Retro-Commissioning for Existing Facilities

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WELCOME!
Discussion Points

- What is Cx and RCx?
- Optimization of HVAC Systems
- Optimization of Control Systems
- Electrical System Evaluation and Improvement
- System Performance and Operations Evaluation
- Operator Instruction and Training
COMMISSIONING (Cx)
Flavors of Commissioning (Cx)

- New Construction Commissioning (NC-Cx)
- Retro-Commissioning (RCx)
- Ongoing/Continuous Commissioning
Defining Retro-Commissioning (RCx)

Retro-Commissioning:

The systematic process by which systems are tested and optimized to perform interactively to meet the current operational needs of the owner.

This may include remedial design and construction to accomplish this goal.
Defining Retro-Commissioning (RCx)

All forms of building commissioning share the same goals:

– Produce a building meeting the unique needs of its owner and occupants

– Operate as efficiently as possible, while providing a safe, comfortable work environment

– Operated and maintained by a well-trained staff or service contractor.
Cx vs. RCx Drivers

Cx – Owner Performance Requirements (OPR)

RCx – Current Facility Requirements (CFR)
Why is RCx Important?

<table>
<thead>
<tr>
<th>Year Built</th>
<th>% of Building Stock Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960 to 1999</td>
<td>66%</td>
</tr>
<tr>
<td>2000 to 2003</td>
<td>9%</td>
</tr>
<tr>
<td>2004 to 2010</td>
<td>7%</td>
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</table>

Taken from DOE 2010 data
How to improve Building Performance?

• Make what we have work through RCx

• Keep what we have working through Operations for Performance
Building Performance is dependant upon 4 legs of the stool

Take one away and you have an unstable building
Building Performance

What’s not working?

Commissioning

- Most buildings are not working correctly when they are turned over to the owner
- Construction is driven by schedule and costs, not performance
Building Performance

What’s not working?

Operations

- Most buildings do not measure performance so they do not improve
- Since performance is not measured, operators are not held accountable for performance
The Owner and the Cx provider survey the facility to determine the extent and purpose of the project.
RCx Process

RCx Pre-Site Investigation

Before beginning site investigation field work the Cx:

– Create RCx Plan
– Review existing documents
– Review utility use and costs (Energy Audit)
– Review maintenance management work orders
– Perform Management & Operator interviews
RCx Process

RCx Site Investigation

The site investigation phase includes Cx Team work activities:

– Occupant interviews
– Change of use for occupancy and change of use from original design (CFR)
– Heat load study (if required)
RCx Process

RCx Investigation and Analysis

As issues are discovered the Cx analyzes each issue and associated causes and impacts:

– Analyze interaction between systems
– Create an issue report including:
  • Description of the issue
  • Recommend corrective action
  • Estimated costs
  • Estimated savings, payback and ROI
The Owner decides which corrective actions implemented and when.

- Contract for remedial design
- Procure contractors or equipment
- Perform corrective construction
RCx Process

Retro-Commissioning

Retro-commission and optimize energy-using building systems:

- HVAC Systems
- HVAC Control Systems
- Lighting Systems
- Electrical Systems
OPTIMIZATION OF HVAC SYSTEMS
Report Cards

- Comfort
- Costs
  - Energy
  - Maintenance
  - Reliability
DIS - Comfort
Costs

- Energy
- Maintenance
- Reliability
AIR SIDE PERFORMANCE ISSUES

Mechanical Issues

Maintenance

- Lowest possible filter drop
  - 300 FPM or Less
  - Low Pressure Drop Pleated Material
- Clean coils and condensate pans
- Clean fan blades
- Tight balanced fan belts
- Lubricated and adjusted dampers
- Seal all air leaks
- Annual sensor calibration and point checks
AIR SIDE PERFORMANCE ISSUES

Mechanical Issues

Air Balance

• Low Pressure Balance
  – At least one grille should be 100% open
  – Proportional Balance

• Cooling diversity no lower than 75%
  – % AHU CFM to total of all Zone CFM

• Heating diversity no lower than 100%
Mechanical Issues

Design

- Duct Taps
- Duct Transitions
AIR SIDE PERFORMANCE ISSUES

Mechanical Issues

Design

- Flex Duct
- Max Length 6'

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Maximum CFM</th>
<th>Velocity FPM</th>
<th>Maximum Length</th>
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<tbody>
<tr>
<td>4&quot;</td>
<td>45</td>
<td>500</td>
<td>8'</td>
</tr>
<tr>
<td>5&quot;</td>
<td>75</td>
<td>550</td>
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<tr>
<td>24&quot;</td>
<td>3450</td>
<td>1100</td>
<td>6'</td>
</tr>
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1. Flow based on the following conditions (14.7 psi, 60°, 0.01 roughness factor)
AIR SIDE PERFORMANCE ISSUES

Mechanical Issues

Design

• System Effect
WATER SIDE PERFORMANCE ISSUES

Mechanical Issues

Maintenance

• Clean coil tubes
• Clean strainers
• Correct suction pressure
  – 12#-15# at pump suction
  – No air in system (Auto vents)
WATERSIDE PERFORMANCE ISSUES

Mechanical Issues

Water Balance

• Low Pressure Balance
  –Coil Valve Trains
  –Pump Balance Valves
• Chilled Water Diversity no lower than 80%
• Hot Water Diversity should be 100%
WATERSIDE PERFORMANCE ISSUES

Mechanical Issues

Design

• Counter Flow CW Coil
  – Coldest water enters at air leaving side of coil
WATER SIDE PERFORMANCE ISSUES

Mechanical Issues

Operation

• Running Multiple Pumps

[Diagram showing parallel fans with CFM and diameters labeled: Fan 1 900 CFM, 2.0"; Fan 2 1500 CFM, 2.0"
Diagram showing series fans with CFM and diameters labeled: Fan 2 800 CFM, 1.3"; Fan 1 0.75".]
OPTIMIZATION OF CONTROL SYSTEMS
Things to Check

• Sequence of operation appropriate?

• Is it set up like it’s supposed to be?
WATER SIDE PERFORMANCE ISSUES

Control Systems

Sequence of Controls

• Schedule Control
• CW Leaving Temperature / Chiller $\Delta T$
  – $>10^\circ$
  – Lowest possible lift
• Condenser Water Temperature
  – Normal Design 85° / 95°
  – Intel Study Recommends 5° Above Wet Bulb
    » Cold water OK if lift is small or newer chillers
CONTROL PERFORMANCE ISSUES

Control Systems

Sequence of Controls

• Schedule Control Setpoints
  – Occupied 75°-78°
  – Unoccupied 84° - 86°

• Dead Band Control
  – Difference between cooling and heating action
  – Dead Band 2° - 4°
CONTROL PERFORMANCE ISSUES

Control Systems

Sequence of Controls

• VAV Supply Air Temp Reset Control
  – Reset from terminal unit load
  – Not average load but low or high select

• Supply Air Pressure Reset Control
  – Make sure this does not fight temp control

• CW or HW Temp Reset Control
  – Reset from valve position

• CW or HW Pressure Reset Control
  – Make sure this does not fight temp control
CONTROL PERFORMANCE ISSUES

Control Systems

Sequence of Controls

• Air Side Economizer Control
  – Verify Operation
  – Db Control

• Run FPT Data Trend Analysis
  – Room Temperature
  – Supply Duct Temperature
  – CW Differential Temperature
  – Condenser Water Temperature
ELECTRICAL SYSTEM EVALUATION AND IMPROVEMENT
Systems

- Controls
- Lighting
- Plug Loads
- Process Loads
Report Cards

• Comfort

• Costs
  - Energy
  - Maintenance
  - Reliability
Report Cards

Comfort
Report Cards

- Costs
  - Energy
  - Maintenance
  - Reliability
Perform a detailed electrical site investigation

- Deferred Maintenance
- Equipment Assessment
- Load Balance
- Equipment Thermal Image
ELECTRICAL PERFORMANCE ISSUES

Electrical Systems

– Verify phase loading of panels, should be within 10% of each other (Move loads to balance)

– Verify power factor, should be greater than 0.87 (Install capacitors to correct)

– Perform infrared survey of breakers. Make sure no breaker is overloaded (Install larger breaker and wire)

– Perform power quality survey with a power quality meter data log
SYSTEM PERFORMANCE AND OPERATIONS EVALUATION
SYSTEM
**Process**

Perform a detailed control system inspection

- Point to Point Verification Test
- Sensor Calibration
- Function Test
- Sequence Review
Bad List

- Disable Schedule to get the space in temperature in the morning
- Disable or override setpoint reset to make it colder or hotter
- Override any automatic setpoint reset
- Override control point output with manual switch
- Allow deferred maintenance items to exist
Good List

- Find the cause and fix it instead of reacting to symptom
- Document any temporary measures taken and change them back as soon as issue is resolved
- Measure performance often to see how you are doing
  - Energy
  - Comfort
OPERATIONS

Measurement Plan

Verify Implementation

Collect Data

Make Changes

Analyze Data

Report Results

Normalize Data

Compare Results

Usage Baseline
OPERATIONS

Collect Data
- Utility Bill or Submeter Data

Analyze & Normalize Data
- Normalize for standard days per month
- Normalize for annual weather data
OPERATIONS

Compare Data to Baselines
  – Compare to last years data
  – Compare to national data base (Energy Star)

Report Results
  – To Management, Operators and Occupants

Make Corrections
  – Verify Implementations
  – Start the Process Over
Measurement Protocols

ASHRAE PMP Best Practice Guide

• Energy Use Performance

• Water Use Performance

• IEQ Performance
  – Lighting Performance
  – Acoustic Performance
  – Comfort Performance
  – IAQ Performance
OPERATOR INSTRUCTION
AND TRAINING
Considerations

Personnel Turnover
Considerations

Task Assignment

Right person for the right job?
Considerations

Operator = building user?

– Building performance affected by users – 40%
Considerations

Real Training

On the actual system, components and how it integrates into the building system
Considerations

Solving service call systems without clearly understanding the “ripple effect”
Considerations

“As designed” vs. “As Operated”
Considerations

To what level should we train O&M staff?

– Basis of training
  • How do the pieces fit together
  • Cause and effect
Considerations

Effective maintenance request system

– Users are less likely to fiddle around or “self-help” when an responsive maintenance system exists
– Chronic maintenance problems become visible allowing for proper fixes reducing user discomfort/dissatisfaction.
– Avoid possible higher repair/replacement/operating costs
Considerations

If building performance is way off design projections it could be due to:

– Systems not properly designed
– Systems not properly installed
– Systems not properly commissioned
– Systems not properly operated/maintained
– Systems not appropriate for current use
THE HORIZON
The Horizon

Water

– Energy and water nexus
– CBECs
  • Revitalized
  • Revision to include water consumption

Emphasis on Commissioning

– Consolidation and Control
– Government Policy
CONCLUSION
QUESTIONS?
Retro-Commissioning for Existing Facilities

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