have intermediate occupany often benefit greatly from occupancy sensors. If lights are left on in these areas, they often remain on for days. Comment by KM of EMC on 2009-04-22.

Limited space prevents separate areas for heat pumps. Filters will be installed at RA grilles to eliminate the need to access heat pumps for routine maintenance. Comment by KM of EMC on 2009-04-20.
Commissioning - Design

• Looking For
  • Coordination with Architectural
  • Coordination with Electrical
  • Maintenance access
  • Enough details to reduce RFI, change orders
  • Sequences and Points lists
  • Specs that can be “leaned on” when needed
Commissioning - Design

- Mechanical Details to Watch for
  - Water-side Free Cooling with Enthalpy based enable
  - DX capacity control when needed
    - Hot Gas Bypass or digital scroll
    - Displacement Ventilation....
  - Turndown on boilers, gas furnace
  - Condensing boiler control strategy
  - Minimum flow bypass in 2-way pumping
  - Chiller minimum flow control
  - Design day sizing...???
    - Not really. Engineer of record holds this responsibility
Commissioning - Design

- Mechanical Details
  - Duct pressure testing
  - Motor efficiencies
  - Evaporative cooler drain/ fill piping location
  - Slope of cooling tower piping, bleed off, conductivity sensors
  - Return air path details coordinated with Architect
  - Access hatches for drywall areas
  - Electrical room cooling with condensate drains to hallway
  - OBD Vs balance dampers in hard-lid areas
Commissioning - Design

• Mechanical Details
  • System compatibility
    • Bad: Baseboard radiation at 180F with condensing boilers at 140F HWS
    • Bad: Solar hot water heating that requires frequent heat dump
    • Bad: 4-pipe fan coil with min fresh air (no air or water econ)
    • Good: Evap cooling, displacement vent, water-side econ
    • Good: Unit heaters and condensing boilers
    • Good: Energy Recovery Ventilators, min fresh air, radiant floor heat/cool
    • Good: Chilled beam, radiant heat/cool, min fresh air ERV
Commissioning - Design

• Control Details
  • Evaluate existing systems for integration
  • Develop BAS solution that is right for the client
  • Open or proprietary BAS protocols
  • Define graphics, trending, points lists, alarms
  • Define detailed sequences
  • Define integration with packaged/ factory controllers
    • Bacnet, Lonworks, Modbus, other
    • Define Ethernet wiring, and responsible party

Get it all in the design so there are minimal questions, and bids are complete
Commissioning - Design

• Control Details
  • CO2 Demand Controlled Ventilation
  • Optimal Reset Strategies
  • Optimize Energy and Comfort
  • Demand control strategies defined
  • Continuous Cx…???

Get it all in the design so there are minimal questions, and bids are complete
Cx Process – Construction Phase

- CxA communicates with GC and subs to stay up on construction progress – **attend monthly meetings**
- **Periodic inspections** of installation to verify conformance to project documents
- Assist with developing project closeout schedule
- Each trade needs enough time to do their work well
  - *Rushed schedules results in sloppy work*
Cx Process – Construction Phase Coordination Meetings

- Attend **Pre-con** meeting

- Hold a **Commissioning Kickoff** meeting
  - Jointly! The message comes from the GC to the subs

- **Controls coordination** meeting
  - Discuss controls details during the submittal phase, NOT during checkout

- **Commissioning Coordination** Meetings
  - Monthly, weekly……
  - Discuss RFIs, equipment, startup
  - Design team and owner should attend
  - Closeout schedule, closeout trades
Site Observation Report

Photos, Notes, Issues, and place for contractor response and CxA Review
**Cx Process – Acceptance Phase**

- Perform functional testing to verify correct system operation
  - Point to Point, Functional testing
- Check all systems in **all modes of operation**
  - normal, emergency, failure, fire, power loss
- Verification of test, adjust, and balance
  - Accurate outside air control
  - Validate Test, Adjust, & Balance Readings
- Trend control variables for stable operation – use BAS and our own dataloggers
  - Test HVAC system operation over time
  - PID Loop Tuning
# Functional Test Plans

## Occupancy Sensor

<table>
<thead>
<tr>
<th>Procedure/Task/Response</th>
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<th>Value</th>
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<th>Date</th>
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<tbody>
<tr>
<td>Trip Occupancy Sensor During Occupied Hours</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>FCU Shall control normally to meet the Occupied Setpoints</td>
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<td></td>
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<tr>
<td>Simulate the space unoccupied during occupied hours by covering the occupancy sensor. Simulate a Space Temp Between 67°F-70°F</td>
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<tr>
<td>System Setpoint Changed to Standby Setpoints of 67°F/70°F</td>
<td>✔</td>
<td></td>
<td>JS</td>
<td>2009-06-09</td>
</tr>
<tr>
<td>Fan S/S=Off</td>
<td>✔</td>
<td></td>
<td>JS</td>
<td>2009-06-09</td>
</tr>
<tr>
<td>Fan Status=OFF</td>
<td>✔</td>
<td></td>
<td>JS</td>
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</tr>
<tr>
<td>FCU Occupancy=OFF</td>
<td>✔</td>
<td></td>
<td>JS</td>
<td>2009-06-09</td>
</tr>
<tr>
<td>Economizer Damper Closed</td>
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<td>JS</td>
<td>2009-06-09</td>
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<tr>
<td>Cooling Coil Valve Closed</td>
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<td>JS</td>
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<td>Heating Valve Closed</td>
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Simulate the space unoccupied during occupied hours by covering the occupancy sensor. Simulate a Space Temp Less Than 67°F

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<td>Fan S/S=On</td>
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**Cx Process – Acceptance Phase**

- Track Issues on Issues Log
- Regular Meetings until items are resolved
- **Follow through that commissioning issues are resolved**
- Substantial completion not reached until CxA is complete AND Issues log is minimal

**ACCEPTANCE**

- Witness & Verify Functional Performance Testing
- Hold Cx Team Meetings & Report Progress
- Coordinate Owner Training
- Turnover Cx Record

System Performance Documented & Accepted
WebCx – Issues Logs
**Cx Process – Warranty Phase**

- Seasonal testing to double-check building performance.
- Trend Data Analysis to verify operation over time.
  - Insure proper operation while the building is loaded
  - Look for anomalies and poor PID control
- Speak to building users to identify any problem areas that may have developed.
- Support owner in getting issues resolved.
- Provide follow-up training to O & M staff.
Short-Term Diagnostic Monitoring

• Confirmation – Post FPT
  • Using STM after Functional Performance Testing has occurred
Short-Term Diagnostic Monitoring

• Confirmation – Post FPT
  • Validate Functional Performance Testing
    • Data and analysis proves that you the Cx provider did your job with FPT and the sequences work properly
    • Documents that it worked when you left the project
  • Seasonal Testing
    • Use STM to monitor how the systems operate in the opposite season
    • May save a jobsite visit if BAS data is available remotely

• Fully Occupied Building
  • How do the systems operate under normal loads?
  • Are the processes “tuned”
Short-Term Diagnostic Monitoring

• Confirmation – Post FPT
  • PID Tuning Evaluation
    • FPT is often performed with few or no occupants
    • FPT does not show true dynamic interaction of systems relative to changing loads, mass, weather, etc
    • PID tuning issues are found with STM
    • STM clearly shows good and bad PID tuning
    • Identify PID problems during warranty period!
      • Data is hard to argue with
Short-Term Monitoring

Boiler Plant Control

- Parallel Condensing Boiler Plant

2 Boilers in Parallel

1 Boiler Operating

Graph showing the monitoring of different boilers over a period of hours from 06:00 to 13:00 on 11/11/04.
Commissioning – High Value

• Get the most out of the Cx process
• Have high expectations of the Cx agent
• Interview Cx agent for qualification based selection
• Don’t select on fee alone
• Get involved with commissioning!
Thanks for Listening!

Questions….???