Session 17: Construction Phase Commissioning: It’s Not Just Testing

Commissioning Findings from Design Review and Construction Observation

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“… Sometimes, the Magic Works and Sometimes It Does Not”

Chief Dan George as Old Lodge Skins in Little Big Man
A Problem in the Making

White cloud at the combustion air intake of a boiler on a common flue with other boilers:

- Condensing flue gas inside
- Carbonic acid
- Corrosion
  - Heat transfer surfaces
  - Combustion air system
  - Combustion air fan
  - Controls
  - Casing

Major Damage to 8 Boilers During Temporary Operation!
How Could This Happen?

• Commissioning Included From Early Design Phases
• Major Construction
• Experienced Design and Construction Team
• Owner Heavily Involved in Construction
• Problem Identified Early
• Problem Discussed Frequently
• Potential for Damage Acknowledged By All

• My answer:
  I don’t really know, but “sometimes the magic works and sometimes, it does not”.

This Begs the Question:

What Makes the Magic Work?
Starting Early Helps the Magic Work

The Owners intent to provide a high quality internal environment leads the commissioning provider to ask a question during a design review meeting:

*Do we really need to humidify in Seattle?*

_Hmmmm, lets think about that for a minute ...._

Seattle + Winter = Mild and Moist

There are approximately 384 hours per year (out of 8,760) where the outdoor specific humidity is below the bottom of the space design window. Approximately 71 of them occur when the building would be operating.
Looking Humidification in the Bigger Picture

- **Lost**
  - Absolute assurance that indoor humidity will not be below 25 - 30% for 70-100 hours per year

- **Gained**
  - $100,000 savings in first cost
  - $6,000 savings in annual operating cost

What Made the Magic Work?

**Technical Stuff**
- Being aware of the environment
- Commissioning

**Non-Technical Stuff**
- Thinking outside the box
- Flexibility
Does Fixed in Design Mean its Fixed?

Design review identified critical 100% Outdoor air AHU design issues:
- Desirability of maximum face area
- Need for access
- Need for space for freezestat
- Preheat vs. warm up issues

... and the construction drawings reflected these comments

The Shop Drawing Reflects a Problem

Note the lack of space between the coils!
Shop Drawing Mark-ups

- Note coil problem and other issues
- “Approved as Noted” to maintain schedule

The Equipment Arrives on Site …
... and a Problem Arrives With It

Coil connections match the uncorrected shop drawings, not the construction drawings

The Issues

- **Freezing Issues**
  - Equipment failures
  - Climate extremes

- **Access issues**
  - Maintenance
  - Sensor installation

- **Operational issues**
  - Potential nuisance shut downs
  - Draining the coil
The Good News

- The problem was solved without major modification or expense via:
  - Focusing on solving the problem rather than assessing blame
  - Flexibility on the part of the Owner, Designer, and Contractors
  - Thinking “outside the box”

The Solution

- Use a feed-forward control strategy to operate the preheat valve based on entering conditions rather than leaving conditions
- The chilled water coil backs up an evaporative cooling process, so keep the coil drained
- Start-up and continuous commissioning to make sure it all works
What Made the Magic Work?

Technical Stuff
– Being aware of the environment
– Commissioning
– Technology

Non-Technical Stuff
– Thinking outside the box
– Flexibility

Making the Magic Work Requires Attention on Many Commissioning Fronts

Out of sight, out of mind in the Midwest
– 100 kW of electric snow melt installed at the new Emergency Room entrance
– No energy management system tie-in

*Design phase Cx lapse*
Making the Magic Work Requires Attention on Many Commissioning Fronts

The commissioning process
- Turned on during a snow storm
- Success – No snow or ice at the ER entrance!
- Forgot to turn it off after the storm

Construction phase Cx lapse
- No utility bill tracking program

Ongoing Cx lapse

Long term results
- No snow or ice at the ER entrance all winter
- Dry sidewalks after a thunderstorm in July

Ongoing Cx insight
- 2,400 kWh per day for months!

Cash flow lapse
The Solution

• Turn off the snow melt in the summer
• Add a pilot light to the contactor
• Be more aware of what’s going on

What Made the Magic Work?

Technical Stuff
– Being aware of the environment
– Commissioning
– Technology

Non-Technical Stuff
– Thinking outside the box
– Flexibility
– Taking action
Making the Magic Work Requires Training

• Owner requirement
  – AHU starters have “Test” – “Off” – “Auto” switches
  – Safeties (including the freeze-stat) overridden in the “Test” position for troubleshooting purposes


Making the Magic Work Requires Training

• Engineer’s push-back
  – Prefer no safety overrides
  – If non-negotiable, then spring return from test

Making the Magic Work Requires Training

• The result
  – Frozen coil

• The reason
  – Lack of training on spring return feature
  – A crescent wrench clamped to the switch tang holding the switch in the test position

The Solution

• Train the operators
• Re-think compromise on critical issues
What Made the Magic Work?

Technical Stuff
– Being aware of the environment
– Commissioning
– Technology

Non-Technical Stuff
– Thinking outside the box
– Flexibility
– Taking action
– Courage of convictions

Magic Worked

Magic Didn’t Work
Knowledge Makes the Magic Work

- Mid-1980’s vintage Midwest high rise (13 floors)
- Engineered smoke control cycle
  - Shuts down and isolates some units
  - Runs others to pressurize or exhaust fire floor
- Control system addresses smoke damper interlocks
  - Analog discharge static limit control
  - Limit switches

Test Results – Initial Engineered Smoke Cycle Functional Test

- Smoke damper closure triggered by fire alarm.
- Fan shutdown triggered by smoke damper limit switch.
- Smoke dampers close in less than 1 minute (5 seconds).
- Duct is leak free.
- Duct pressure rating is good.
  - Ray Baltimore (control fitter) notes that the duct pressure gauge indicated 6 inches w.c. before we heard the bang; duct pressure class is 4 inches w.c.
Control System Design Didn’t Address:

Pneumatic actuator speed
– The control designer probably should have thought of this
– (The control designer was me)

Air hammer
– The control designer never heard of this until Tom (graciously) said “WE must have air hammered the duct!”

See the FT Guide supplemental information for Chapter 13 – Distribution to learn more about air hammer and how to prevent it.
The Solution

- Train the control designer/commissioning technician about air hammer (beyond having him blow the duct apart).
- Add restrictor tees to the bleed ports of the solenoids serving the actuators to slow them down on the close stroke.
- Zip screws
- Angle iron

What Made the Magic Work?

Technical Stuff
- Being aware of the environment
- Commissioning
- Technology
- Knowledge

Non-Technical Stuff
- Thinking outside the box
- Flexibility
- Taking action
- Courage of convictions
- Try to look on the bright side

Magic Worked

Magic Didn't Work
Lesson’s Learned Make the Magic Work
(Although some take a while to sink in)

- Mid-1980’s vintage Midwest low-rise (6 floors)
- Combination fire/smoke dampers isolate return ceiling from return shaft on fire alarm
- Control system addresses the potential for problems
  - Restrictors installed on the pneumatic actuators
  - Field personnel trained
  - Return static limit switches contemplated
    - Eliminated due to budget
    - “What could go wrong on the return side with the actuators slowed down, right?”

A Little Pressure Over A Lot of Area is What Can Go Wrong

- Air supplied to the dampers to hold them open for temporary AHU operation
- Fire alarm installation in progress
  - Fire alarm not powered up
  - Fire alarm relays energize solenoids to open dampers
    - Solenoid tubing connections temporarily reversed so non-energized solenoids hold dampers open
    - Condition placarded and discussed at job meeting
Test Results – Fire Alarm Panel Power-On Test

- Fire alarm panel inadvertently energized.
- Return shaft smoke dampers start to slowly close.
- Commissioning tech and control fitter on 3rd floor note “whooshing” sound.
- Ceiling tiles begin to drop from the grid around the return shaft as the shaft wall deflects.
- Commissioning tech and control fitter on 3rd floor put two and two together.

- Commissioning tech and control fitter exchange brief remarks about the situation.
- Control fitter makes mad dash to rooftop mechanical room and pulls disconnects on the air handling systems, averting disaster.
- Commissioning tech buys control fitter a 6 pack.
- Commissioning tech gets permission to purchase static limit switches.

What Made the Magic Work?

Technical Stuff
- Being aware of the environment
- Commissioning
- Technology
- Knowledge

Non-Technical Stuff
- Thinking outside the box
- Flexibility
- Taking action
- Courage of convictions
- Try to look on the bright side
- Being in good physical shape

Magic Worked

Magic Didn’t Work
Magic May Not Work if Things Are Cast in Concrete (But it may keep them from becoming that way!)

- Northwest Regional Training Facility and Warehouse
  - LEED Gold
  - Radiant slab heating
  - Turn-key project
  - Aggressive construction schedule

- Contractor concerned about radiant slab pour
  - Tubing located to miss future floor penetrations
  - Tubing supported to prevent damage during pour
  - Plan of action to detect and repair damage during the pour
  - Plan of action to document tubing installation before the pour

Contractor Requests Cx Support on the Morning of the Concrete Pour

Contractor responsibilities
- Tubing installed
- Concrete ordered and on the way
- Worry

Cx verification checks
- Tubing layout matches plans
- Tubing layout documented
- Tubing installed per manufacturers recommendations
- Plan of action to detect and repair leaks in place
- **Perimeter insulation in place**
Solution

- Send concrete trucks back
- Continue to breath normally
- Install insulation

What Made the Magic Work?

Technical Stuff
- Being aware of the environment
- Commissioning
- Technology
- Knowledge

Non-Technical Stuff
- Thinking outside the box
- Flexibility
- Taking action
- Courage of convictions
- Try to look on the bright side
- Being in good physical shape
- Luck

Magic Worked

Magic Didn't Work
Magicians Make the Magic Work

• Water feature pump targeted for impeller trim during ARC.
• Motor failure leads to motor replacement with a lower speed, lower horsepower motor

<table>
<thead>
<tr>
<th>Original</th>
<th>Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 hp</td>
<td>7-1/2 hp</td>
</tr>
<tr>
<td>20 amp</td>
<td>8 amp</td>
</tr>
<tr>
<td>1760 rpm</td>
<td>1180 rpm</td>
</tr>
</tbody>
</table>
Magicians Make the Magic Work

- Water feature pump targeted for impeller trim during ARC.
- Motor failure leads to motor replacement with a lower speed, lower horsepower motor.

Motor replacement cost - $1,000
Estimated savings per year - $4,000

Magicians Make the Magic Work

- Water feature pump targeted for impeller trim during ARC.
- Motor failure leads to motor replacement with a lower speed, lower horsepower motor.
  - Water feature aesthetics maintained
  - Preserves operation at “sweet spot” vs. impeller trim
  - Captures savings with normal maintenance expenditure.
Magicians Make the Magic Work

What Made the Magic Work?

Technical Stuff
- Being aware of the environment
- Commissioning
- Technology
- Knowledge

Non-Technical Stuff
- Thinking outside the box
- Flexibility
- Taking action
- Courage of convictions
- Try to look on the bright side
- Being in good physical shape
- Luck
- Leadership and enthusiasm

Magic Worked

Magic Didn't Work
Buildings Are Prototypes

• Complex interactive machines
• Built and operated in a highly dynamic environment
• Built under tight time and budget constraints
• Incorporate constantly changing and evolving technology

A Few Problems Shouldn’t Be A Surprise…

They Should Be Anticipated!

Design and Construction Phase Commissioning…

Part of the Magic that Solves or Prevents Problems…

... and, it Works More Often Than Not!
But, It’s More than Just Saying You’re Doing It

Technical Skills are Essential
- Familiarity with Commissioning
- Knowledge of the Fundamentals
- Familiarity with the Technology
- Being aware of the Environment

Other Skills Can Be **Extremely Useful**
- Thinking outside the box
- Flexibility
- Being Proactive
- Trusting Yourself
- Optimism
- Leadership and Enthusiasm

… and being open to good fortune can’t hurt!

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Try Some “Magic”;

Make
- Trouble-free verifications
- Smooth start-ups
- Long term benefits

appear on your projects

**Thanks for Attending!**

**Good Luck with your Projects**