Session 23 – New Commissioning Tools from a Collaborative Research Project
What is the Functional Testing Guide and How are We Enhancing It?

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Origins of the Functional Testing Guide

- Research and Development Project
  - California Energy Commission’s Public Interest Energy Research Program (PIER)
  - U.S. Department of Energy
  - Lawrence Berkeley National Laboratory’s High Performance Commercial Building Systems
- Original Goal
  - Compile a library of functional tests
  - Identify the gaps
Origins of the Functional Testing Guide

• Research and Development Project
  – California Energy Commission’s Public Interest Energy Research Program (PIER)
  – U.S. Department of Energy
  – Lawrence Berkeley National Laboratory’s High Performance Commercial Building Systems

• PG&E’s Commissioning Test Protocol Library
  – Focused on a similar goal
  – Reviewed 400+ functional tests
  – Compiled a library of publicly available tests
  – Not all testing requirements fully covered
  – Missing theory behind the tests

• NCBC 2000 Round Table Discussion
  – Should the project be re-focused?
  – What should the new focus be?
Origins of the Functional Testing Guide

• Research and Development Project
  – California Energy Commission’s Public Interest Energy Research Program (PIER)
  – U.S. Department of Energy
  – Lawrence Berkeley National Laboratory’s High Performance Commercial Building Systems

• Revised Goal
  – Complement the CTPL with a testing guideline
    • CTPL says *how* to test
    • FTG says *why*
      – Base on fundamentals
      – User adapts as needed
    • Provide cost benefit information
    • Begin to fill CTPL gaps
    • Provide a development framework

Released at NCBC 2003

• CD’s
  – NCBC
  – PG&E training classes

• Download from:

• Judging user acceptance
  – Feedback form at download
  – Word of mouth
  – LBNL survey
Enter, stage left: the DOE FT Guide Enhancements Project

- Project Goal – Enhance the FT Guide based on user feedback
  - Develop the Integrated Control and Operation Chapter
  - Expand the Guide
    - Pumping Systems
    - Chiller/Condenser Systems
    - Boiler Systems

Enter, stage right: the STAC* Project

- Project Goal - Address barriers to the widespread uptake of Cx
  - Enhance the FT Guide
  - Add tests to the FT Guide
  - Provide Cx and RCx training
  - Develop/deploy a functional test checklist tool

*State Technologies Advancement Collaborative
### Parallel FT Guide Development Paths, Comprehensive FT Guide Structure

<table>
<thead>
<tr>
<th>Test Specifications</th>
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<tbody>
<tr>
<td>Organized by System Components</td>
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<tr>
<td>Benefits and Tips Tables</td>
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</tbody>
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Integration Tests

**DOE Sponsored Integrated Control and Operation Chapter**

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### Current Status

**DOE Project**

- **Final Drafts**
  - Integrated Control and Operation Chapter
  - Integration related tests
    - Recovery from power outage
    - Fire and smoke damper
    - Building pressurization
    - Relative calibration
  - Benefits and Tips Tables
    - Pumping Systems
    - Chiller/Condenser Systems
    - Boilers
- **June 2005 Release**
Current Status

DOE Project

- Final Drafts
  - Integrated Control and Operation Chapter
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    - Building pressurization
    - Relative calibration
  - Benefits and Tips Tables
    - Pumping Systems
    - Chiller/Condenser Systems
    - Boilers
- Late May 2005 Release

STAC Project

- Research Conducted on the Use of the current FT Guide
- Top 25 Most Desirable Test Additions Identified

Top 25 Most Desirable Additions

(By rank)

1. Pump Performance Test
2. Freezestat Test
3. Evaporatively Cooled AHU Test
4. AHU Safeties And Integrated Operation Test
5. Valve Leak-by Test
6. Smoke/Fire Damper Test
7. Packaged Rooftop Units Test
8. Generic "Build Your Own Procedure" Form Test
9. Demand Controlled Ventilation Test
10. Visual Envelope Inspection Test
11. Discharge Temperature/Pressure Reset Interaction Test
12. Building Pressurization Test
13. Radiant Slabs Test
Top 25 Most Desirable Additions
(By rank)
14. Heat Recovery Ventilator Test
15. Power Failure Recovery Test
16. Steam Boiler Test
17. VAV Flow/System Integration Test
18. High Turn Down Ratio Test
19. Loss Of Control Network Communications Failure Mode Test
20. Air-cooled Dx Condenser Test
21. Stairwell Pressurization Test
22. Underfloor Supply Plenum Test
23. Heating Hot Water System Integration Test
24. Condensing Hot Water Boiler Test
25. Fluid Coolers Test

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STAC Project
• Research Conducted on the Use of the current FT Guide
• Top 25 Most Desirable Test Additions Identified
• Training curriculum developed
• Functional testing checklist tool
• Work to date released with the DOE June 2005 release
• Work still in progress will be released next year
Content Organization

- How to Use the Guide Chapter
  - Navigation
  - Commissioning process
- Introduction to Functional Testing
  - System concept
  - Elements common to all functional tests
- Individual component chapters
  - Move through AHU from inlet to exhaust
  - Integration issues
A Work in Progress

• Not all chapters fully developed in the first release
  – All chapters contain *basic* information
    • Testing benefits table
    • Testing field tips table
  – Some included supplemental information
    • Design related issues
    • Theory and details
  – Some include proposed development path

Using the FT Guide for Design Phase Cx

A successful test has its foundation in a good design
Reviewing the Design

Integrating design intent with operating reality
- Non-design conditions
- Non-steady state issues
- Operation and maintenance issues

Planning the Test

- Developing a commissioning plan
- Developing specifications
- Developing sample tests and first drafts
- Identifying additional design issues
Using the FT Guide for Construction Phase Cx

Proper design execution the key to success.

“Shhh, Zag! ... Here come one now!”

Reviewing shop drawings

Integrating design intent with operating reality
- Actual configuration vs. specified
- Actual performance vs. specified
- Actual accessories vs. specified

• Fixing things on paper is more cost effective than fixing them with a cutting torch
Monitoring Construction

Setting things up for success from the start
- Proper assembly
- Proper field application
- Accessibility for maintenance and inspection

Verifying Integrated Construction

Bringing the integration perspective to construction observation
- Assessing the installation of assemblies involving multiple trades and disciplines
- Verifying things that are hidden by subsequent construction
Planning the Test

Identifying potential weak spots and/or critical performance issues

- Potential field improvements prior to testing
- Future testing and verification targets

Using the FT Guide to Develop a Test

System manual discrepancy

- Economizer change over by comparison to return air temperature vs.
- Economizer change over based on outdoor air temperature

When the outside air temperature is greater than the return air temperature, the cooling coil chilled water control valve (TCV I) shall modulate vs. return to maintain the supply air temperature at set point and the economizer dividers shal be positioned to provide the minimum design outside air CFM. The exhaust fans EF-706 shall be programmed "off."

Supply Air Temperature: 59°F (15.0°C) Kest by Available Cooling Demand

Outdoor Air Temperature (TA): <72°F Economizer Operating Mode, >72°F Minimum Outside Air Operating Mode
How the Guide Might Help

• Understand economizer theory
  – General operating theory
  – Related parameters like minimum outdoor air and building pressurization
  – Typical components
  – Control strategies
  – Typical problems

How the Guide Might Help

• Understand economizer change over strategies
  – Approaches
  – Determining a set point
  – Equipment
How the Guide Might Help

• Provide a test template
  – Start with an existing CTPL test
  – Development options
    • Use the existing test on the fly
    • Quickly modify the existing test
    • Modify and format to your “look”
    • Use trending

Using the Calculation Appendix

Fan Energy: A Function of Head and Flow

\[ P_{Fan} = \frac{Q \times SP}{K \times \eta_{Fan} \times \eta_{Motor} \times \eta_{Drive}} \]

Where:
- \( P_{Fan} \) = Horsepower into the motor serving the fan
- \( Q \) = Flow rate in cubic feet per minute
- \( SP \) = Static pressure in inches water column
- \( K \) = Units conversion constant = 6,356
- \( \eta_{Fan} \) = Fan static efficiency
- \( \eta_{Motor} \) = Motor efficiency
- \( \eta_{Drive} \) = Drive efficiency
Fan Energy Savings

- Overview
  - Identifying energy savings
  - Troubleshooting
- Equations
  - Horsepower
  - Energy
- Additional Savings
  - Fan heat
  - Other resources
- Examples

The Control Design Guide; Part of the Package

Design/Operation Synergy

- Targeted at Designers
- Provides support for Commissioning Providers
Design Process and Point Selection Information

- Design process example
- Design aids
  - Spreadsheets for valve and damper sizing and scheduling
  - Standard details that can be opened in AutoCAD®
  - Quality improvement ideas
- Control points
- Monitoring points
- Safety points
- Sensor Selection
  - Calibration
  - Accuracy
  - Installation

System Configurations and Point List Recommendations

- Common system types
- Sample system diagram
- Point list recommendations
  - Starting point for construction documents
  - Control cost estimating tool
  - Design review tool for a Cx provider
Thanks for Attending!

The End