USING COMMISSIONING TO MAKE BUILDINGS BETTER

WHAT WE WISH EVERYONE KNEW

Taitem

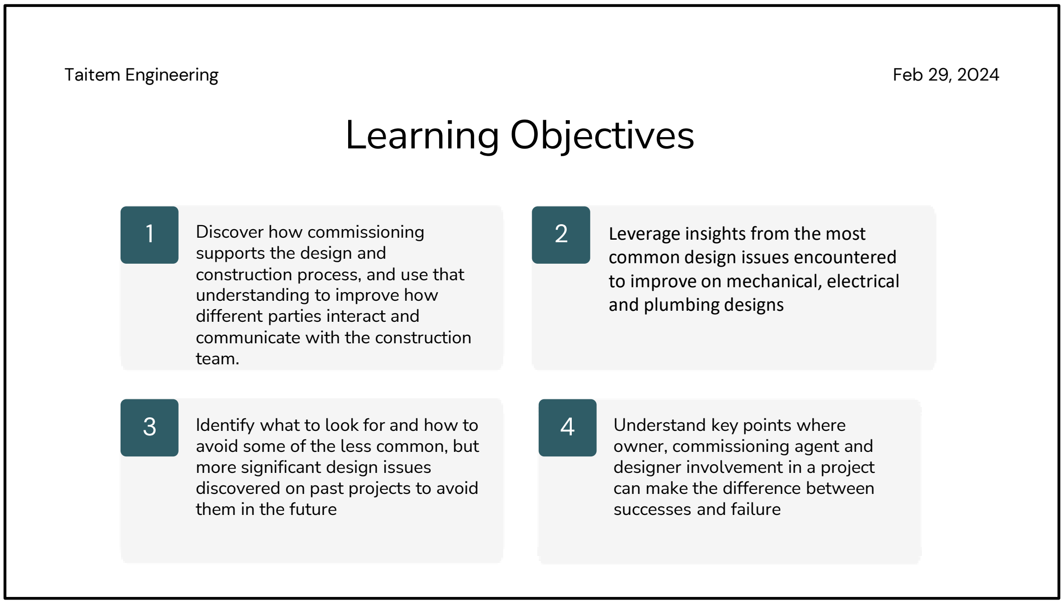
Certified B Corporation

Buildings are starting out compromised

- Some common issues – some more preventable than others
- See these on a significant percentage of projects
- How do we minimize this at scale?

https://commons.wikimedia.org/wiki/File:Leaning_Tower_of_Pisa_%284%29.jpg

Will get into more details on this more, but this is the crux of our presentation – what tools can we give you to avoid some of these common pitfalls



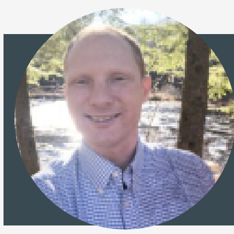
Obligatory intro stuff-

Bottom line – we want you to walk away with some concrete tips on ways you can avoid some of these issues, and an increased awareness of common problem areas

Who We Are

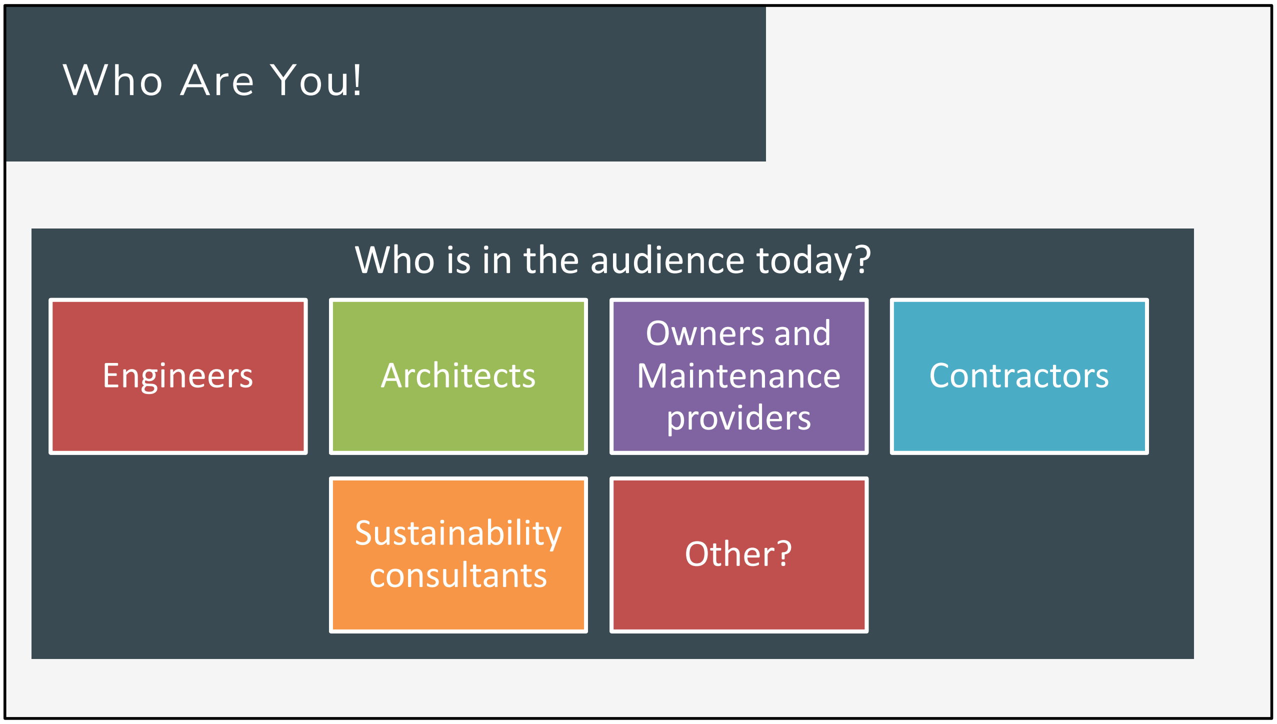
Taitem

Full Service Consulting Engineers



NATE GOODELL, PE, CCP, EBCP
SENIOR ENGINEER

You can read my bio later, but as a point of interest, I have experience as both a design engineer, commissioning agent and commercial building owner, so I have a little insight from multiple different perspectives.



Raise your hand if you fall into the red (engineers, consultants), green (architects), purple (ownership), blue (contractors/installers) or orange (other?)

Presentation Organization

Intro
- Defining the problem

Lighting Controls
- Problems and Solutions
- Example

Plumbing Systems
- Problems and Solutions
- Example

Mechanical Systems
- Problems and Solutions
- Example

Controls
- Problems and Solutions
- Example

Conclusions & Questions

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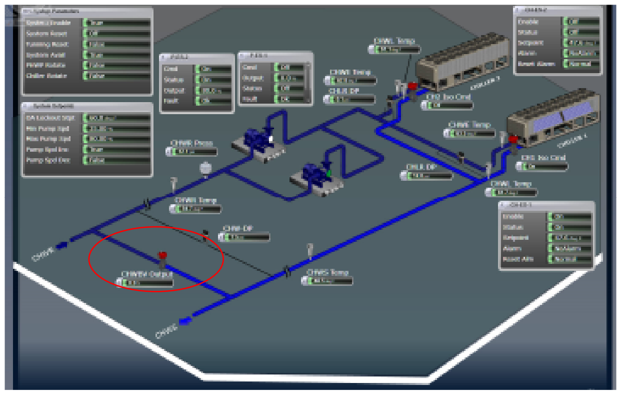
This is way more detail than you need, just note that we will start each section with an overview of issues, and then move into a more interactive applied example

DEFINING THE PROBLEM:

Buildings are starting out already compromised

What do we mean by this?



Lets get back to my first real slide – the WHY are we giving this presentation – Well, first, what are we talking about when we say buildings are compromised?

Simple example:
- chillers require a certain amount of water flow through them to operate. Often that is more than the flow required by one or two terminal units calling for cooling.
- To combat this, we design in a bypass, so water can circulate back through the chiller without needing to go through the terminal units
- What happens when this bypass is undersized (by design, or poor installation), or more commonly, the chillers go through a substitution *or product upgrade*, and now require a higher minimum flow rate?
- Usually the owner/project team don't put in temporary cooling, drain the system and replace the bypass with a correctly sized one. They usually try to make what was installed work.
- This results in the chillers cycling, not being able to handle part loads well, resulting in efficiency impacts and usually some level of comfort impacts.

This is a key crux of our presentation – how do we prevent this! And how do we prevent it in a better way than one project at a time?
- I don't have a good answer for the chiller example, other than having this issue on your radar and looking closely at equipment substitutions, but there are some issues that we do have some easier solutions for.

And with that, lets jump right into the lighting controls section

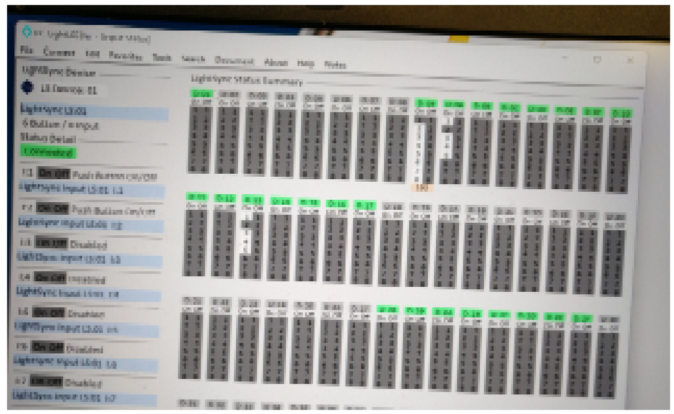
8:00

Lighting Controls

TAITEM ENGINEERING

Lighting Controls

- Increasingly sophisticated & networked
  - More capabilities!



- But…does complicated = better or more energy efficient?

Increasingly sophisticated and networked:

But…does complicated = better or more energy efficient?

Harder to setup correctly, troubleshoot and correct if there are problems

Owners don't always understand the system

Proprietary sequencing/algorithms (not always interchangeable)

Still see the standard 15 minute delay

- in my experience, the more complicated the system, the more likely it is to have really conservative defaults programmed to ensure occupants don't complain (because owners and techs don't want to have to make adjustments)

- so far – 100% of the networked systems we have commissioned have had major operational issues

Lighting Controls

- What do we need to do to make these work?

- Clear upfront understanding of owners goals, and local requirements
- Clear basis of design/intended sequence
- Work closely with the system vendor
- Substitutions may not be practical
- Include training in the specs for the owner

Solutions:

Clear upfront understanding of owners goals, and local requirements

Consider not having things be so complicated

Do we need networked controls?

Automatic adapting systems?

Stand alone system with 30 second off time…

If you do go with the complicated system:

Clear basis of design/intended sequence

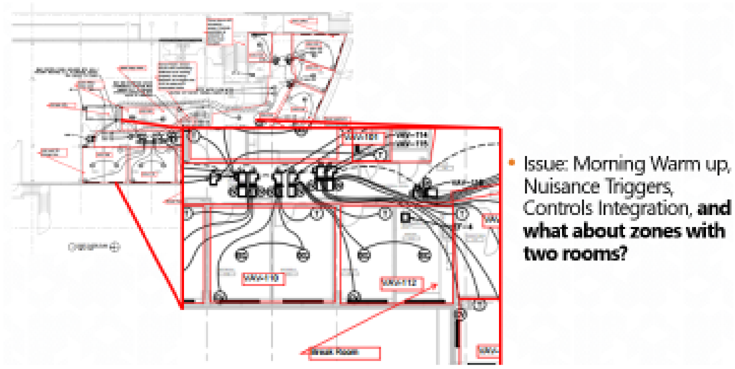
Substitutions may not be practical

Work closely with the system vendor

Include training in the specs for the owner

11:00

Occupancy and HVAC integrations



Lighting control zones vs. VAV thermal zoning

Suggestions:

Scheduled pre-warm,
Reduced daytime setbacks
Primarily use to control ventilation

Differences in zoning, speed of response
- it takes spaces a while to heat up (versus turning the light on)
- not unusual for two rooms to be on a shared HVAC zone, but they will definitely have individual lighting controls

Solution – scheduled pre-warm, reduced daytime setbacks- primarily use to control ventilation

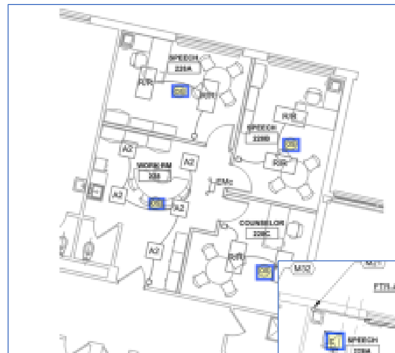
As time allows:

Clearly define responsible parties
- three or four different contractors could be involved in connecting occupancy sensors to the HVAC system – who does what? Who has the overall responsibility for making it work?

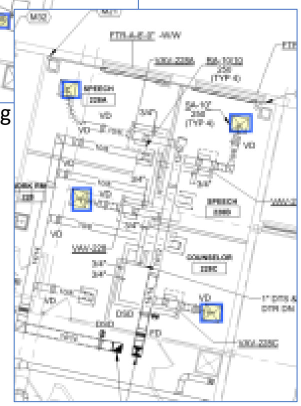
BMS monitoring systems
- some temperature controls now have integrated occupancy sensors – not always a great fit due to temperature sensor locations
- more advanced lighting controls often getting digital signal (not latching relay) to indicate occupancy triggers, etc. Need to ensure the two systems are on the same page

Installation Issues:

- Sensor locations:
  - Proximity to HVAC: 50%
  - Open door/nuisance triggers: 15%
  - Unexpected Furnishings: 10%
- Mechanical vs Digital Switches: 15-20%
- Failure to Program: 75%
- Bonus: Small movement vs. large movement sensors



Lighting Controls drawing



Ductwork (diffusers) drawing

These percentages are roughly how often we see this as an issue in projects. For the sensor locations, that is on a per-space basis, others are likelihood that it will occur at least a couple times in a project.

So – what you should do:
- keep sensors 5’ from HVAC vents, 12 feet away from other ultrasonic sensors
- mask sensors as needed to prevent nuisance triggers
- Understand where furniture is likely to be, and its effects. We saw some really interesting things with plexiglass shields added during covid for example

Mechanical vs. digital switches –
- ensure you are not cutting power to the sensor when you turn out the lights
- what happens with a vacancy or occupancy sensor when the switch is off? What happens with a vacancy sensor when the switch is left in the on position?

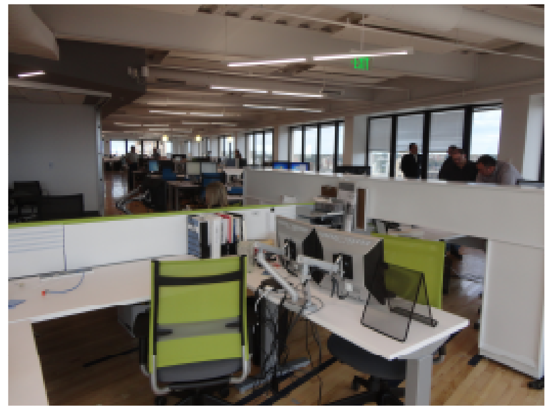
Very rare that we see a contractor take the time to do any custom programing for individual space sensitivities, often we don’t even see them adjust the time delays to what is called out in the drawings.
- Owners –you need to reach out if a space is not responding correctly. Have heard over and over again of spaces where occupancy sensors are just disabled because the sensitivity is not set correctly

Often not specified differently, but when they are, these are easy to get mixed up – want small movement for offices, large movement for corridors.

Daylight Harvesting

18:00

- Non-trivial to install and configure correctly: 90%+ failure rate
  - Multiple projects have reported that they won't do it again after bad experiences
- Solutions?
  - Still working on solutions other than ensuring testing, training and calibration are well defined in scope



Non-trivial to install and configure correctly

Should be done at three times prior to turnover

Bright light,

Overcast/night

When space is fully furnished

We have seen it done correctly first time on ONE project so far.

Bottom line – its just not that simple to do well

Multiple projects have reported that they won't do it again after a failed initial project

Still working on solutions other than ensuring testing, training and calibration are well defined in scope


19:00
Lighting Control
EXAMPLE

Vacancy sensor lighting controls

- Ceiling dual tech occupancy/vacancy sensor, with wall mounted on/off switch.
- Requested sequence:
  - Lights are turned on manually,
  - Auto off after 10 minutes
  - Occupants can manually turn off sooner

So lets set the scene – you are working on a general office building, and looking at a larger training room (but pretty typical of all the open office space)

The Issue(s):

- Sensor powered by wall switch
- System left in default occupancy mode
- Ceiling sensor located right by HVAC diffuser
- Mechanical (not digital) on/off switch used

- Solutions:
  - controllable relay, permanent power to sensor, careful coordination of sensor placement

First two you can't know from the photos:
Sensor powered by wall switch- not super common – seen on 3 or 5 projects – usually caught by installing contractor
(when switch off, no power to sensor, slight warm up time, which resulted in delayed light on time)
System left in default occupancy mode- super common, 75% or more of the time we see this.
(not how the owner requested, slight energy impact)

How many people had those on their radar?
Anyone see others from the photos?

Ceiling sensor located right by HVAC diffuser
(false triggers) – remember, that is pretty common

Mechanical (not digital) on/off switch used – less common, but harder to correct
(if the system was manually turned on, but turned off on vacancy, you have to turn the switch off then on to turn the lights back on)

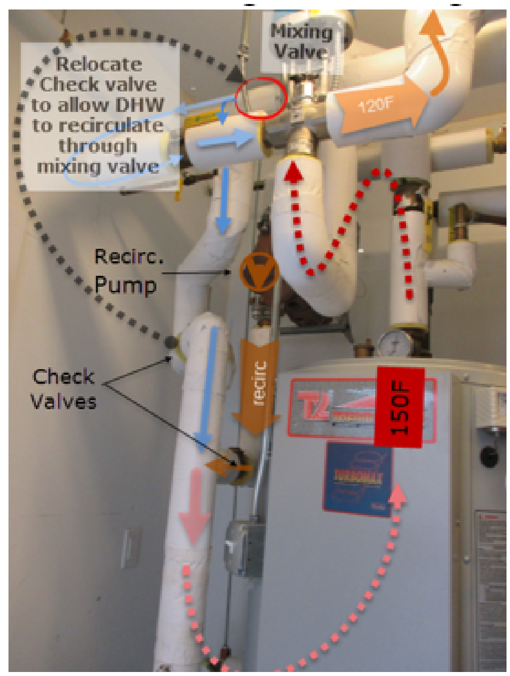
21:00

Plumbing

TAITEM ENGINEERING

Expansion tanks and check valves

- Need to understand where these are in the system, and what effect they will have:
  - 20-30% of projects have some check valve/expansion related issue
  - Some equipment has internal check valves!



Need to understand where these are in the system, and what effect they will have

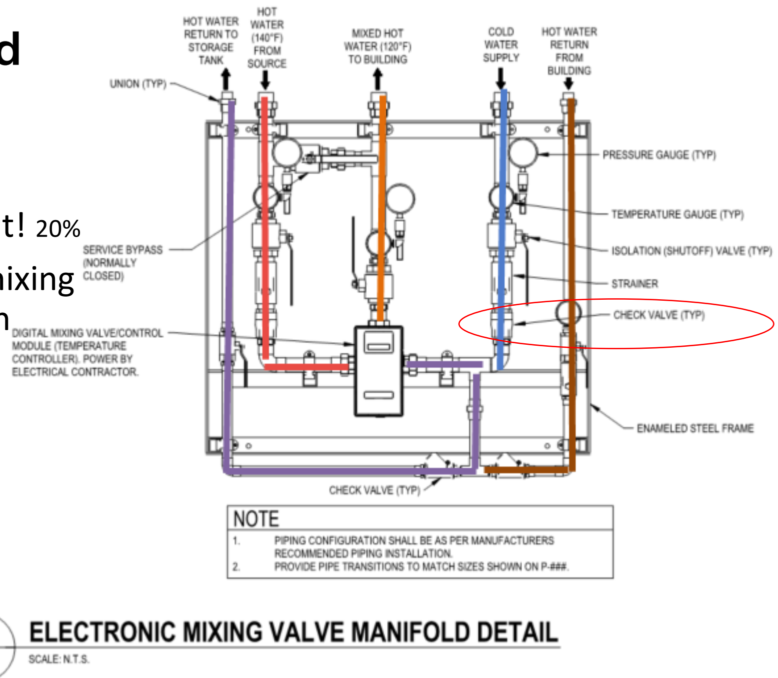
Example – saw one project where hot water came up through the toilets, melted the wax seals (similar project has issues with urinal)

Consider packaged components which may include check valves (mixing valves for example)

Consequences – if a check valve isolates a portion of the system that is regularly being heated up from the expansion tank, that can lead to large stresses on the system

Mixing valves and recirculation

- Low flow fixtures make runout length important! 20%
- Careful integration of mixing valves with recirculation controls: 80%
- Recirculation pump setpoints: 60%



Low flow fixtures make runout length important!
- 20’ of ¾” pipe has almost ½ gallon of water in it. With a 0.5 GPM aerator, it will take almost a minute before you get hot water at the tap, assuming you are mixing to full hot

Careful integration of mixing valves with recirculation controls –
- Mixing valves ability to mix is impacted by availability (or lack) or recirculation water to mix with
- if you turn off recirculation, (or stop it) then flow stops through mixing valve when no DHW demand, resulting in valve opening to full, then going way too hot at first demand (valve motion is not instant)

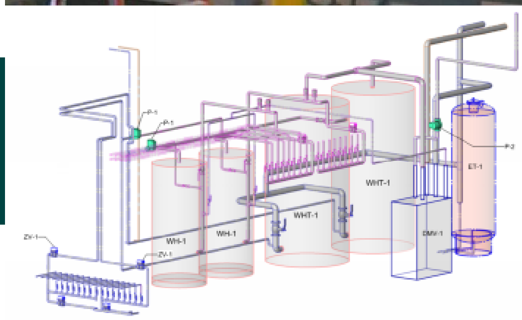
Recirc setpoints – this is usually an installation issue
- so often we see aquastat controls, either on the wrong spot in the pipe, triggering in reverse, or set to an impossibly high setpoint

Heat Pump DHW

Central HP systems

DESIGN CONSIDERATIONS
- Efficiency & return water temperatures (recirc?)
- Stratification and storage
- Lower max temperature
- Backup systems and how they integrate
- Unit specific sequences and operating characteristics

Suggestions:
- Careful design
- coordination with manufacturer and installer
- extra testing and monitoring



This is pretty specialized and new – enough for a 3hr+ presentation (ask me how I know)
- main take away – this is not a 1:1 replacement of a boiler DHW system - the design and installation of these systems is complex and needs to be budgeted and scheduled for accordingly.
- some of these more applicable to CO2 based systems, but not entirely

Design needs – central system

Efficiency – takes a hit with high return water temperatures

Consideration for recirculation systems

Stratification and storage

Lower top temperature capabilities

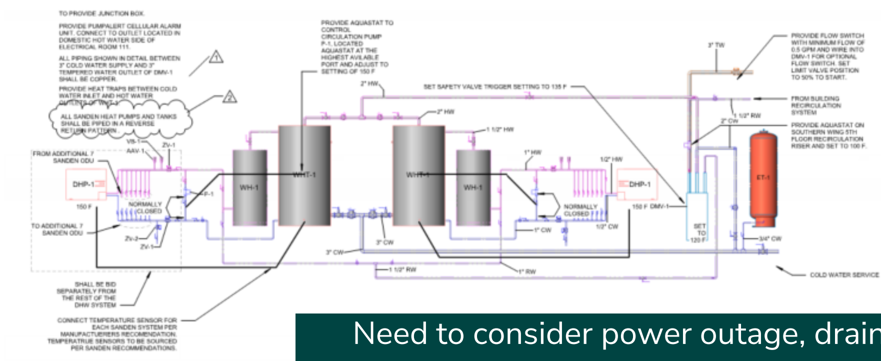
Consideration of backup systems and how they integrate (on/off, and interference with regular operation/efficiency of heat pump systems)

Solutions: careful attention, close coordination with manufacturer and installer, extra testing and monitoring built in from the start

Heat Pump DHW – CO2 based

FREEZE PROTECTION

- Consideration with newer heat pump systems – exterior potable water



WATER HEATER SCHEMATIC
1/4" = 1'-0"

Need to consider power outage, drainback systems

Calling this out separately as it won't just result in comfort or efficiency impacts. It can destroy equipment (and I am personally aware of at least two instances where water based heat pump systems have catastrophically frozen)

Freeze protection

Consideration with newer heat pump systems – exterior potable water

Solutions:

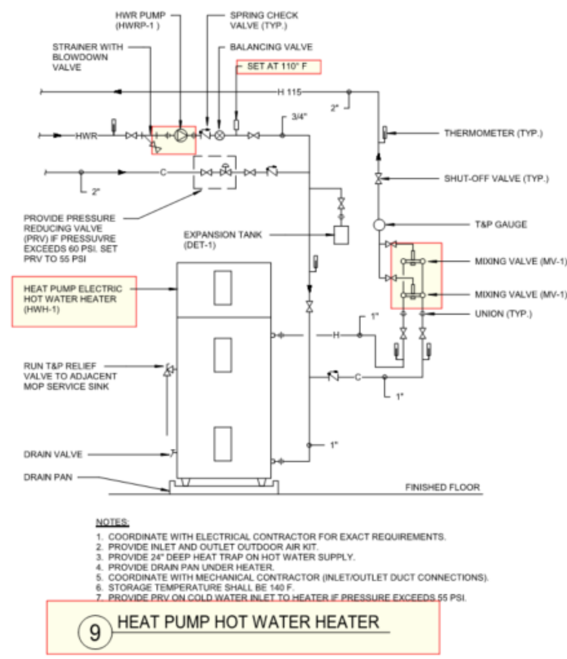
Need to consider power outage, drainback systems → more on this later

Heat Pump DHW

Local systems

DESIGN CONSIDERATIONS

- Peak demand charges
- source of air to transfer heat from



Suggestions:

- ducted air kits,
- pro/con analysis of demand charges and coincident peaks

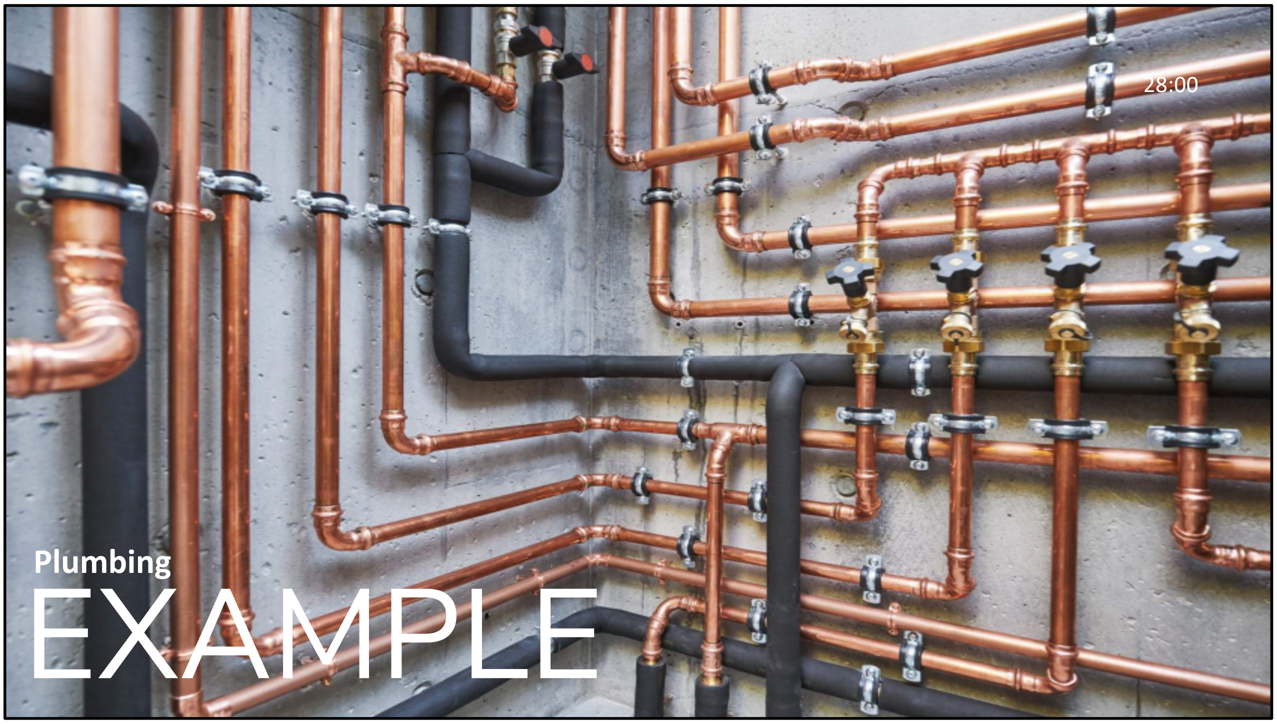
Local systems – talking about storage/hybrid heat pump systems, and point of use systems

Design Considerations

Peak demand charges – especially point of use systems

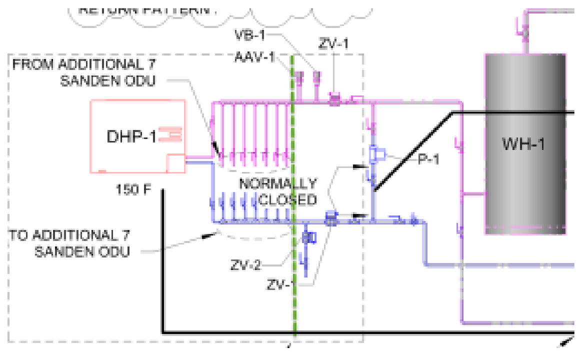
source of air to transfer heat from – heat pump systems

Solutions: careful design, ducted air kits, pro/con analysis of demand charges and coincident peaks


28:00
Plumbing
EXAMPLE

Auto-drainback freeze protection sequence

- How it works:
  - Two sets of valve, with a spring return (normally open/normally closed)
  - When power is lost, a set of valves that are normally powered open where the water leaves the building to go to the heat pump outdoor units automatically close.
  - Two other valves going to drains that are normally closed open at the same time, draining the outdoor portion of the system.
  - This requires careful installation and slope of the outdoor piping.

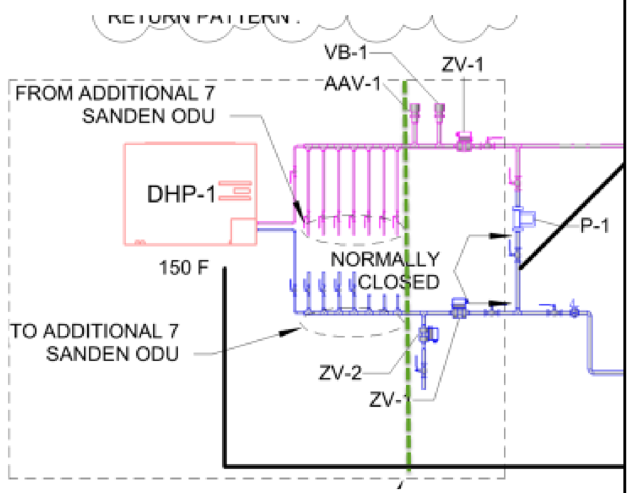


Remember I mentioned freeze protection – well lets look at that as our example – in this situation we have outdoor units that are circulating potable water –what happens when you lose power?

Auto-drainback freeze protection sequence

- What issues would you expect?
  - Water caught in the system?
  - Incorrectly installed valves?
  - Other?

- The drainage system actually worked great…



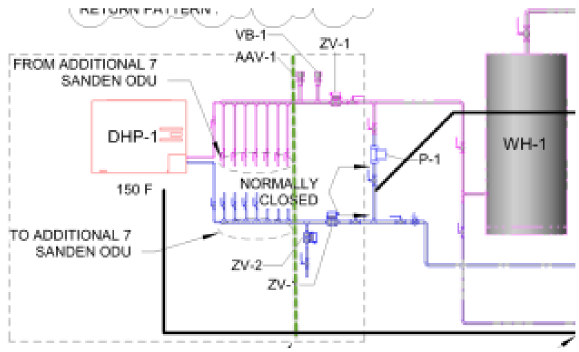
Give the audience some time to think on this..

Main issue was actually on refill of the system

30:00

- When power was restored, the valves all reverted, trapping a large amount of air in the system.
- More than could be handled by the automatic air vent
- Heat pumps were getting air bound and faulting out in error.

Solutions?



When power was restored, the valves all reverted, trapping a large amount of air in the system.
More than could be handled by the automatic air vent
Heat pumps were getting air bound and faulting out in error.

No centralized controller reporting these, so over time, just general decrease in capacity

Air caught in system on auto-refill (from freeze protection drainback)

Main issue was actually on refill of the system

- When power was restored, the valves all reverted, trapping a large amount of air in the system.
- More than could be handled by the automatic air vent
- Heat pumps were getting air bound and faulting out in error.

Solutions?

SOLUTION

- Customized delay offsets in some of the valves to purge and fill system automatically

→Water fully fills the system and starts to drain before upper vent valve closes

Solutions: customized delay offsets in NO/NC valves to purge and fill system automatically

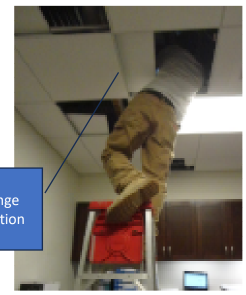
31:00

MECHANICAL

TAITEM ENGINEERING

Maintenance Access

- Issues:
  - Busy Ceilings – Can't find/access equipment: 60%+
  - Solution: Identification Stickers, Access Doors
  - High Roof Curbs/Ductwork Obstructing Equipment Access: 30-40%
  - Solution: Catwalks and Duct Bridges
  - Above Ceiling Clearances for Controls, Filters, Replaceable Components, etc.: 30%
  - Solution: Build Clearances into design as graphic elements on plans, access doors in ceilings.



Ok here are some super common pretty self explanatory issues
I wouldn't bring them up, but we keep seeing them
One recent project had expensive custom ceiling tiles, very difficult to remove. It turned out they also didn't have enough clearance to change filters because of the ceiling grid in those locations. The proposed solution was to take down part of the ceiling grid every time a filter change was needed. How often do you think those filters are going to get changed?

Substitutions and Value Engineering (VE)

- 40-50% of substitutions we see introduce some new issue
  - When can you do this, when will it cause issues
    - Be wary of unanticipated side effects
  - Areas of concern:
    - Accessories
    - Integration with other systems, particularly controls
    - Technologies and limits on performance
- Almost 100% of VE changes caused issues
  - What should owners know?
- Note – not always avoidable.

When can you do this, when will it cause issues
Many heat pump systems (and other larger, more complex systems) have proprietary control sequences
VE or substitutions may require changes to the design sequences, but should not impact the design intent – MAKE SURE THESE CHANGES ARE CAPTURED AS PART OF THE SUBSTITUTION APPROVAL
Haste makes waste! Easy to feel pressured to get order in and review/fix while waiting out long lead time. Suggest trying to pre-identify units with long lead times and define these requirements in more detail up front, allow less flexibility with alterations

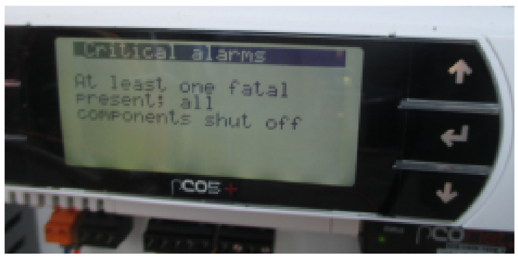
Areas of concern:
Accessories
Integration with other systems, particularly controls
Technologies and limits on performance (low ambient limits, maximum speeds, variable speed versus dual speed, different low end minimum capacity, different peak amperage, voltage, fuel pressure…)
Something as simple as a different filter access can make a substitution result in problems if not accounted for (see previous slide)

OWNERS –
VE changes in my experience usually do not save money, they just shift where that money is coming from and when. Often this is just shifting cost to future maintenance. - can give an example of a recent project where VE changes results in what I can only guess are 100's of thousands of dollars in extra costs for the project.
Recognize that this is a danger area! Review will require more expense for the designer. Also, these costs often come at the end of a project (recall of original design criteria, budget also usually expended)

Note – not always avoidable – sometimes basis of design units no longer available by the time building is in construction.

Substitutions and Value Engineering (VE)

- Solutions:
  - Investigate availability (lead times) and cost of major/critical units before bid
  - Avoid the temptation to defer design work assuming long lead times or project delays will give you time to work out details later
  - Consider including a clause in contracts allowing you to bill for extra time spent on design work due to changes from basis of design model



RECAP – already covered?

When can you do this, when will it cause issues

Many heat pump systems (and other larger, more complex systems) have proprietary control sequences

VE or substitutions may require changes to the design sequences, but should not impact the design intent – MAKE SURE THESE CHANGES ARE CAPTURED AS PART OF THE SUBSTITUTION APPROVAL

Haste makes waste! Easy to feel pressured to get order in and review/fix while waiting out long lead time.

Suggest trying to pre-identify units with long lead times and define these requirements in more detail up front, allow less flexibility with alterations

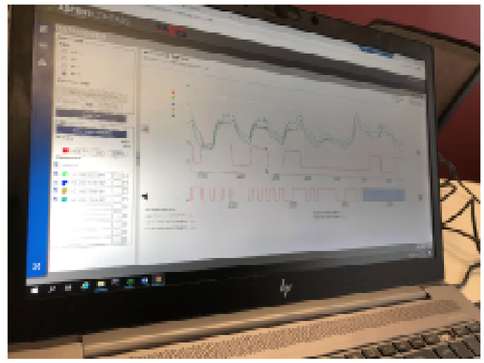
OWNERS - Recognize that this is a danger area! Review will require more expense for the designer. Also, these costs often come at the end of a project (recall of original design criteria, budget also usually expended)

Solutions? Some engineers contractually back-charge for involved submittal review of substitutions and VE changes to the submitting contractor

Opposite season operation

- Considerations for Sizing
  - Heating vs cooling & Oversizing:
  - 20-30% of projects

  - Coil Selection



Sizing

Heating vs cooling, you do have to size for one or the other, but be aware what that does in the opposite season
- avoid oversizing for loads that rarely occur
- CYCLING/ Air Temp swings
- COMFORT ISSUES

Understand how coil selection, especially dual temp coils, can cause issues
- not just sizing, but what side of the coil the fluid is entering, how many passes the coil has – all have an impact! Also consider the airflow – we have some projects that won't run their equipment at full load due to noise issues!
- what season are you selecting for,

    How will that effect the operation during the other season?

I don't have a perfect solution here, just being aware this will cause issues and clear understanding of how the system will be used and what the owners requirements really are.

Detour – Dual Temp Coils

36:00

- Freeze concern for multi-pass coils
  - Which side of the coil is the fluid entering
  - Was the coil sized for heating or cooling
  - What is the expected minimum flow and temperature range?

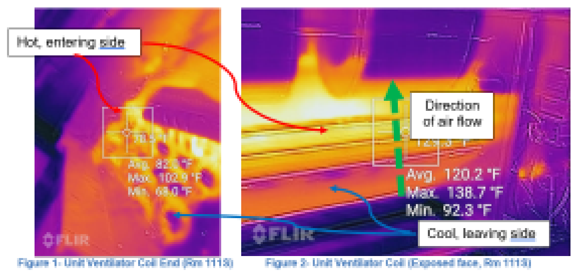


Figure 1- Unit Ventilator Coil End (Rm 1113) Figure 2- Unit Ventilator Coil (Exposed face, Rm 1113)

For the most part oversizing and coil selection is going to be an efficiency and comfort thing – there is an aspect that is more critical though:

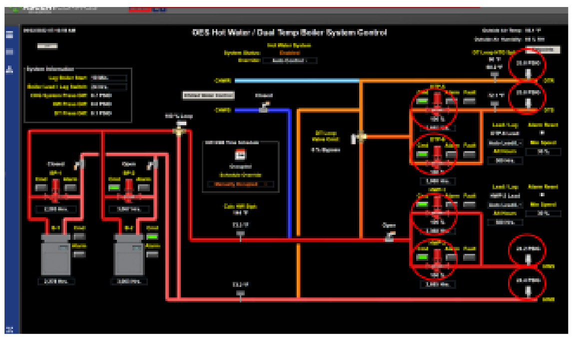
This is rare – but important to be aware of – consequences are major!

Multi-pass coils – more efficient delivery of heat for their size
- water enters at one end, passes over the airflow path multiple times before exiting
- Especially if these are sized for a high cooling load, and with entering water at the outlet side of the coil, this can be a freeze concern.
- Efficient enough that relatively low water flow rates can satisfy the room demands, and provide reasonable supply air temperatures
- we had one project with a 3-pass coil on a unit ventilator, coil froze while in use, with 80F discharge air

Same concerns can carry over to oversized heating systems that are not multi-pass and have to cycle though.

Opposite season operation

- Availability of reheat: close to 100%
- Condensation during cooling: 20%
- How/when does the central system switch over: 30%+



Availability of reheat

Many buildings - Boilers will be off in the summer, this will impact what temperature air you deliver to the spaces from central ventilation systems

(need a different sequence than for a building with always available central heat)

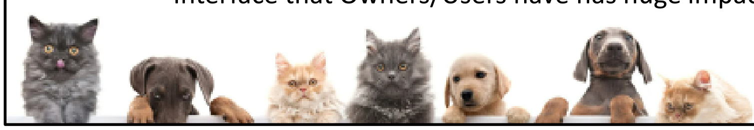
Condensation – whenever you have cooler surfaces – including condensate lines and dual temp pipes (or heating pipes after a cooling coil)

Is the central plant schedule the same as the end spaces? Is the schedule based on calendar, outdoor air temperature, other?
- what happens in between heating/cooling modes?
- Think about switch over in a dual temp system – all of a sudden units need to switch how they control valves if the dual temp loop switches over
- we had a project where the central boiler system went from a manual enable to outdoor air enable. This first triggered overnight in early fall – the boilers were drained and valved off for maintenance, but the control system didn't know that and tried to start them anyway!

40:00

Pet Peeves

- Unoccupied VAV operation: 90%+
  - What runs when a single space needs heat?
  - Does the entire system know its unoccupied?
  - Priority heating devices
- Zoning
  - IT closets need their own zone: 30%
  - Think for current use and schedules AND future modifications when grouping spaces
  - Large open spaces need a central control device [HPs especially]: 20-30%
- Freeze protection and safeties: 30%
  - Make sure these are thought through with new efficient systems
- Usable Thermostats and Schedule Controls: 60-90%
  - Interface that Owners/Users have has huge impact on how the system is used



Unoccupied VAV operation

What happens to the RTU when one of the zones calls for heat

how do the controls see the system as unoccupied…

Often the RTU goes unoccupied, but the zones are left as-is, resulting in built up demand for heat/cool, blasts of air when RTU finally becomes occupied, etc.

Usually want the air side system to come on for primary heating when occupied (and ventilating), but during unoccupied, often good to prioritize other systems like FTR

Zoning

IT closets need their own zone

Think for current use and schedules AND future modifications when grouping spaces

Large open spaces need a central control device [Electrification Item – very common for HPs]

Freeze protection and safeties

Make sure these are thought through with new efficient systems (contractors quick to throw under the bus)

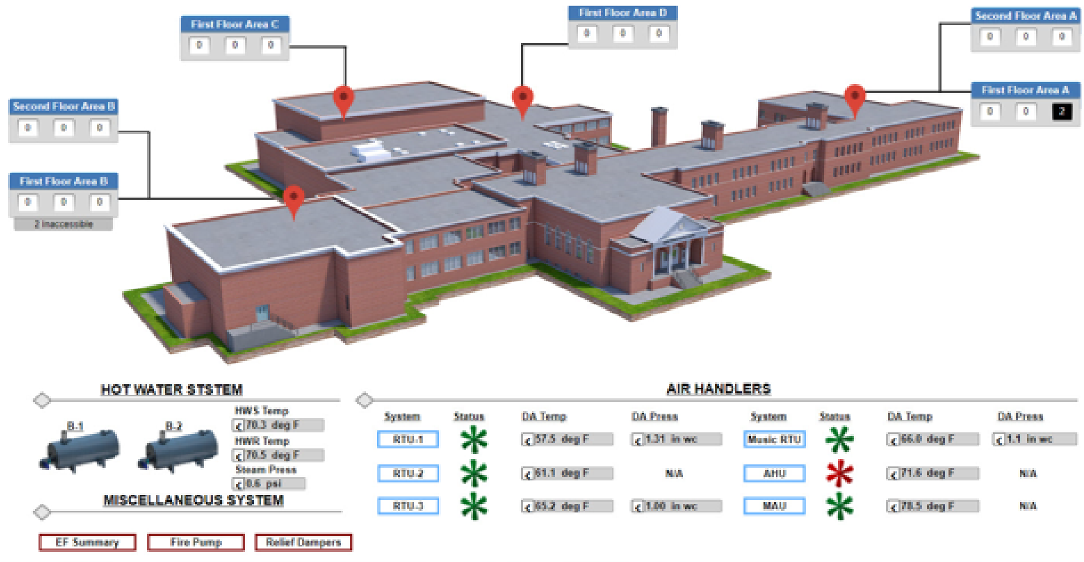
Scheduled and thermostats

- I know of at least one major district wide controls upgrade project that was driven largely if not entirely by the owners need for easy access to adjust schedules and setpoints

Mechanical

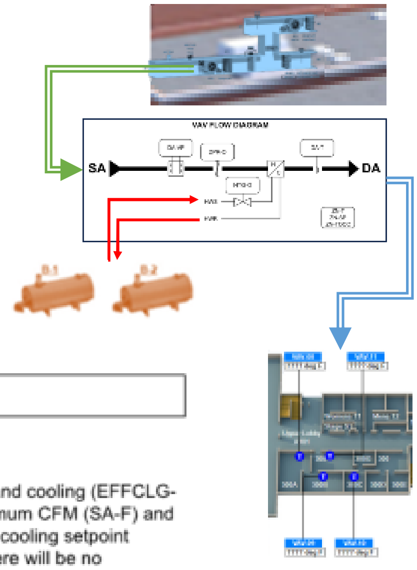
EXAMPLE

43:00



Set the scene:
School project – new HVAC systems for the main offices
- using a school because the example is clearer, but we see this on lots of other projects too (offices, commercial spaces, etc.)

School Offices – served by VAVs



- Dedicated rooftop unit serves VAV system
- Central Heating Plant serves VAV reheat coils
- Offices stay open all summer

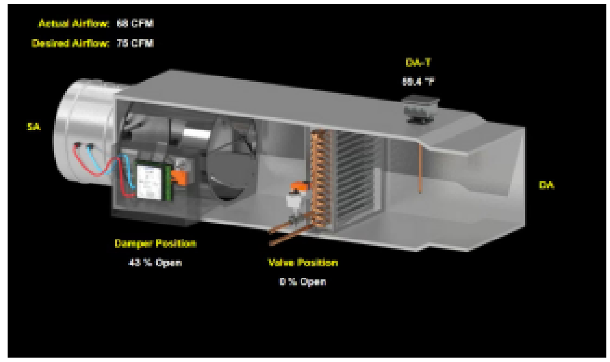
SEQUENCE OF OPERATION

OCCUPIED MODE:
When the zone temperature (ZN-T) is between the occupied heating (EFFHTG-SP) and cooling (EFFCLG-SP) setpoints (inside of the bias), the primary air damper (DPR-O) will be at the minimum CFM (SA-F) and there will be no mechanical heating. On a rise in zone temperature (ZN-T) above the cooling setpoint (EFFCLG-SP), the primary air damper (DPR-O) will increase the CFM (SA-F) and there will be no mechanical heating. On a drop in zone temperature (ZN-T) below the heating setpoint (EFFHTG-SP), the reheat coil will be fully utilized before the supplementary heat coil is enabled and the damper (DPR-O) is controlled to provide a minimum CFM (SA-F).

Anyone run into this issue before?
- take a minute – see what issues you can come up with while I provide some additional details on the system

Typical VAV with Reheat sequence

- Central AHU provides air to all VAVs
- AHU supply air temperature controlled based on how cold it needs to be to satisfy the hottest space (and/or satisfy dehumidification needs).
- All other VAVs use reheat coils to heat that cold air so their spaces are comfortable.
- VAVs also modulate a motorized damper between minimum and maximum flows to deliver more or less conditioned air to space.



GO INTO THIS DETAIL IF NEEDED
Central heating plant in basement, controlled for the entire building by a management company.
Both floors served by a central air handling unit that provides ventilation and conditioned air to a series of variable air volume (VAV) units with reheat coils (providing zone level control to different office spaces).

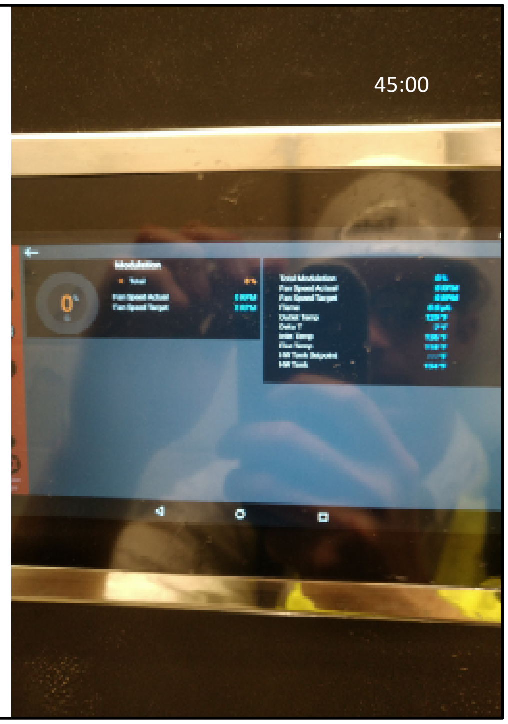
The Issue?

- Remember this is a VAV system serving a school office.
  - School is out over the summer, but the office stays open.
- Boiler plant is turned off for the summer

- Availability of reheat!
  - Spaces overcooled

Solution:

- Switchover sequence the operates differently when reheat is not available



Availability of reheat

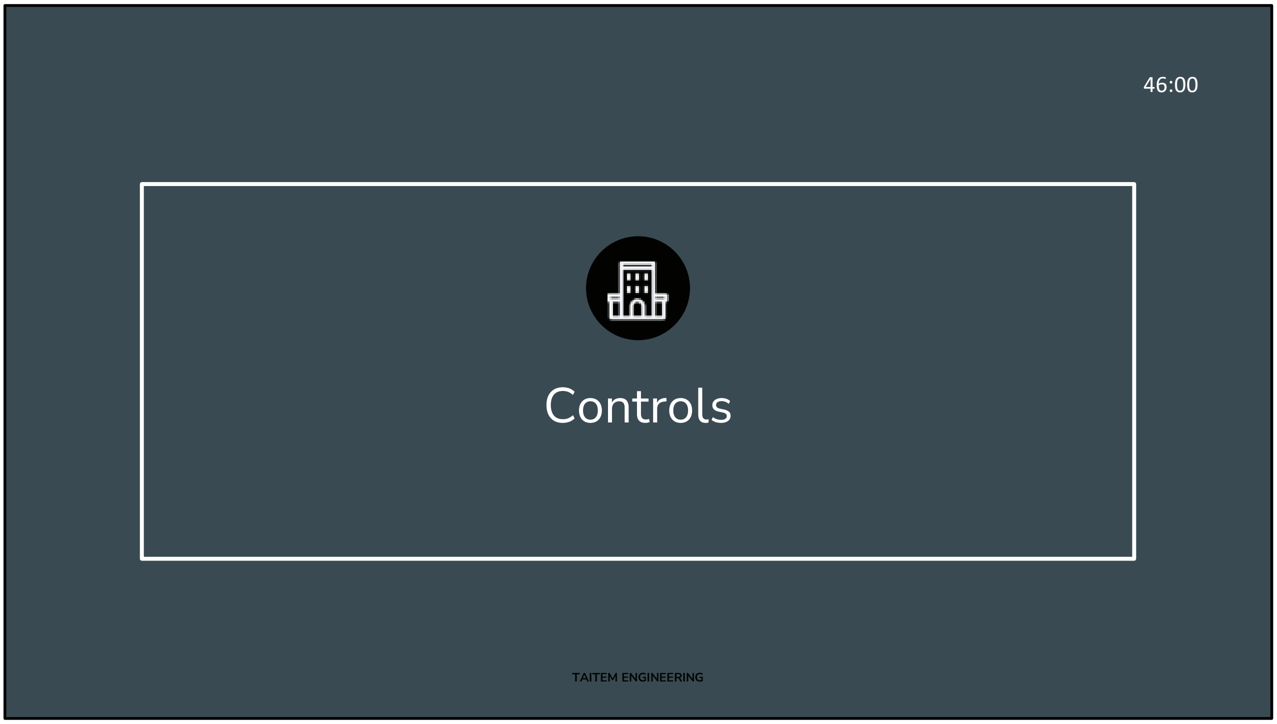
Boilers will be off in the summer, VAV systems won't have reheat capacity

(need a different sequence than for an office building)

- in schools it usually seems to be the principals office and front desk.

SOLUTION

You need to have a switchover sequence that operates differently when reheat is not available. Instead of coldest space, either provide air to satisfy the maximum number of spaces, or alternate high and low temperatures. VAVs then need to know what the supply air temperature is relative to their space temperature and setpoint, and modulate airflow only to meet that setpoint.



Guessing that we don't have a ton of controls contractors in the audience – so this will be pretty high level – what I am aiming for is general information for designers and owners that can be used to improve outcomes

Frequent Controls Issues

46:00

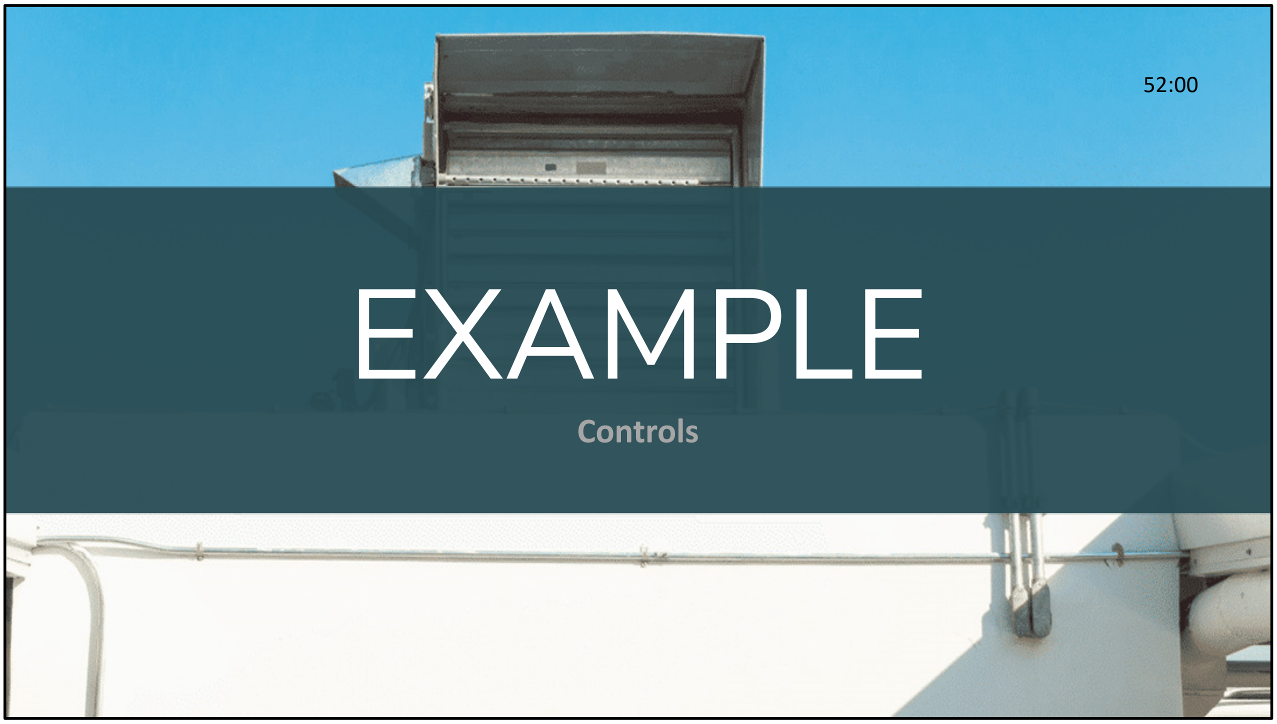
- Multiple units serving the same spaces: 30-40%
- Packaged controls vs. central BMS: 65%
- Control sequence extremes: 30%
  - Reliance on controls contractor VS packaged sequences VS over-constraining
- Who owns what? 25%
- Coordination with TAB, startup, owners IT (and Cx of course)
  - Almost always see at least one coordination issues

Multiple units serving the same spaces (simultaneous heating and cooling)
Packaged controls integrating into central BMS systems – lots of packaged controls are intentionally black box type systems – manufacturers don't want other people messing up their unit operation (optimize for no complaints vs efficiency)
Reliance on controls contractor/packaged sequences and/or over-constraining
    Sequences should spell out intent and key deliverables, as well as efficiency goals
Who owns what
    Clear distinction of what scope is done by which contractor is key.
    Ideally the fewest number of contractors are involved.
Coordination with TAB, startup, owners IT (and Cx of course)
- Can't stress the need to start bringing IT into the conversation early these days. More and more attacks, IT coordination results in delays, last minute product changes and limits on features

There are lots of other common issues, but most boil down to contractors being overworked and not having the time to finish or do the quality work they know how to do.

SUGGESTIONS
Have a dedicated budget for cx and engineering support of controls through construction
Don't leave to the end!!!!
On more complex projects, have a controls consultant involved to consult on communication protocols, etc.
- example –network protocol can have huge impacts on installation – Rapid spanning protocols – only allow 4-5 controllers per loop, Media redundant system – several hundred devices

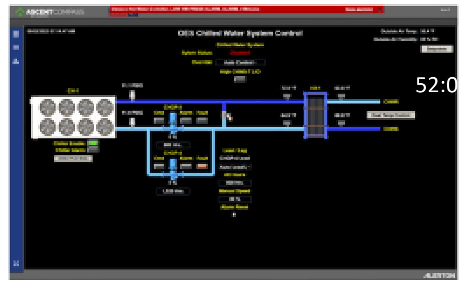
If possible, it is great to have the installation and programming done by the same person (not just company) that will be providing ongoing service – vested interest in setting up correctly

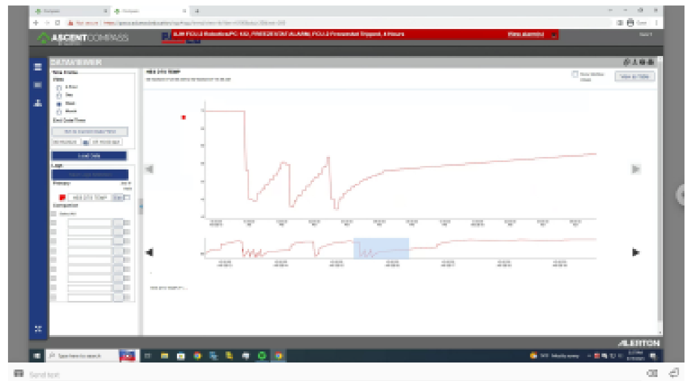


Set the scene for the last one/two examples (time dependent)
These are from a building with central control system that was tied into two new pieces of equipment with packaged controls – a new chilled water plant (chiller) and a rooftop ventilation unit serving offices.

Controls example: Chiller

- Packaged controls integration with BMS –
  - Chiller cycling – fixed supply water setpoint, enabled/disabled by BMS
- Solutions?





Packaged controls integration with BMS –

What this ended up looking like:
- BMS controlled circulation pumps
- Bypass valve locked at fixed percentage based on manufacturer minimum flow requirements
- BMS enables/disables chiller based on delivered water temperature to the main building loop
- Chiller takes care of all its own sequencing beyond that

So what is the issue?
- the chiller doesn't know what the rest of the system needs, so it reacts the same way on a super hot summer day at noon as it does at 5pm on a warm fall day right before the building shuts down.
- the chilled water setpoint has to be the coldest expected to be needed, resulting in lots of overshoot
-also, in this case the chiller sequencing was messed up and it had no ramp down modulation, so it ramped up to full capacity, stayed that way for 5-10 minutes, then shut down all stages within 30 seconds

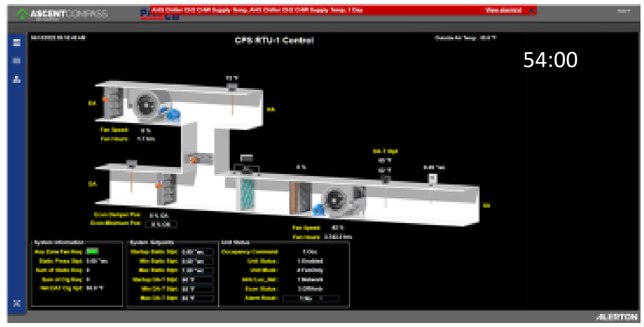
So this is a pretty common issue – we see it in about 50% of projects like this for a central plant like a chiller (larger more complex central plants often have more controls integration than something like a rooftop unit)..

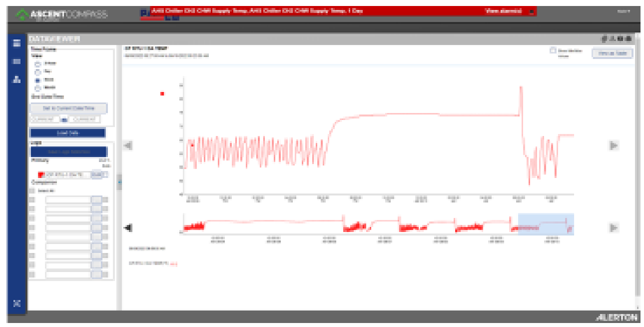
Chiller cycling (chiller has SW setpoint, no reset, system calls on/off only – OA reset was called for but not implemented due to gap in scope assignment)

Controls example

- Packaged controls integration with BMS –
  - RTU excessive SAT cycling
  - (+/- 5-10F, trends)

- Solutions?





Packaged RTU is provided an enable/disable and mode command – setpoint is theoretically provided as well, but does not seem to be applicable as the unit overshoots constantly, then shuts down and won't re-cool until the anti-short cycle delay for the refrigerant system has elapsed.

See this in most projects that have a combination of packaged and central controls

Only solutions I have are to write in a maximum allowed tolerance on the supply air side in the construction documents and keep checking and hammering on that requirement until startup techs either tune the unit correctly, or manufacturers write programing that allows the system to communicate better with other control platforms


54:00
Conclusions

54:00

Lots of things go wrong during construction!

Recent project we worked on:

New Construction, Multifamily Building

All Electric, High Efficiency. Not a bad project!

Some of the issues we discovered:

- Heat Pumps
  - Leaks: 5-10%
  - Controls : 90% at some level
- ERVs
  - Incorrect units: Rare, 5%
  - Factory default controls: 80%+
- DHW System
  - Coordination between primary and backup system: 100%/TBD
  - Inaccurate submittal information: 10%
- Lighting Controls
  - Controls were not set up until after occupancy: 10%/60+% have setup related issues

All preventable, but some more easily than others…

Touched on these in isolation, but what do they look like all together?– this is a pretty typical project – it was actually just the most recent project to complete commissioning while we were working on this:

AS WE GO THROUGH some of the issues we observed – THINK ABOUT HOW SOME OF THESE COULD BE PREVENTED

100% of the heat pumps

Faulty component from manufacturer, resulted in slow refrigerant leak – 5-10%

Incorrectly set up controls – resulted in lock out of heat pumps when two rooms in the same apartment were in different operating modes – 90% at some level

ERVs – already discussed this..

Incorrect units delivered to the site and installed (net loss in efficiency) – somewhat rare – maybe 5% of projects

Units left with 'factory default' settings and setpoints – unnecessarily dehumidifying spaces served by heat pumps – this or something similar, probably 80% or more of projects

DHW system

Incorrectly set up backup boiler setpoints/controls resulted in system overheat and shutdown on high temperature. – special case, but 100% so far

Undocumented check valve provided with packaged mixing valve product isolated hot portion of the system from the expansion tank. – fairly rare – 10% have similar issues

Lighting controls… so many issues – enough that the owner asked for the controls to be disabled for the initial operation until issues could be worked through

One big issue – schedule –startup didn't occur until after building had been occupied for over a month, factory defaults were not at all appropriate. - maybe 10% of projects have that specific issue, probably 60% plus have some setup related issue

COMMISSIONING AGENTS DON'T SOLVE EVERYTHING

We can be the eyes, ears and experience for an owner, but at the end of the day, all we can, and should, do is make suggestions.

We are just one part of a team that helps ensure the systems are operating correctly!

- Still need design engineer
- Still need owner involvement
- Need installers there to help us!
- Focused on larger systematic issues

We are not superheros -

Still need design engineer involvement – Particularly during construction!
Still need owner involvement and investment to correct issues
Need installers there to help us test – its not our equipment!
Don't usually test 100% of things (sample for larger systematic issues)

Fortunately at the end of the day everyone involved has the same goals – we all want the system to work correctly and the owner to be happy!

Find the balance point of cost and effectiveness

56:00

HOW CAN WE USE THIS INFORMATION TO IMPROVE AS AN INDUSTRY?

What are your ideas?

How do we take this information from something we see and correct on a project-by-project basis to information that impacts lots of projects, starting earlier in the process?

QUESTIONS

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Enjoy some info on Taitem while I take questions

...and the people who depend on them

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