Engineer’s Perspective

Facts

- 80% of commissioning work is Controls.
- A successful project has all MEP systems operating properly to meet the Owner’s requirements.

Common miscues that lead to unsatisfactory projects

- Incomplete construction documents that lead to different interpretations.
- Engineers do not have a clear understanding of how equipment or the control systems work.
Common miscues (continued)

- Incomplete control diagrams
  - Not enough sensors/devices to aid commissioning
  - Unclear control sequences of operations
- Contractor indicates they are done with their work, but actually they are not
- Controls system check not performed
- CxA finds problems, but leaves it to the engineers to fix without providing recommendations.
Engineer’s Perspective

Design Process

• Determine Project Scope
  ▪ Programming with Owner input

• Develop Basis of Design (BOD)
  ▪ Establish design criteria
    - Codes and standards
    - Owner requirements and design guidelines
    - Budget limitations
    - Space restrictions
    - Energy efficiency goals
Engineer’s Perspective

Design Process (continued)

• Systems and Equipment Selection
  ▪ Required sizes and capacities

• Coordination:
  ▪ Confirm that the other consultants understand your requirements
  Do not assume they know and understand
    Email (paper trail) and follow-up with phone call
    ✓ Verbal interaction is more comprehensive
    ✓ Eliminates guessing and incorrect assumptions

• Review the other consultant’s drawings.
Design Process (continued)

- Understand how the specified equipment works
- Renovation projects
  - Review existing installation in detail.
  - As-built drawings are never 100% accurate.
  - Observe other disciplines’ installations that may impact your work.
- Documentation / Deliverables
  - Drawings
  - Specifications
- Design Review
- Issue for Construction
Engineer’s Perspective

- **Design Process**
  - Some sequences of operation are better than others, and not all engineers get the training they need to fully understand controls.
  - When the engineer does not have sufficient understanding of how controls work, SOO’s typically become “fuzzy” and open to interpretation.
  - It is possible they get implemented as intended, but just as possible they are misunderstood and implemented some other way.
Example of poor SOO: Chiller Plant

Typical SOO for secondary chilled water loop:

- A secondary pump, 02-GP-016, located in the pipe chase at the 3rd floor shall circulate secondary chilled water through a piping loop for equipment cooling on the 3rd floor, this pump will run whenever any process equipment requiring cooling is in operation.
- A 2" piping loop shall circulate 40 gpm of water or 25 tons of cooling based on a delta T of 15°F, 55°F supply and 70°F return, The pump shall circulate chilled water through the loop to meet a set point.

Which equipment is that? Not spelled out – is it possible the controls contractor will leave out some equipment which was intended to be included, and this will have to be found out during functional testing and remedied?
Example of poor SOO: Chiller Plant (continued)

- Typical SOO for secondary chilled water loop:
  - A secondary pump, 02-GP-016, located in the pipe chase at the 3rd floor shall circulate secondary chilled water through a piping loop for equipment cooling on the 3rd floor, this pump will run whenever any process equipment requiring cooling is in operation.
  - **A 2" piping loop** shall circulate 40 gpm of water or 25 tons of cooling based on a delta T of 15°F, 55°F supply and 70°F return, The pump shall circulate chilled water through the loop to meet a set point.

The size of the piping loop should not be in the sequence of operation – the controls contractor can’t help that!
Example of poor SOO: Chiller Plant (continued)

- Typical SOO for secondary chilled water loop:
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  - A 2" piping loop shall circulate 40 gpm of water or 25 tons of cooling based on a delta T of 15°F, 55°F supply and 70°F return, The pump shall circulate chilled water through the loop to meet a set point.

The pump shall circulate which –
- 25 tons worth of cooling – but what if the ΔT is not 15°F? The pump cannot force the water to come back at 70°F
- Isn’t the amount of cooling determined by whatever load is present, and not by what “the loop shall circulate”??
Example of poor SOO: Chiller Plant (continued)

- Typical SOO for secondary chilled water loop:
  - A secondary pump, 02-GP-016, located in the pipe chase at the 3rd floor shall circulate secondary chilled water through a piping loop for equipment cooling on the 3rd floor, this pump will run whenever any process equipment requiring cooling is in operation.
  - A 2" piping loop shall circulate 40 gpm of water or 25 tons of cooling based on a delta T of 15°F, 55°F supply and 70°F return, The pump shall circulate chilled water through the loop to meet a set point.

The pump shall circulate water to meet what set point?
- Pressure perhaps? Possible, but how? With a VFD? Is there one? Is the speed signal directly controlled off the setpoint?
- Or perhaps the pump is controlled to lower flow until the ΔT is at least 15°F? Possible
- Entirely up to contractor to decide what to do – or send 5 RFI’s for these 2 paragraphs
Engineer’s Perspective

Example of good SOO:
Manifolded Lab Exhaust Fans

NOTES:
1. VFD INTERFACE.
2. TEMPERATURE MONITOR.
3. STATIC PRESSURE MONITOR. SEE FLOOR PLANS FOR SENSOR LOCATIONS.
4. ISOLATION DAMPER.
5. ISOLATION DAMPER CONTROL. (NORMALLY CLOSED).
6. DAMPER CLOSE MONITOR.
7. SEE PLANS AND AIR FLOW DIAGRAMS FOR RISER ARRANGEMENTS.
8. EXHAUST FAN INLET AIRFLOW SENSOR.
9. EXHAUST AIRFLOW MONITOR.
10. 3rd FLOOR MAIN EXHAUST DUCT.
11. 2nd FLOOR MAIN EXHAUST DUCT.
12. 1st FLOOR MAIN EXHAUST DUCT.
Example of good SOO: Manifolded Lab Exhaust Fans

**SEQUENCE OF OPERATION**

FANS RUN ACCORDING TO SCHEDULE WITH RESPECTIVE SUPPLY FANS. AT NORMAL OPERATING CONDITION, ONLY 2 FANS SHALL OPERATE. THE THIRD FAN IS A BACK UP.

MONITOR THE EXHAUST DUCT AND PLENUM STATIC PRESSURE. VARY THE EXHAUST FAN SPEED TO MAINTAIN THE EXHAUST DUCT SETPOINT (LOW SELECTOR), INITIALLY SET AT –1.0” W.G.. TRIGGER ALARM IF IT EXCEEDS THE SELECTED POINT (LOW BY 20%). SELECT STATIC PRESSURE POINTS AS RECOMMENDED BY THE BALANCER.

THE FMCS SHALL SEQUENCE AND MODULATE THE LEAD AND LAG EXHAUST FANS TO MAINTAIN THE AVERAGE DUCT STATIC PRESSURE SETPOINT. THE FMCS SHALL MONITOR THE EXHAUST FAN AIRFLOW RATE AND SHALL LIMIT THE MINIMUM AIRFLOW RATE OF EACH FAN TO 50% OF THE MAXIMUM FLOW. (1750 FEET PER MINUTE OF STACK DISCHARGE VELOCITY).

MONITOR SP AT PLENUM AND DUCT BRANCHES. SEE PLANS FOR LOCATIONS AT DUCT BRANCHES.

IF ONE FAN FAILS, THE FMCS SHALL START THE BACK UP FAN AND SEND FAN FAILURE ALARM.

WHEN THE FAN STOPS OR FAILS TO OPERATE, THE ISOLATION DAMPER SHALL CLOSE. IF THE EXHAUST FAN IS COMMANDED TO RUN, THE FMCS SHALL OPEN THE ISOLATION DAMPER FIRST AND RAMP START THE FAN WHEN THE END DAMPER SWITCH CLOSE SIGNAL IS OFF. FAN SHALL NOT START IF THE ISOLATION DAMPER IS CLOSED. SEND ALARM FOR ISOLATION DAMPER FAILURE.

ROTATE THE HEAD, LAG AND BACKUP FAN MONTHLY, OR AS DIRECTED BY THE UNIVERSITY.

SAFETY: THE EXHAUST SYSTEM SHALL CONTINUOUSLY RUN IN AUTOMATIC MODE IN ALL FIRE ALARM CONDITIONS.

MONITOR FAN VFD.
Engineer’s Perspective

Construction

- Pre-construction meeting w/sub-contractors:
  - Review project scope
  - Flag areas of importance or requiring careful coordination
- Respond to RFI’s
- Submittal Review
- Periodic field observations:
  - Catch mistakes early, instead of waiting until the end.
  - Review equipment start-up.
  - Report observations.
Engineer’s Perspective

- Near End of Construction
  - Equipment Start-up
  - Commissioning (Cx)
    - Preliminary meeting w/CxA to review design intent.
    - Review Pre-commissioning checklist & FPT’s.
    - Review Cx Plan.
    - CxA is the engineer’s second eye in the field.
    - Participate in correcting problems.
      Work with CxA and Subs
  - Performance Evaluation
    - *Are Expectations Met?*
Reference materials:

- ASHRAE Standard 202
- CalGreen chapter 5 Cx rules
- LEED Cx rules
- ASHRAE Guideline 0
- CCC Commissioning Guide
- Many other Cx guides also in circulation
CxA’s Perspective

- Major milestones in almost all of the standards and guidelines: CxA involved with
  - OPR creation (before design)
  - BOD review (during design)
  - Design review (may be multiples, but usually at least the 90-95%CD set)
  - Submittal review
  - Issues log tracking
  - Startup/checkout forms review
  - Test creation, Contractor test review, witness test
  - Training assistance/attendance
  - O&M and Record Drawing review
  - Systems Manual
In all of these steps, the CxA in an ideal world:

- Is the Owner’s eyes and ears, has the Owner’s confidence
- Has no contractual link with any of the contractors (and so cannot instruct them directly outside of their specified/contractual obligations)
- Is included in all relevant jobsite correspondence
- Makes complex issues more intelligible to Owner, provides feedback on what is factually true or not in technical discussions, and assists in resolving issues by thinking as an unencumbered third party
Case Study 1

- Specification for controls sequence could not be executed
  - EC-1 evap cooled unit serves tenant spaces, those spaces were not in base contract
  - Air supply to those spaces dependent on TAB results
  - But no TAB could be done because tenants not built out yet – originally scheduled overlap did not occur
Case Study 1

Correct Resolution:

A. Controls contractor brings the issue up in Cx meeting
B. CxA confers with EofR and notes in issues log
C. EofR/Owner agrees to recommended solution
D. RFI officially submitted and answered as project paper trail
E. Tests re-written and executed with new sequence
Case Study 1

- The mechanics of this process should be discussed in the OPR phase and recorded in the Cx Plan!
  - Who does what
  - What document transfer mechanisms are used
Case Study 1

- Correct Resolution:
  A. Controls contractor brings the issue up in Cx meeting
  B. CxA confers with EofR and notes in issues log
  C. EofR/Owner agrees to recommended solution
  D. RFI officially submitted and answered as project paper trail
  E. Tests re-written and executed with new sequence
Case Study 1

Correct Resolution:

A. Controls contractor brings the issue up in Cx meeting

EC-1:
I have a question about running EC1. According to the sequence of operations EC1 runs at various set speeds depending on how many FC's are running. I need to know those speed set points as percentages to command EC1. It looks like all three FC's run at 2000cfm so I would need (3) set points.

Asked – did not just re-program “as necessary”
Correct Resolution:

B. CxA confers with EofR and notes in issues log

The sequence (Shown on page 80 of 321 in the approved controls submittal) currently just uses the dampers as isolation dampers, and the airflow sensors as consumption meters for billing purposes. So the sequence would change to read as follows:

- Fan Speed Control: Fan speed shall be controlled to maintain duct static pressure at setpoint. Duct static pressure shall be reset in a slow-acting loop to maintain the airflow of each of the (3) airflow sensors at setpoint. The airflow sensor whose reading is furthest from setpoint (in %) shall be used as the input to the control loop which resets duct static pressure. Each flow setpoint shall be individually adjustable. Initial values shall be set at 2,000 cfm per flow station.

CxA Suggestion
Case Study 1

Correct Resolution:

B. CxA confers with EofR and notes in issues log

<table>
<thead>
<tr>
<th>Priority</th>
<th>Issue#</th>
<th>Started</th>
<th>Title, Description, Proposed and Final Resolution</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not Prioritized</td>
<td></td>
<td>11/5/2013 EC-1 operation for fan speeds - Not clear how to operate EC-1 fan speeds, since no tenant ductwork is connected, Proposed: Balance with temporary duct, later tenants will have to match</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>11/5/2013</td>
<td>28 days</td>
<td></td>
</tr>
</tbody>
</table>

12/3/2013 Agreement from [REDACTED] Engineer of Record that operation of EC-1 should be based on existing airflow sensors and volume dampers for back of house areas. [REDACTED] to change sequence accordingly.

11/5/2013 Fancoil units are not in [REDACTED] contract, and still covered in plastic wrap, but no ductwork connected to FCU's so cannot balance them. Could put a dummy duct on the units for a traverse reading, but with new tenants and custom ductwork, this pressure loss will change and EC-1 speeds will change.
Case Study 1

Correct Resolution:

C. Engineer of Record and Owner agree to recommended solution

From: [Redacted]
Sent: Tuesday, December 03, 2013 2:12 PM
To: Reinhard Seidl
Cc: [Redacted]
Subject: [Redacted]

Reinhard,
I am in agreement with this approach.
Thank you, [Redacted]

EofR Agreement
Case Study 1

Correct Resolution:

D. RFI officially submitted and answered as project paper trail

J. INDIRECT EVAPORATIVE COOLING SYSTEM (EC-1)

4. Fan Speed Control: Fan speed setpoints shall modulate to maintain supply air duct static pressure setpoint of 1.0"WC (adjustable) when unit is on. be determined and programmed as setpoints during balancing for the following operating conditions: The modulating zone dampers for BOH 1, BOH 2 and BOH 3 shall modulate to maintain the required fixed supply airflow required for each space (refer to Tenant Drawings) as measured by the airflow stations in each space.

Design change issued
Case Study 1

Correct Resolution:

D. RFI officially submitted and answered as project paper trail

Issues log for design change closed out
Case Study 1

- Correct Resolution:
  - D. RFI officially submitted and answered as project paper trail

### Issues Log for Design Change

<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/5/2013</td>
<td>EC-1 operation for fan speeds - Not clear how to operate EC-1 fan speeds, since no tenant ductwork is connected, 77 days. Proposed: Balance with temporary duct, later tenants will have to match.</td>
</tr>
<tr>
<td>1/21/2014</td>
<td>Response to RFI 1757 issued with updated sequence. Unit now operates to maintain fixed static pressure and dampers in main branches maintain fixed airflow to tenants or set during completion of TI work.</td>
</tr>
<tr>
<td>12/3/2013</td>
<td>Agreement from Engineer of Record that operation of EC-1 should be based on existing airflow sensors and volume dampers for back of house areas.</td>
</tr>
<tr>
<td>11/5/2013</td>
<td>Fancoil units are not in spiraloc contract, and still covered in plastic wrap, but no ductwork connected to FCU’s so cannot balance them. Could put a dummy duct on the units for a traverse reading, but with new tenants and custom ductwork, this pressure loss will change and EC-1 speeds will change.</td>
</tr>
</tbody>
</table>

Implement new sequence prior to testing. See continuation of airflow on EC-1 in issues log #8 during field testing - issue closed here.

Issues log for design change closed out.
Case Study 1

Correct Resolution:

E. Tests re-written and executed with new sequence
Case Study 1

- Correct Resolution:

E. Tests re-written and executed with new sequence
Case Study 1

- Correct Resolution:

E. Tests re-written and executed with new sequence

Testing related Issues for this unit go from 3/12/2014

3/12/2014
Airflows are lower than reported; pressures, fan power and flows don't seem to add up.
Not clear if unit is (2) 5 Hp motors as shown on TAB report or (2) 10 Hp motors as shown in submittals. EoR to confirm design
Case Study 1

- Correct Resolution:

**E. Tests re-written and executed with new sequence**

Testing related Issues for this unit go from 3/12/2014 through 8/6/2014.

8/6/2014 TE review - request confirmation that earlier test results that showed unstable heating and cooling (cycling) have been resolved before final witness test.
Correct Resolution:

**E. Tests re-written and executed with new sequence**

Testing related Issues for this unit go from 3/12/2014 through 10/10/2014...

10/10/2014  Review of latest TAB report, section 6.32, deliverable 230593 rev.4 from 9/18/2014: EC-1 Design is 22,400 cfm but actual air supply to 3 current tenants should be 2,000 cfm, 6,920 cfm to , and 6,300 cfm to the for a total of 15,970 cfm.

The TAB report shows 6,780 cfm on December 2, 2013 and 9,460 cfm on December 19, 2013. That is not the appropriate record, even if entries in the issues log report show a later RFI 1765 and approval for to change the unit’s control strategy in September of 2014. The TAB results from December 2013 should be updated to reflect final conditions.
Case Study 1

Correct Resolution:

E. Tests re-written and executed with new sequence

Testing related Issues for this unit go from 3/12/2014 to 4/26/2015..


4/26/2015 TE review shows TI values close to measured values, and original EC-1 setpoints also close to measured values. EoR and [ ] to confirm whether this is acceptable.
Case Study 1

Correct Resolution:

1. Did not take “shortcuts”
2. Lots of paperwork, seems like overkill
3. True for one issue, but had ~80 similar issues on the project
4. Multiple issues cross-related. Incorrect TAB resulted from mid-stream change of sequence
5. Without good record keeping and tracking, these relations are lost and confusion reigns “that never worked”
Case Study 2

- Not related directly to controls
- But an example of why building engineer can end up with a system that does not work
Miscommunication

- CxA hired long after contracting team on board, and after submittals started to be submitted (not atypical)
- CxA attempting to catch up on submittal reviews
- Getting messages that reviews are overdue, but no notice that submittals were received, and unable to find submittals in project management platform
Case Study 2

- Attempt to clarify, from CxA to EofR

Deliverable numbering does not match

Thanks for the heads up.

1. I only have the 5/19 VFD submittal and our 5/23 response.
2. For “Piping Specialties” I have 232114 as the submittal number (I don’t have 232116 at all) from 5/19, with a 5/23 response from us.
3. I replied to split units 238126 on 7/3, see attached. However, I reviewed the 5/28 version and not the 6/26 version you show which I don’t have.
4. Pumps – we’ve reviewed the 5/19 version but not the 6/20 version which I don’t have.

So perhaps there’s a few submittals that got lost in the shuffle as I handed the project to me – I looked at the website, the program has an “open submittals for your review” section, but it’s blank, and when I talked to Ed the other day, he mentioned he doesn’t use that program, since they track items separately.

If you can help me figure out how to get these submittals (or just send them to me), I will review ASAP.

I have asked that take off their distribution list, and put me on it – not 100% sure that’s happened yet, but we should be ok from here on out I hope – I should be getting updates from now on.

Apologies for the inconvenience.
Case Study 2

- Attempt to clarify, from CxA to EofR

Thanks for the heads up.

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Case Study 2

- Attempt to clarify, from CxA to EofR

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I have asked that take off their distribution list, and put me on it – not 100% sure that’s happened yet, but we should be ok from here on out I hope – I should be getting updates from now on.

Apologies for the inconvenience.
Case Study 2

Attempt to clarify, from CxA to EoF

Delivery method unclear

Thanks for the heads up.

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2. For “Piping Specialties” I have 232114 as the submittal number (I don’t have a 232116 at all) from 5/19, with a 5/23 response from us
3. I replied to split units 238128 on 7/3, see attached. However, I reviewed the 5/28 version and not the 6/26 version you show which I don’t have.
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If you can help me figure out how to get these submittals (or just send them to me), I will review ASAP.

I have asked that [person] take [person] off their distribution list, and put me on it – not 100% sure that’s happened yet, but we should be ok from here on out I hope – I should be getting updates from now on.

Apologies for the inconvenience.
After numerous phone calls, discover that the whole setup from the beginning was incorrect – CxA was directed to the contractor’s site, not the design team site.
Case Study 2

- Correct setup:
  - One site for constr. team
Case Study 2

- Correct setup:
  - One site for constr. team
  - Send submittal
Case Study 2

- Correct setup:
  - One site for constr. team
  - Send submittal
  - Second site for design team
  - CxA and rest of team is notified of submittal posting
  - CxA reviews
  - EofR reviews, taking CxA comments into account
  - Owner is notified of review
Correct setup:

- One site for constr. team
- Send submittal
- Second site for design team
- CxA and rest of team is notified of submittal posting
- CxA reviews
- EofR reviews, taking CxA comments into account
- Owner is notified of review
- Review back to contractor
What actually happened?
- CxA was assigned to contractor site
- Contractor posts submittal
- CxA and rest of team is notified of submittal posting
- CxA reviews
- Contractor sees CxA review, EofR has not commented
Case Study 2

- What actually happened?
  - CxA was assigned to contractor site
  - Contractor posts submittal
  - CxA and rest of team is notified of submittal posting
  - CxA reviews
  - Contractor sees CxA review, EofR has not commented
  - Contractor sends response to CxA comments
  - EofR, Owner confused
Case Study 2

- Submittal review process “So Obvious” there is no need to discuss?
  - Many processes have been done often in the past, but often done badly
  - The whole point of Cx is to do them better
  - The mentality of ACTUALLY doing them better (rather than just hoping to do so) takes some time to set in

- Holds true for many other aspects of projects undergoing Cx
Typical items, done “old style”

- CxA not brought on board early
- Reviews and project exchange mechanism not configured well
- Record keeping and sign-off not agreed upon well or executed consistently
- Issues log recording and follow-through not done consistently (trail goes cold after a few months)
- O&M’s much too late
- Warranty letters delivered after end of warranty
“Controls don’t work!”

- So keeping the “old style” working mentality in mind can “controls not working” be because

  - Original design review comments on controls were never responded to?
  - The submitted control sequence was never signed off on?
  - No end-to-end checkout was ever done (or if submitted, was signed long after tenant move in and only because CxA kept asking?)
  - Functional tests failed but were never resolved because nobody “hunted” down issues in the issues log after contracting team left?
  - Trend review showed problems but was not followed through on?
“Controls don’t work!”

- Example end-to-end checkout

<table>
<thead>
<tr>
<th>Tag No.</th>
<th>Comments</th>
<th>Expected Result</th>
<th>Observed Result</th>
<th>Initials</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC-12</td>
<td>Fan Coil</td>
<td>HMI and Field Device Agree.</td>
<td></td>
<td>MD</td>
<td>05/09/14</td>
</tr>
<tr>
<td>FC-16</td>
<td>Fan Coil</td>
<td>HMI and Field Device Agree.</td>
<td></td>
<td>MD</td>
<td>05/09/14</td>
</tr>
<tr>
<td>Zone 1 - 2</td>
<td>Radiant Zone 1-2</td>
<td>HMI and Field Device Agree.</td>
<td></td>
<td>MD</td>
<td>05/09/14</td>
</tr>
<tr>
<td>GAS Meter</td>
<td>Turned grill off and on</td>
<td>HMI and Field Device Agree.</td>
<td></td>
<td>MD</td>
<td>05/12/14</td>
</tr>
</tbody>
</table>

- Every item looks exactly the same
- One single checkmark for an entire fancoil unit
- Every point on the facility (200 ksqft) checked in a few days by one single technician. Tenants moved in Jan 2014

- Do you believe it?
“Controls don’t work!”

- Led to 140 items flagged by building engineer where interface and field devices were not communicating correctly

<table>
<thead>
<tr>
<th>Item</th>
<th>Origin</th>
<th>Description</th>
<th>Assigned</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td></td>
<td>EC-1 link does not work</td>
<td>TB</td>
<td>Done</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td>VAV-005 is not being picked up by schedule for occupied time.</td>
<td>TB</td>
<td>Done</td>
</tr>
<tr>
<td>33</td>
<td></td>
<td>CHW VFD link does not work on water systems page</td>
<td>SR</td>
<td>3/1/14</td>
</tr>
<tr>
<td>34</td>
<td></td>
<td>DHW circ pump command and status do not match.</td>
<td>TB</td>
<td>4/3/14</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td>FC-13 not working.</td>
<td>TB</td>
<td>Done</td>
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<tr>
<td>36</td>
<td></td>
<td>Tenant schedules?</td>
<td>TB</td>
<td>Done</td>
</tr>
<tr>
<td>37</td>
<td></td>
<td>No bank space VAV on graphic for 1st floor.</td>
<td>TB</td>
<td>Done</td>
</tr>
<tr>
<td>38</td>
<td></td>
<td>No graphic for [redacted] VAV.</td>
<td>TI</td>
<td>Done</td>
</tr>
<tr>
<td>39</td>
<td></td>
<td>No graphic for [redacted] FC</td>
<td>TB</td>
<td>4/8/14</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>No graphic for [redacted] FC or VAV</td>
<td>TB</td>
<td>4/9/14</td>
</tr>
<tr>
<td>41</td>
<td></td>
<td>[redacted] VAV graphic.</td>
<td>TB</td>
<td>Done</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td>[redacted] VAV should be shut off when sliding door is opened.</td>
<td>TB</td>
<td>Done</td>
</tr>
<tr>
<td>43</td>
<td></td>
<td>Interlock for sliding door at [redacted] does not work.</td>
<td>TB</td>
<td>Done</td>
</tr>
</tbody>
</table>
Lessons Learned

- Leave a “trail of breadcrumbs” that allows complex systems to be re-visited and changed throughout construction project
- Stick to the facts
- Respect the chain of command
- Actually do what the Cx standards and guidelines say, don’t just make a lots of documents that let you pretend that you did
The Controls Contractor (CC)

- Works for the GC, often under the MC
- Performs work as specified in contract documents, with a design-build component.
- Generally responsible for installation, programming, user interface, control system startup, and training.
- Often the last contractor off the jobsite.
Primary difficulties with the CC:
- System functionality doesn’t meet the intent of the engineer, CxA, and/or Owner
- Poor quality control and/or documentation

The CC’s most common difficulties:
- Incomplete or boilerplate design documents
- Vague or irrelevant RFI responses
- CxA brought on late, raising issues post-submittal
- CxA asking for procedures not known at bid time
SUCCESS: What does it look like?

- Mutual success is impossible to achieve unless everyone agrees on what it is!
- Building Controls are complex and misunderstandings are very common.
- The CC, Engineer, and CxA must determine and review project intent & expectations in the beginning and throughout the project.
CC’s Perspective

Assuming that the CC and Cx were not involved in the design process (great if so but the exception rather than the norm), the first major opportunity is…

The Controls Submittal

- Datasheets
- Control Drawings
- Sequence of Operation

Who reviews it:

- The Engineer of Record
- The Owner and CxA
- Any other interested parties
CC’s Perspective

- The Submittal Review is crucial in defining project success!
  - A thorough and timely review helps all parties
  - Revisiting the design late in the job almost always results in pain
  - It is often valuable to supplement the hard review process with a clarification meeting.
  - An “approved” submittal (*i.e. one that doesn’t say Revise & Resubmit*) is the foundation for both the CC and CxA’s work ahead.
CC’s Perspective

- Post – Submittal Approval: CxA
  - All CxA’s should have a good tracking log to use
CC’s Perspective

- Post – Submittal Approval: CxA
  - CxA should begin creating PFTs and Functional Test Procedures right away to be reviewed by the CC and Engineer.
  - Pre-Functional Tests are rarely completed accurately for a variety of reasons.
  - CxA’s often purpose to visit jobsites during Point to Point checkout / PFT but rarely do – we recommend it.
  - Time spent during PFT will usually translate into time saved during FT, when schedules are tight.
CC’s Perspective

- **The “Soft” Submittal**
  - Depending on the project, a programming and graphics submittal may be a valuable requirement.
  - Provided late in project by necessity
  - Includes logic created from SOO & graphic pages

- **Review Meeting with Engineer, CC, & CxA**
  - Printouts are nearly worthless. Meet in person!
  - CC Programmer will walk through logic for clarity.
  - Assures all parties that sequence is implemented.
Functional Testing: Crunch time!

- If success was defined early on and communication was maintained, the most intense and challenging part of the project will become much easier due to management of the factors within our control.

- Even if deficiencies were found early on and documented, but a resolution was not reached, at the very least there will not be surprises, and the Owner / GC will be able to respond appropriately and in good time.
CC’s Perspective

The Future Looks Bright

• Networking technology will improve the commissioning process
  ▪ Dedicated BMS network architecture
  ▪ Machine-Machine 4G/Wireless routers
  ▪ Independent BMS servers & cloud storage

Technology will not replace diligence in communication and collaboration!