NEBBinar: Technical Commissioning: The most effective commissioning process for new buildings

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Jim Huber, NEBB President-Elect and President of Complete Commissioning

Jim Huber is the President of Complete Commissioning. He has over 30 years of industry experience, is a Certified Energy Manager, and has extensive experience with BACNET, LON, MODBUS, and other building automation protocols and communication networks. He has programming, tuning, and testing experience with multiple systems and applications, as well as building systems commissioning, sound and vibration measurement, and testing and balancing.
Dave McFarlane, Principal Project Director, Atkins

Dave McFarlane is a principal project director in the asset management practice and head of the Building Performance Group for Atkins, one of the world’s leading engineering, design, and project management consultancies.

Prior to joining Atkins, Dave was the president of Technical Commissioning, Inc. (Fort Myers, FL) and McFarlane, Inc. (Grand Forks, ND). He was a member of NEBB’s Commissioning Committee; he chaired the committee in 2003-2004 and rejoined in 2011. Dave serves as an instructor for NEBB’s courses in Commissioning and Retro-Commissioning. He speaks at conferences nationwide, and has written numerous articles for a variety of industry publications.
Technical Commissioning

Owners Project Requirements: Resolve Outstanding Issues

Basis of Design: Resolve Outstanding Issues

Design Documents Review

Pre-Functional Tests - Field Installation: Resolve Outstanding Issues

Pre-Functional Tests - Operational Performance Tests: Resolve Outstanding Issues

Functional Performance Tests (FPT): Resolve Outstanding Issues

Question and Answers
25 years of lessons learned

- Owner’s expectations not clear
- Improper design
- Improper installation
- Inadequate startup
- Inadequate control sequences/check out
- Inadequate test and balance
Technical Commissioning

A systematic, documented process providing verification that critical steps in the planning, design, construction and final system verification have been executed correctly.

The process begins at project inception and continues to project closeout and turnover to the owner.
Technical Commissioning: The critical steps

• Develop an accurate owners project requirement (OPR) document

• Verify the basis of design (BOD) document will produce results that meet the OPR

• Verify the schematic design (SD), design development (DD), and construction documents (CD) will produce results that meet the OPR
Technical Commissioning: Pre-installation meeting

- Conduct pre-functional tests (PFT) that provide verification of the construction process

- Conduct final functional performance tests (FPTs) that verify all systems are working together to produce the results outlined in the OPR
Technical Commissioning:

- Improved project execution
- Ensure that the building meets the owners project requirements
- Optimized energy usage
- Improve occupant comfort
- The number of contractor call backs are significantly reduced
- Corrective actions are completed by the various contractors at the project completion (not the owner’s staff)
The OPR

Help the owner develop an accurate Owners Project Requirement (OPR) document.

You may not get “it” if you don’t ask for “it”

Why am I involved in the process? That’s why we hired a design team.”

The “it” is different for each project.
The OPR

- Space temperatures, pressure and humidity requirements
- Ventilation requirements (ASHRAE 62.1)
- Safety factors–ASHRAE 99.4% or 99%
- Building energy consumption requirements
  - Provide adequate sub-metering for measurement and verification
The OPR

- Sound levels are appropriate for each space
- Vibration levels are appropriate for each space
- Lighting levels
- Routine maintenance performed within reasonable time constraints and ease
The OPR

- Ensure the owner is not locked into a single source supplier for service and repairs
- Ensure that the appropriate redundancy for critical equipment has been considered
- Building security requirements
- Special materials of construction
The OPR

- Expectations of the Cx authority
  - Verify design calculations? Y / N
  - Verify code compliance? Y / N
  - Phasing verification? Y / N

- Vendor selection

- Warranty requirements

- Project budgets requirements

- Project schedule requirements

- Specific LEED rating

- Outline non-negotiable items
Owners Project Requirements

Resolve Outstanding Issues
Review the Basis of Design
Review the Basis of Design

Does the design outline adequately define the measures that will be implemented to meet the OPR?

- Space temperatures, pressure, humidity levels
- Sound and vibration levels
- Lighting levels
- Security requirements
- Energy modeling assumptions
- Equipment redundancy
Basis of Design

• Budget requirements

• Project design and construction schedule

• Typical design criteria outline temperatures/velocities/pressures appropriate for the application

• Project documents written to reduce trade specific duplication of work

• Issue logs to monitor and record issues
Basis of Design

Resolve Outstanding Issues
Develop the Commissioning (Cx) Plan

What did the OPR ask the Cx effort to achieve
Develop Cx Plan

• Outline the Cx scope of work (SOW)
• Define the team
• Define team responsibilities
• Define pre-functional testing
• Define functional testing
Cx Plan: Scope of the project

Typical

• Mechanical HVAC systems
• Plumbing
• Electrical systems
• Building envelope
Cx Plan: Scope of the project

Specialty systems

• Fire protection/alarm
• Smoke control/evacuation
• Security
• Data and IT (Low Voltage)
• Communications (Low Voltage)
• Elevators, intercom systems, misc.
Cx Plan: Outline the team

- Owners Representative
- Design Professionals
- Commissioning Authority
- General Contractor
- Subcontractors within SOW
**Cx Plan: Define responsibilities**

- **Owners representative**
  - Prepare the OPR with help form the CxA
  - Support and be a champion of Cx

- **Design professionals**
  - Ensure the design meets the OPR
  - Schedule design work to allow review
  - Eliminate duplicated subcontract work
  - **Assist in problem resolution**
**Cx Plan:** Define responsibilities

Commissioning authority

- Verify the OPR is accurate
- Verify the design and BOD meets the OPR
- Determine the criteria to be used for Cx
- Review drawings / documents to ensure compliance
- Prepare proper Cx language for contract documents
- Review approved shop drawings for compliance to the OPR
- Assist the GC producing a project schedule
**Cx Plan: Define responsibilities**

Commissioning authority

- Prepare installation, operational and functional performance tests
- Prepare the pre-installation meeting agenda
- Perform or observe a sampling of Pre-Functional Tests
- Perform or observe Functional Performance Tests
Cx Plan
Define responsibilities

Commissioning Authority
Be an active participant or lead problem resolution
Cx Plan: Define responsibilities

General Contractor

• Prepare an accurate phased schedule
• Ensure that subcontractors follow specs
• Assist in problem resolution

Subcontractors

• Attend the pre-installation meetings
• Follow the contract documents
• Assist in problem resolution
Design Documents Review
Design Documents Review

• Are the contractor and CxA commissioning requirements included in the various specifications and general conditions?
Design Documents Review

• Building envelope details appropriate
• Mechanical details clearly defined and appropriate
• Electrical details clearly defined and appropriate
• Security, smoke control details defined

• Will the design produce the results that meet the OPR
Design Documents Review

- Interior zone and exterior zones on the same stat
- 10+ rooms on same zone
- Conference rooms and IT rooms mixed with offices on same zone

Spaces did not meet the OPR
Design Documents Review
Resolve Outstanding Issues
Pre-Functional Tests
Pre-Functional Tests

Pre installation meeting
• Show all how to pass the tests

• Pre-functional tests
  – Developed by the commissioning authority (CxA)
  – Implemented by the installing contractor
  – Contractors QC
  – Spot checked and verified by the CxA
Pre-Functional Tests

Field Installation Verification (FIV)
• Is it installed right?

Requires expertise in that division
### Form 1. Ductwork Field Verifications

<table>
<thead>
<tr>
<th>Pre-functional test</th>
<th>Inspector</th>
<th>Issue log #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure that all ducting is installed per plans and specifications with SMACNA approved offsets, transitions, and elbows.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submit copies of the SMACNA standards used for the specific gauge metal gauge, pressure, and reinforcement type.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify that all ducts are reinforced per specifications.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify that all ducts are sealed to handle the appropriate pressure leakage rate.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify that all end caps are installed and sealed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Submit copies of all duct leakage test reports.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify that properly sized fire/smoke dampers are installed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify that all access doors are properly installed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify that all dampers operate correctly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify that all fire and fire/smoke dampers are in the open position.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify that all volume dampers are properly installed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verify that all temporary ductwork enclosures are dust-tight and secure.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Form 2. Variable Air Volume Field Installation Verifications

<table>
<thead>
<tr>
<th>Pre-functional test for VAV box #</th>
<th>Inspector</th>
<th>Issue log #</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sheet metal contractor verifies that:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A properly sized VAV box is installed in the correct location.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The VAV box is installed in the proper flow direction.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The VAV terminal inlet size conforms to the shop drawing.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The VAV box installed with 4 diameters of straight inlet duct (or per manufacture recommendations).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factory supplied VAV measuring devices are properly installed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The VAV damper can physically open and close.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>An access door is installed by the reheat coil.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The reheat coil is visually clean and fins are undamaged.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Form 2. Variable Air Volume Field Installation Verifications

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</thead>
<tbody>
<tr>
<td><strong>Piping contractor verifies that:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow fitting are installed in the proper flow direction and are accessible for testing.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Control valve and circuit settler are on the leaving-water side of the coil.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow fitting tags are installed with proper flow information.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coil venting is properly installed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valves are correctly installed and open</td>
<td></td>
<td></td>
</tr>
</tbody>
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### Form 2. Variable Air Volume Field Installation Verifications

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<tbody>
<tr>
<td><strong>Control contractor verifies that:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The inlet size of the VAV box that has been stored in the enemy management systems (EMS) matches both the inlet size shown on the shop drawing and the size that was actually installed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The proper area-correction factor has been entered into the EMS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The correct VAV terminal and ID numbers have been entered into the EMS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The correct occupied and unoccupied minimum and maximum airflow valves are entered into the EMS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The required flow offset value has been entered into the EMS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The thermostat is located in a position that will accurately measure room temperature.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The temperature sensor is not affected by temperature differenced in the wall cavity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The proper minimum/maximum set points from the approved shop drawings have been entered into the EMS.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pre-Functional Tests

Field installation tests

Is it installed right?

Contractors QC
Pre- Functional Tests
Field Installation Tests
Resolve Outstanding Issues
Pre-Functional Tests

Operational performance test (OPT)

Is it running properly?
• Provide for a factory startup on all major equipment
Form 3. VAV Pre-Functional Operations Performance Tests

<table>
<thead>
<tr>
<th>OPTs for VAV box# _____</th>
<th>Inspector</th>
<th>Issue log #</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Piping contractor verifies that:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The VAV box has been flushed with all shut-off and control valves open.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water is flowing through the VAV box.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper percentages of glycol and water have been added to the system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All air is vented from the VAV box.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All finned-tube radiant heater elements associated with the box are full of water/glycol mix.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All shut-off valves are open through the VAV boxes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All control valves open and close 100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Electrical contractor verifies:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct fan rotation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper operating voltage and amperage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper unit overload protection is in place.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HVAC/sheet metal contractor verifies:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct fan rotation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper operating voltage and amperage.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration is within acceptable limits.</td>
<td></td>
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Form 3. VAV Pre-Functional Operations Performance Tests

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<tbody>
<tr>
<td><strong>Control contractor verifies that:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All control valves close to 0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All control valves open to 100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VAV Dampers open and close based on space temperature difference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The correct temperature control sequence has been loaded into the EMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The thermostat controls the proper VAV box</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The thermostat is properly calibrated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphic are correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The VAV fan starts under EMS thermostatic control</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Test and balance contractor verifies proper:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum/maximum air flows are correct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air in/out temperatures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water in/out temperatures</td>
<td></td>
<td></td>
</tr>
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Pre-Functional Tests

Operational performance test (OPT)

Is it running properly?

Contractors QC
Pre-Functional Tests
Operational Performance Tests
Resolve Outstanding Issues
Functional Performance Tests (FPT)
The Final Exam
Functional Performance Tests (FPT): The Final Exam

Verification of system operation and interaction of components

Test the sequence
- Response Time
- Stability
- Controls to set point

- Verify
- Produces the design outcome
- Performs the sequence automatically
Improper control too tight
Improper control too loose
Proper Control
Functional Performance Tests (FPT)

Resolve Outstanding Issues
Technical commissioning recap

• Comprehensive approach
• Determine the OPR
• Drive the process to achieve the OPR
• Final result: All Systems work as required
• Satisfied owner
  • A project is delivered that meets the OPR
  • Outstanding issues have been resolved
  • Issues resolved with the contractor $$
• Happy contractors and design team
  • Complaints and call backs are minimal
Question and Answers
Contact information

**Jim Huber**, President-Elect of NEBB and President of Complete Commissioning
Tel: 1.443.221.7020
Email: JHuber@completecx.com

**Dave McFarlane, Atkins**
Tel: +1.239.791.8771 Ext. 460-1021
Email: Dave.McFarlane@atkinsglobal.com
Thank you for joining the webcast.

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