AABC Commissioning Group

AIA Provider Number 50111116

After Hours Cx – Lessons Learned from K-12 Schools

Course Number: CXENERGY1705

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April 26, 2017

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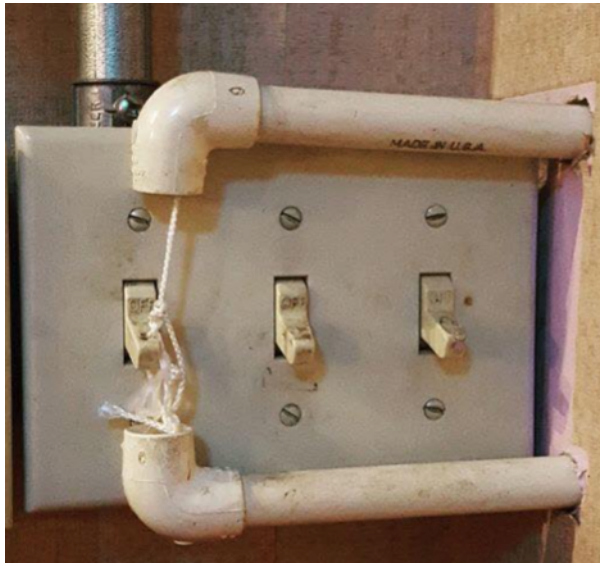
Course Description

This presentation examines lessons learned from commissioning K-12 schools as well as some of the challenges presented to Owners, Architects, Engineers, Contractors and Commissioning Providers.



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Learning Objectives

At the end of the this course, participants will be able to:

1. Learn how the 2015 International Energy Conservation Code adoption impacts building commissioning in the K-12 education sector.

2. Understand the importance of design reviews in 'prototype' schools when they have undergone site adaptation changes.

3. Learn methods of verification of controls integration and coordinating it within the school and with the school district's front end.

4. Learn the proper method of overseeing start-up and verifying proper documentation and TAB verification in K-12 projects.

Overview

Planning and Design, Bid and Award

Construction Management

Acceptance and Occupancy

Case Studies

Hall of Shame

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Planning and Design, Bid and Award

Planning and Design, Bid and Award

PLANNING – BOARD OF EDUCATION

- Firm plans based on fixed school schedule
- Long Range Schedule school/after school/non-school use
- Plan for failure to meet deadlines (alternate accommodations, meal services, after school activities, etc., etc., etc.)
- Contain scope to reasonable phases of construction
- Life Safety and Security focus
- Current Facility Requirements/Budget Operations
- Energy Management

Planning and Design, Bid and Award

PLANNING – BOARD OF EDUCATION

- Pre-purchases and tax exemption
- Service Maintenance Contracts
- Define owner construction administration process
- Change Orders/Approvals tied to BoE meetings
- Plan for Construction Team failure contingencies
- Include O&M/Facilities staff in planning
- Include provisions for service maintenance training
- Determine discrete equipment/software nomenclature
- Implement robust IT staff construction engagement

Planning and Design, Bid and Award

RENOVATIONS AND ADDITIONS DESIGN

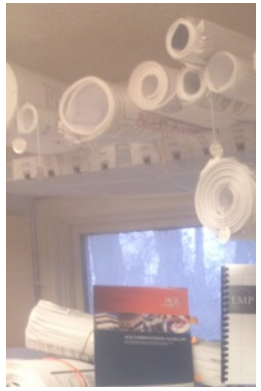
- Impact on existing school operations
  - Occupant wayfinding
  - Segregate construction area
  - Control noise and interruptions

- Schedule for construction: after hours/holidays
- Coordination with existing systems and controls
- Integration of new with existing equipment and utilities
- Outdated versions of equipment or software

Planning and Design, Bid and Award

DESIGN CONSIDERATIONS

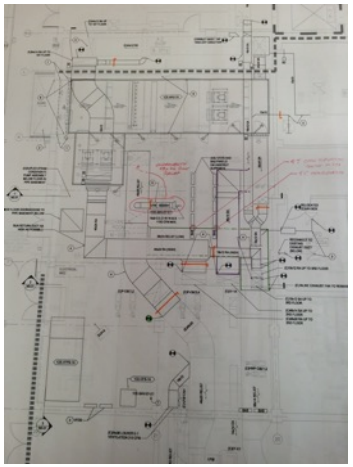
- Oversized/overaggressive scope
- O&M Staff Considerations
- Service Maintenance Contracts
- Undefined controls sequences of operation
- Pre-purchased and Owner procured provisions
- 3rd Party vendors, such as owner procured TAB
- Owner's Project Requirements (OPR)
- O&M staff appropriate systems



Planning and Design, Bid and Award

DESIGN CONSIDERATIONS

- Delivery – CMAR, GC, D-B, D-S-B, Direct Primes
- Closeout provisions
- BoE coordination and cooperation
- 2012 IeCC/2015 IeCC and prevailing codes/regulations
- Local AHJs
- Sustainability goals vs. practical applications
- Can we please KISS already?
- Construction Administration



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Planning and Design, Bid and Award

Cx DESIGN REVIEW

- "Prototype" construction documents are not vetted - require design review for each project
- Review construction documents for trade coordination overlaps and gaps
- Can it be….
  designed? constructed? balanced?
  controlled? operated? adjusted?
  tested? maintained?

... per OPR?

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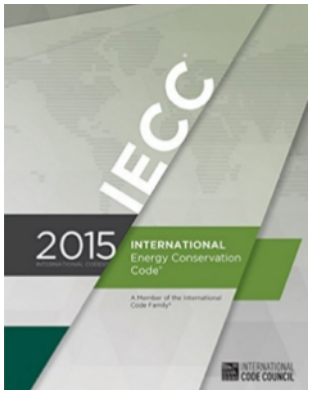
Planning and Design, Bid and Award

2015 INTERNATIONAL ENERGY CONSERVATION CODE

- Cx Plan shall be developed by *registered design professional* or *approved agency* & required for permitting
- Systems required to be commissioned include:
  - Mechanical HVAC systems and associated controls
  - Electrical lighting systems and associated controls
  - Service water heating systems
  - Renewable energy systems

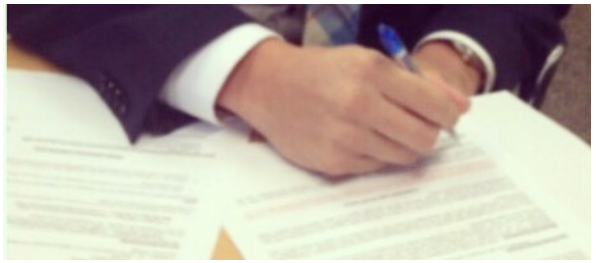


- Code includes requirements for HVAC system balancing, functional testing, and documentation, including O&M manuals
- Building not considered for final inspection, until AHJ receives letter from Owner that he has received the Preliminary Commissioning Report
- Cx impacts building occupancy

Planning and Design, Bid and Award

BID AND AWARD

- CxA participation at Pre-Bid Meeting(s)
- CxA participation at Preconstruction Meeting
- Cx Plan
  - Roles and responsibilities for all team members
  - Incorporate Cx activities in schedule to complete prior to school opening
  - Constraints regarding testing after school opens
  - Provisions for AHJ Cx requirements
  - Communication protocols
  - Commissioning Team



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Construction Management

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Construction Management

RENOVATIONS AND ADDITIONS PRE-CONSTRUCTION

- Accurate Cost Estimating
- Constructability Analysis
- Value Engineering
- Project Coordination
- Site Logistics & Planning
- Equipment Ordering
- Bid Package Development

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Construction Management

RENOVATIONS AND ADDITIONS CONSTRUCTION

- On-Site Project Staff
- Manage Trade Contractors
- Conduct Progress Meetings
- Monitor Cost Control
- Maintain Time & Materials
- Implement Quality Control
- Safety

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RENOVATIONS AND ADDITIONS POST-CONSTRUCTION

- Start-Up/Commissioning
- Punch-list and Inspections
- Fire Marshall Inspections
- As-Built Drawings
- O&M Manuals
- Special Documentation
- Near End of Warranty Review

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SUBMITTAL REVIEW PROCESS

- Pre-purchased equipment/materials
- Owner procured equipment/materials
- Design Team and CxA engagement
- Coordination / compatibility
- Contractor responsibilities
- Warranty requirements

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Construction Management

COMMUNICATION

- OAC and Cx progress meetings
- Site Observation Visits/Issues Log
- Construction Schedule Updates
- Field Testing – Hydronic/Duct Leakage
- Pre-Installation Meetings
- Payroll Requests

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Construction Management

Quality Control

- Pre-Installation Meetings
- Installation Tests (duct/pipe leakage)
- Mock-Up Wall (envelope)
- System Verification Checklists
- Start-Up Reports
- Functional Performance Tests
- O&M Manuals and Training

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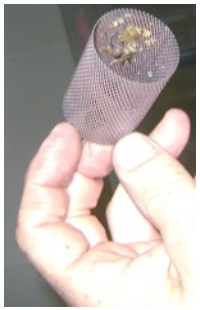
Construction Management

Quality Control – Hydronic Flushing and Treatment

- Specifications include step-by-step start-up & testing procedure details
- Conduct a meeting prior to the contractor starting his flushing, review procedures and witness a portion of the process
- Bypass all coils, control valves and appurtenances, etc. & back-flush fouled components and clean/replace strainers
- After treatment, request water analysis to ensure all parameters (pH, TDS, Chlorides, etc.) are within manufacturer's tolerances.



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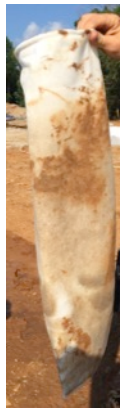
QUALITY CONTROL – HYDRONIC FLUSHING AND TREATMENT

- Chain of custody for water treatment responsibility transfer from contractor to owner at end of warranty
- Clearly establish warranty dates
- Consider extended warranty and service maintenance provisions



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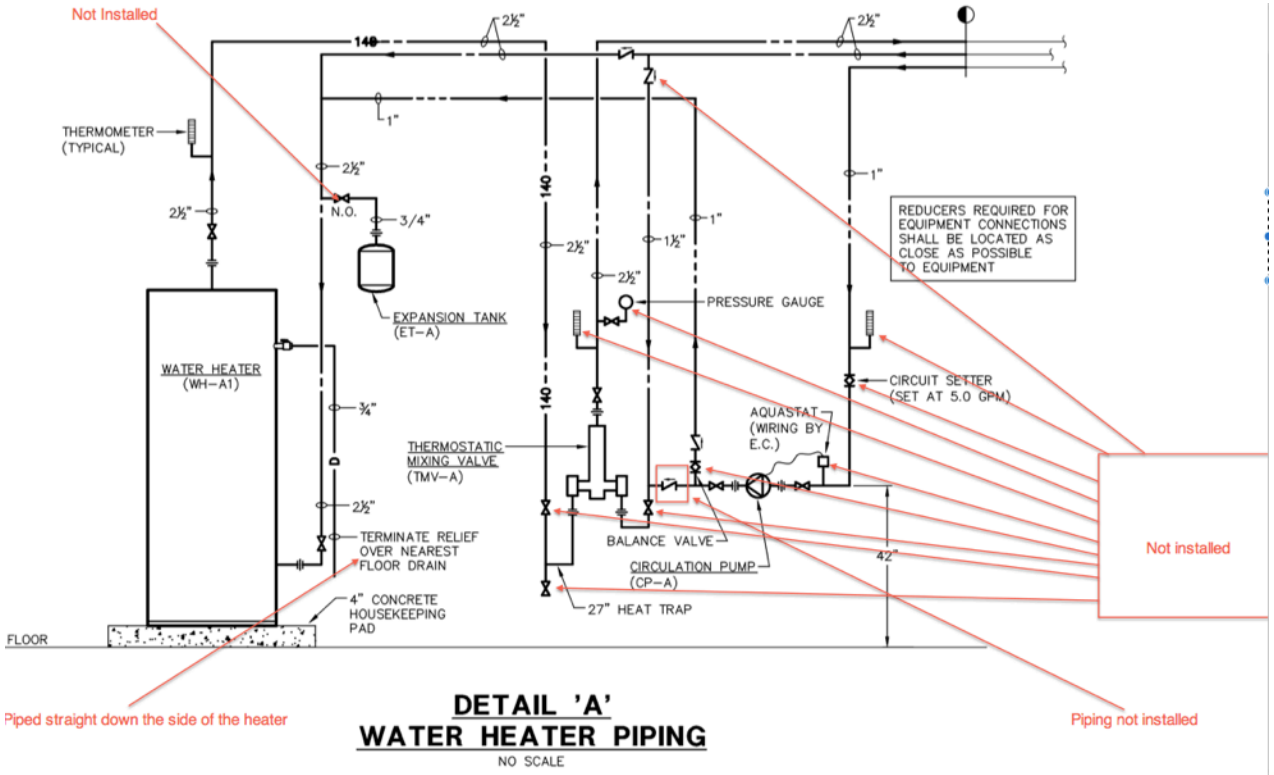
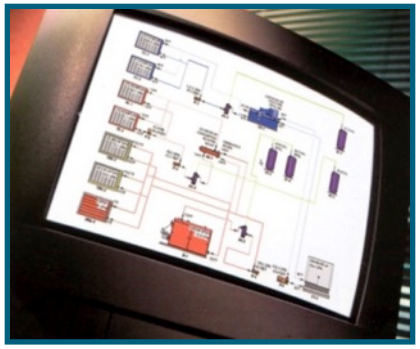
QUALITY CONTROL – SYSTEM VERIFICATION



Construction Management

DESIGN/CONSTRUCTION – INTEGRATION OF BAS AND OEM

- Conduct "Controls Integration and Interoperability" meetings during design and construction
- Include Contractor Responsibility Matrix
- Ensure controls are complete and appropriate for the project
- Integrated, factory mounted, pre-programmed (OEM) controls may operate under a proprietary protocol



Occupancy and Acceptance

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Occupancy and Acceptance

OPERATIONS AND MAINTENANCE (O&M) STAFF TRAINING

- Review Operations and Maintenance Manuals
- Written curricula and sequence for training
- Use factory trained teachers
- ½ day (time) in classroom setting
- ½ day (time) in field with equipment / system
- Video/Audio record training (VHS/DVD)
- Consider Shift Workers
- Sign-In Sheets

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Occupancy and Acceptance

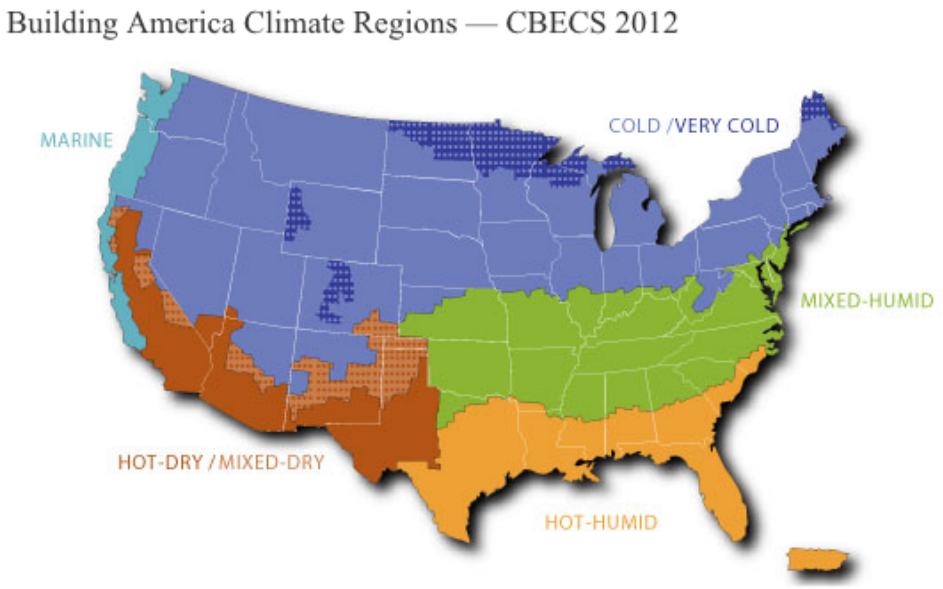
O&M STAFF TRAINING AND HANDS-ON OPERATION

- Description of Systems
- Start-up Procedures
- Operational Procedures
- Shut-down Procedures
- Emergency Procedures
- Maintenance Procedures
- Spare Parts and Tools

Occupancy and Acceptance

WARRANTY

- Close-Out
- Final Payment
- Off-Season Activities
- Preventative Maintenance
- Energy Use Baseline
- Energy Model Calibration
- CEBCS Data
- Near End Warranty Review



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eia Independent Statistics & Analysis U.S. Energy Information Administration

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Occupancy and Acceptance

OFF-SEASON MODE TESTING AND VERIFICATION/TRENDING

- Opposite season FPTs
- CUP Plant Integration
- Winterization
- Seasonal Mode Changes
- PM Questions
- Chronic Issues Log
- Extended Warranties
- Operations Evaluation

Occupancy and Acceptance

OFF-SEASON MODE TESTING AND VERIFICATION/TRENDING

- Review/Create Trends for Performance Evaluation
- Exterior Lighting – Scheduling
- Exterior Enclosures – Infrared Imaging
- Chillers/Cooling Towers/Condenser Water
- Boilers/Heat Exchangers/Steam
- Geothermal/Water-to-Water Heat Pumps
- VRV/VRF Systems – Winter Operation
- Freeze Protection

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Occupancy and Acceptance

OFF-SEASON MODE TRAINING

- Controls DDC/BAS/BMS
- Review Trends and Evaluate Performance
- Review BAS (Scheduling/Alarms)
- Seasonal Preventative Maintenance
- DVD Video/Audio of Training Sessions
- Sign-In Sheets
- Winterization/Seasonal Changes
- Optimization

Occupancy and Acceptance

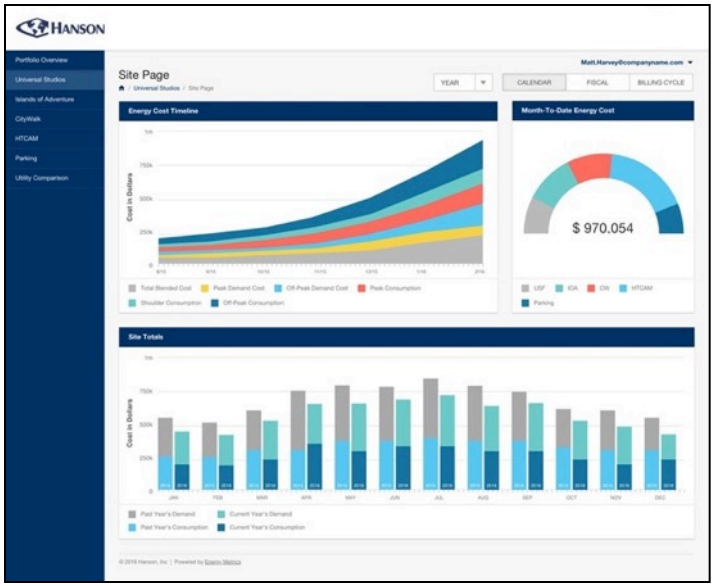
NEAR END OF WARRANTY REVIEW/PROJECT CLOSEOUT

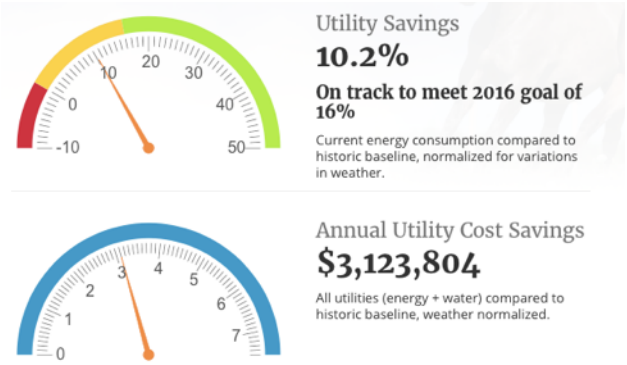
- Review Trends and Evaluate Performance
- Review BAS (Scheduling/Alarms)
- Chronic Issues/Failures
- Operations Issues
- Maintenance Issues/Review Logs
- Utility Bills – Energy Consumption
- Energy Management (Pros and Cons)
- Thorough Walk-Through w/ Project Team

Occupancy and Acceptance

ON-GOING Cx ENERGY INFORMATION

- For School Districts with an ‘Energy Manager’, energy performance may be at odds with comfort.
- More districts monitor and track energy consumption and system performance daily, often relying on Energy Information Systems
- Potential market for CxAs and EMPs for M&V and to support the collection and analysis of this energy data





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COMMONWEALTH ENERGY MANAGEMENT & CONTROL SYSTEM CEMCS

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Cases Studies

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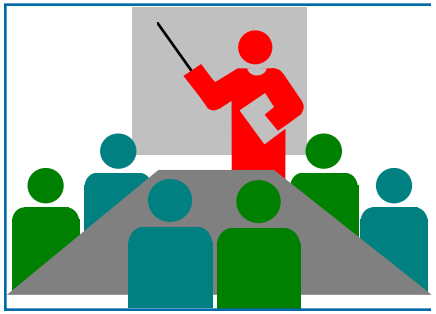
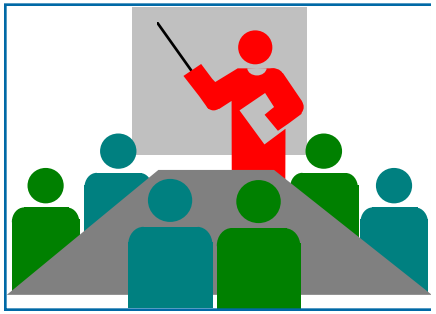
Case Study – Design Cx



Actual Note on Mechanical Drawings re: Minimum Flow Balance for VAVs:

- Minimum Flow scheduled on drawings represents minimum OA during Occupied Mode
- However, this may be less than the required minimum flow required by the terminal box manufacturer
- The TAB contractor and Controls contractor shall determine the difference between the minimum OA and the minimum terminal unit airflow requirement and add the additional air necessary per box to ensure proper operation
- Who is the final designer? ……

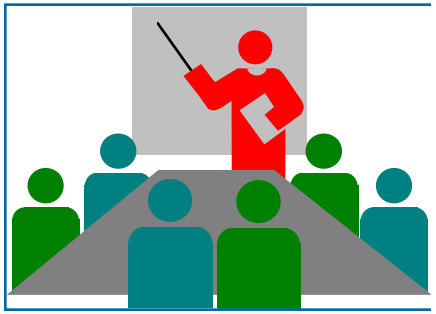


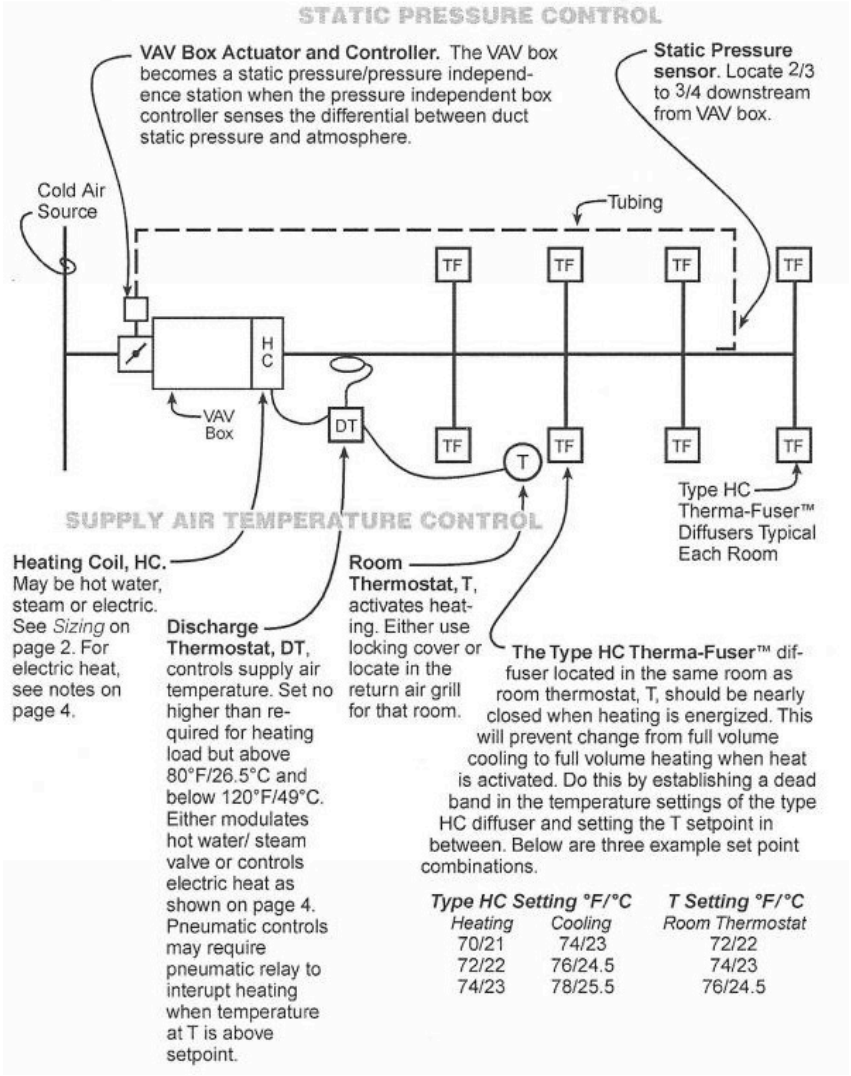
Case Study – Controls Cx

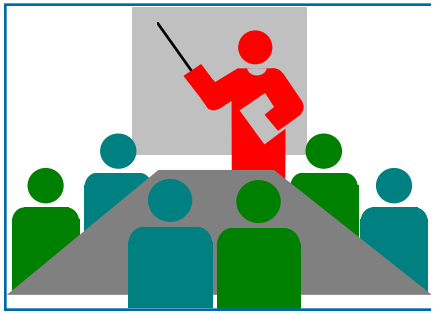
Difference between Chiller with separate Pumps and Chiller with integral Pumps

- Low ambient "soft" freeze protection through BAS vs. pre-programmed low temperature protection sequence within chiller controls
- Different control sensors – outdoor ambient air vs. mixed air temperature upstream of coil
- As written, control sequence would not work, BAS does not control pumps.
- Need to coordinate sequences to work in concert with one another.

Case Study – Controls Cx







Case Study – Controls Cx

VAV diffusers (Therma-Fusers) connected to VAV Terminal Units

- 'Intent' was to provide improved occupant control in individual rooms.
- In lieu of static pressure control for VAV terminal unit, a return air temperature sensor was utilized
- Without static pressure control, too much (or too little) air may be delivered through the Therma-Fusers
- Most VAV terminal units are equipped with on-board controllers that respond to space temperature. These need to be customized for static pressure control

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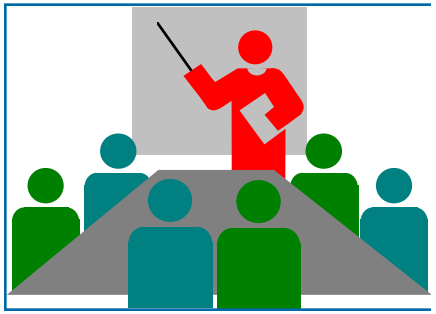
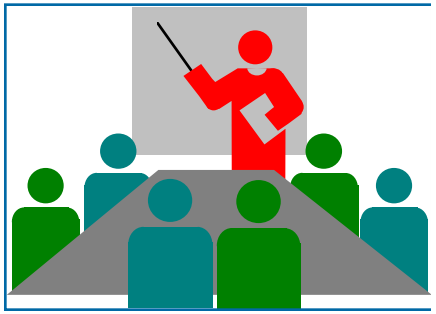
Case Study –
Bi-polar Ionization and Outdoor Air



Bi-polar ionization used for IAQ (air cleaning)

- Desire to reduce volume of outdoor air required and associated equipment sizes
- Belief it decouples the ability (need) to utilize CO2 as an indicator for ventilation required.
- Often low level ozone generation, needs to be properly installed and calibrated.
- A number of schools where these have been installed, cite “sleepy kids”. CO2 levels were measured between 1500 and 1600 ppm

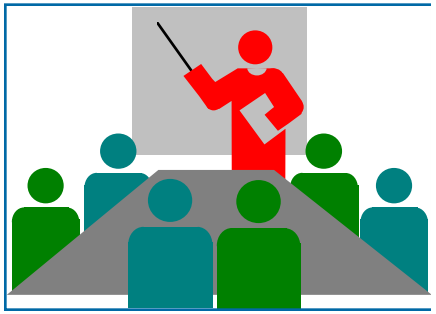
Case Study – Controls Cx Miscellaneous



- Fixed operating schedules established by remote Energy Manager – do not accommodate special school programs
- Sequences incompatible with equipment - Dehumidification sequence on unit without reheat coil
- Location of AHU static pressure sensor – not coordinated

Common Control Issues (Challenges)

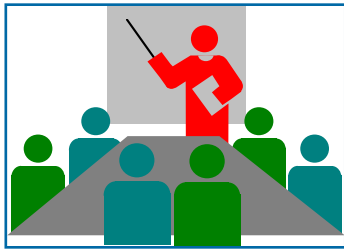
Case Study – Controls Cx



- Location of differential pressure sensor on chillers, especially for chillers with integral pumps (location may affect lead/lag sequence and controllability)
- Global outdoor air temperature and humidity sensors – location is critical (have seen differences of 7 to 8 degrees between chiller yard and roof)
- Fan cut out safety switches (issues with inclusion and/or location)

Common Control Issues (Challenges)

Case Study – Testing and Balancing



- Ongoing issues with inexperienced mechanical contractors performing duct leakage testing.
- A number of schools fail TAB verification (several multiple times!).
- Little attention is paid to the return air system, even when it's ducted.
- Some TAB contractors use an artificially high set point to balance the system. When the setpoint is reset to the typical level, proper airflows cannot be achieved.

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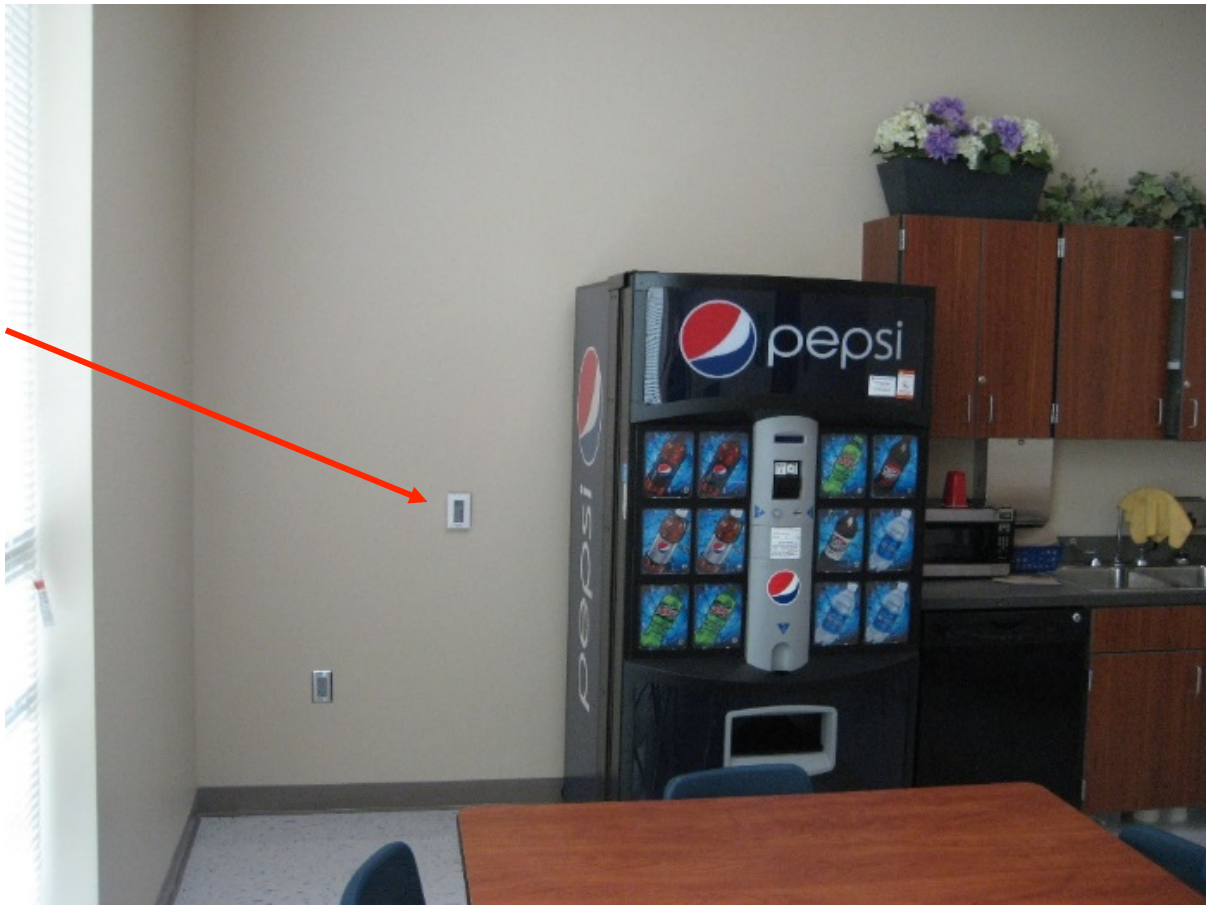
Hall of Shame

Damper Smaller Than the Duct

Wall of Shame



Poor Location for Temperature Sensor
(especially with other soda machine to be installed)

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Packing Material Left in Unit

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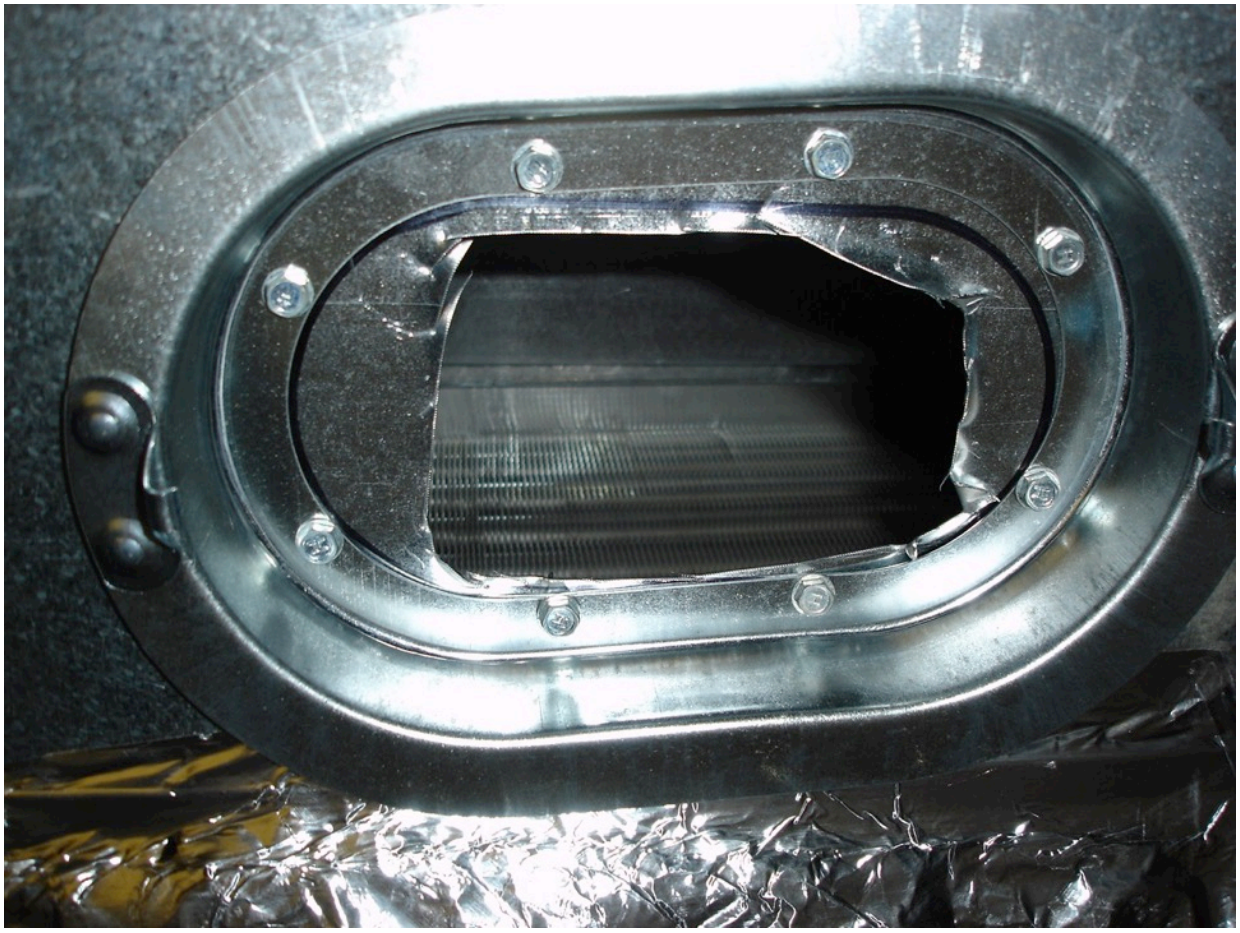

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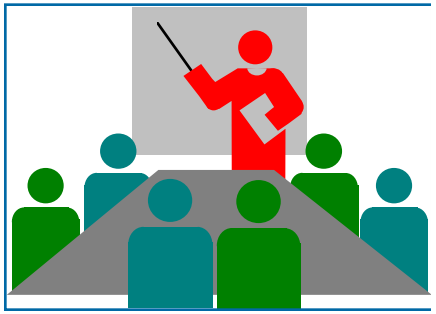

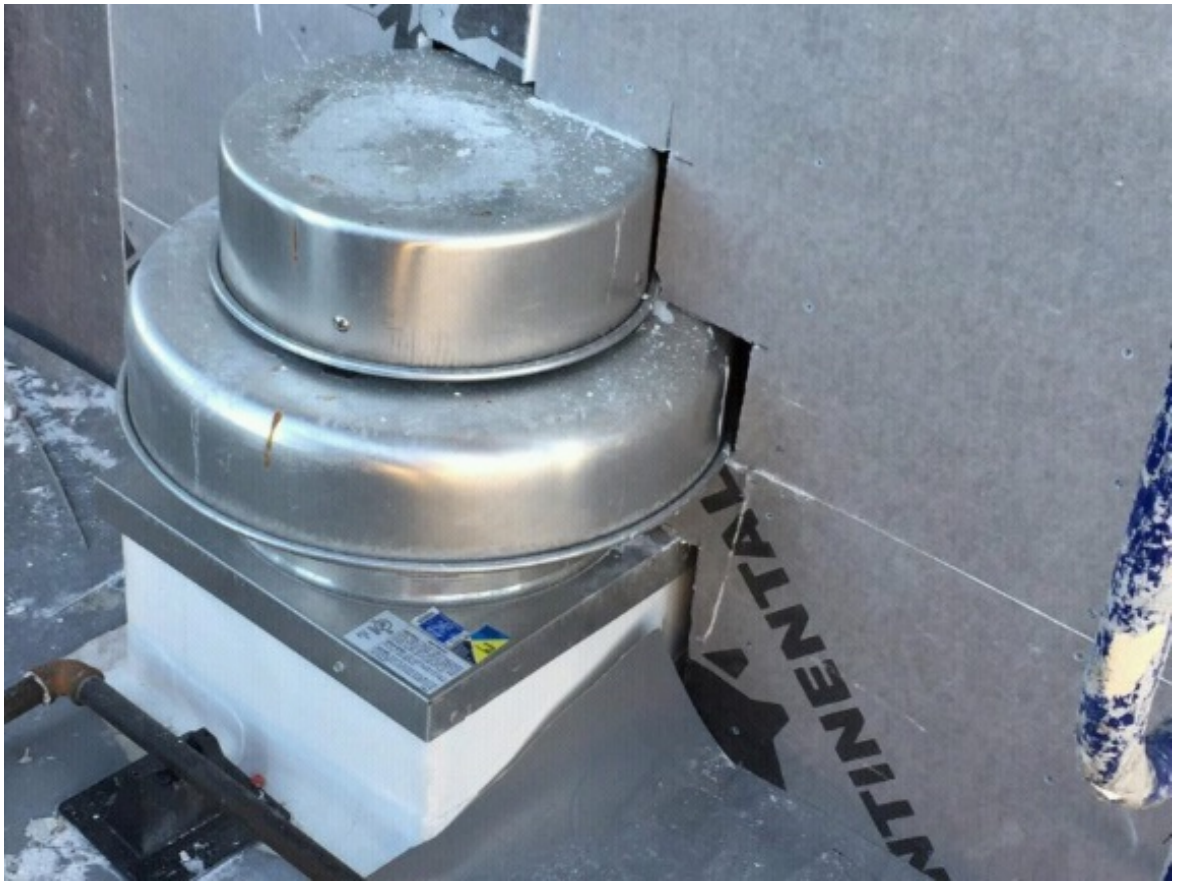

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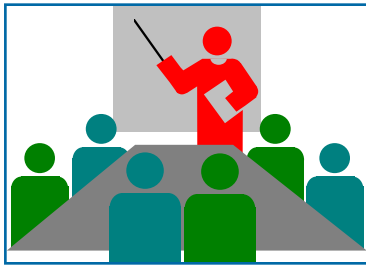

Open gaps to the Exterior

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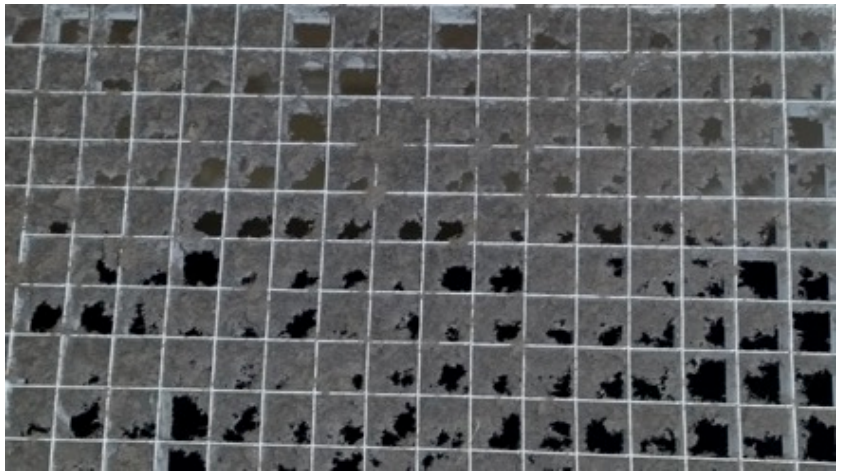
Hall of Shame



Excessively dirty grilles

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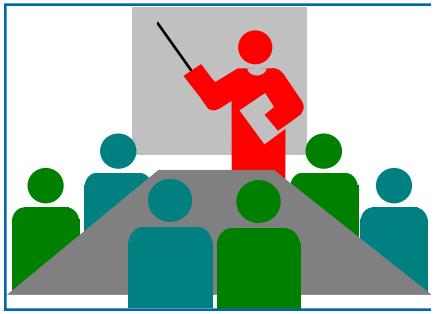

Left in Coil Section of AHU

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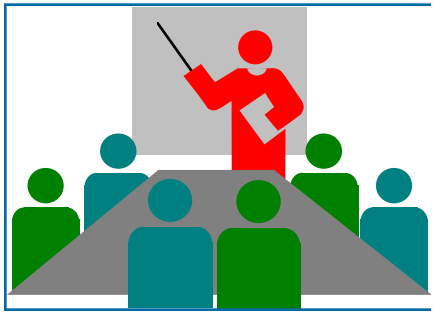

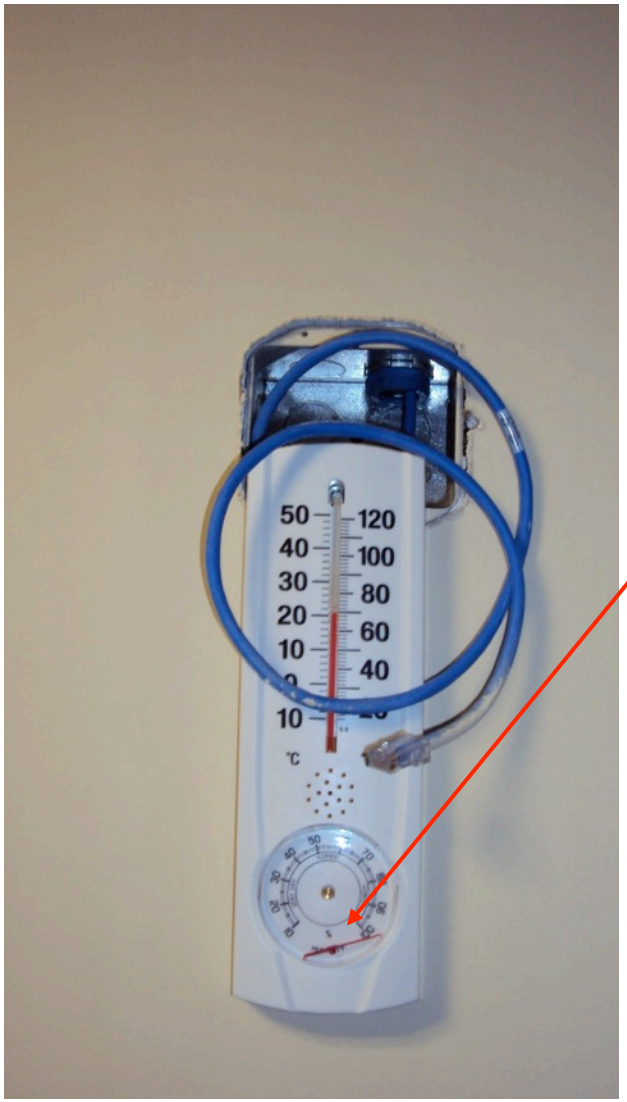

When ‘digital is not available, return to analog

(note broken needle on humidity scale)

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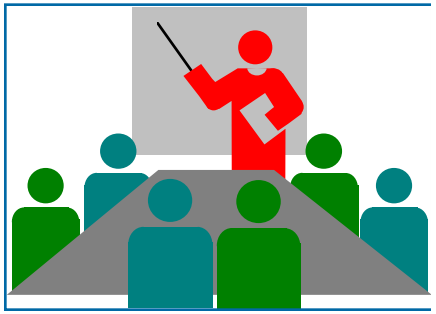

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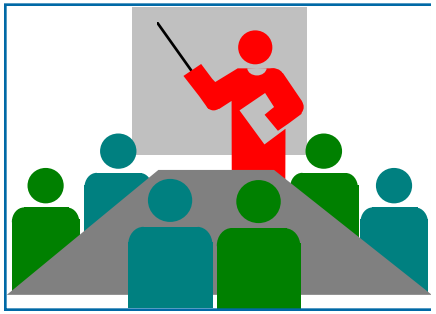
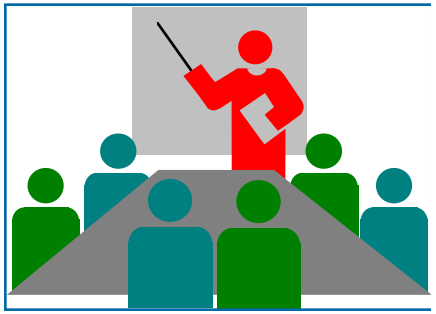
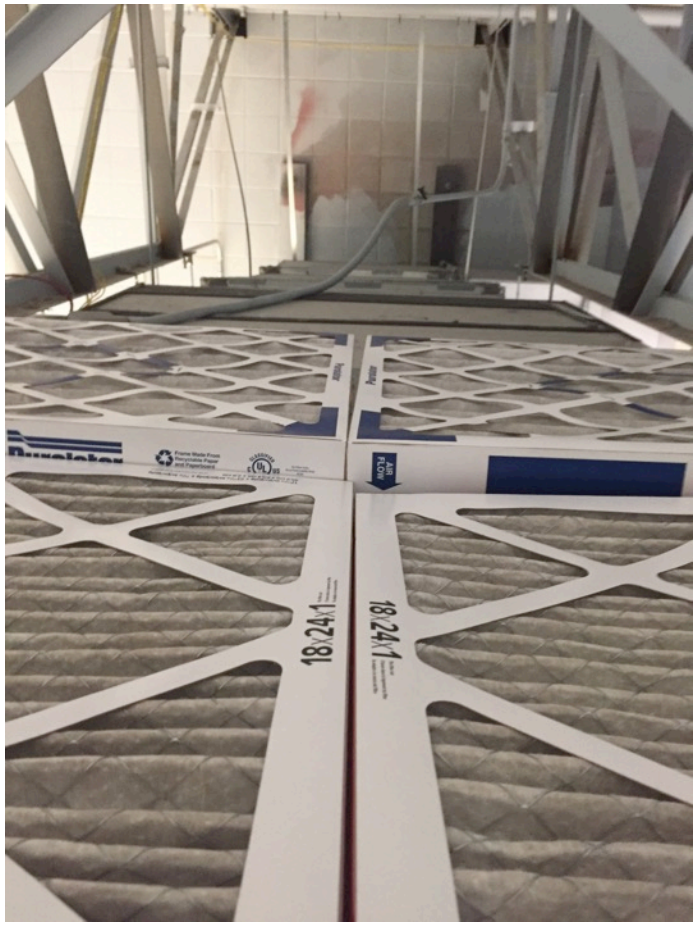
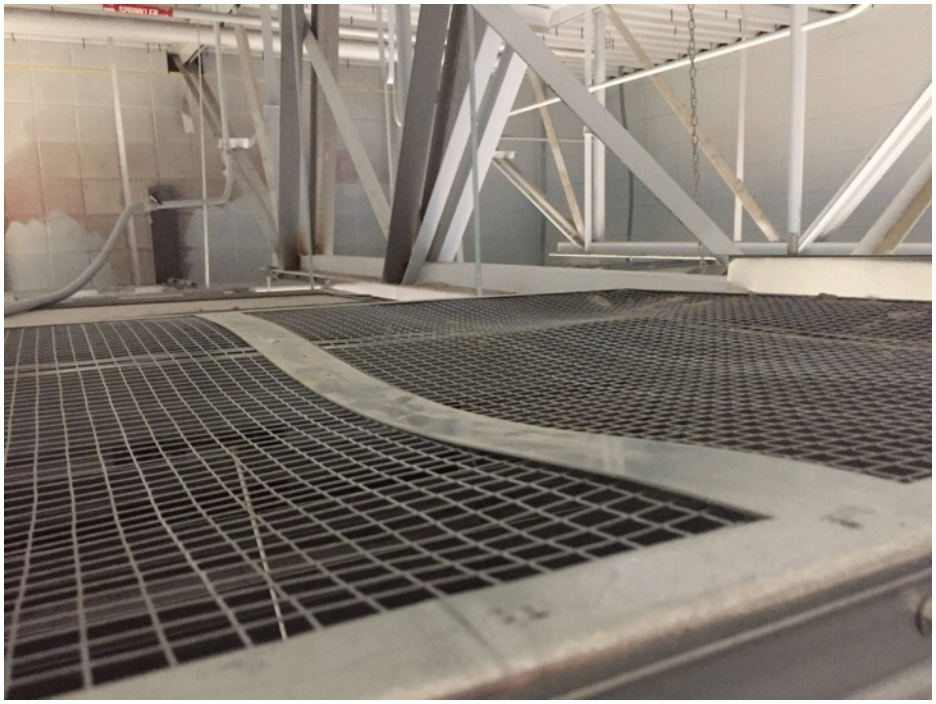


Hall of Shame







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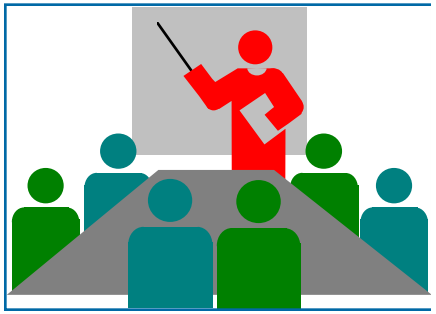

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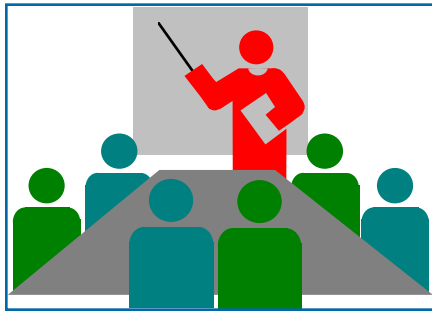

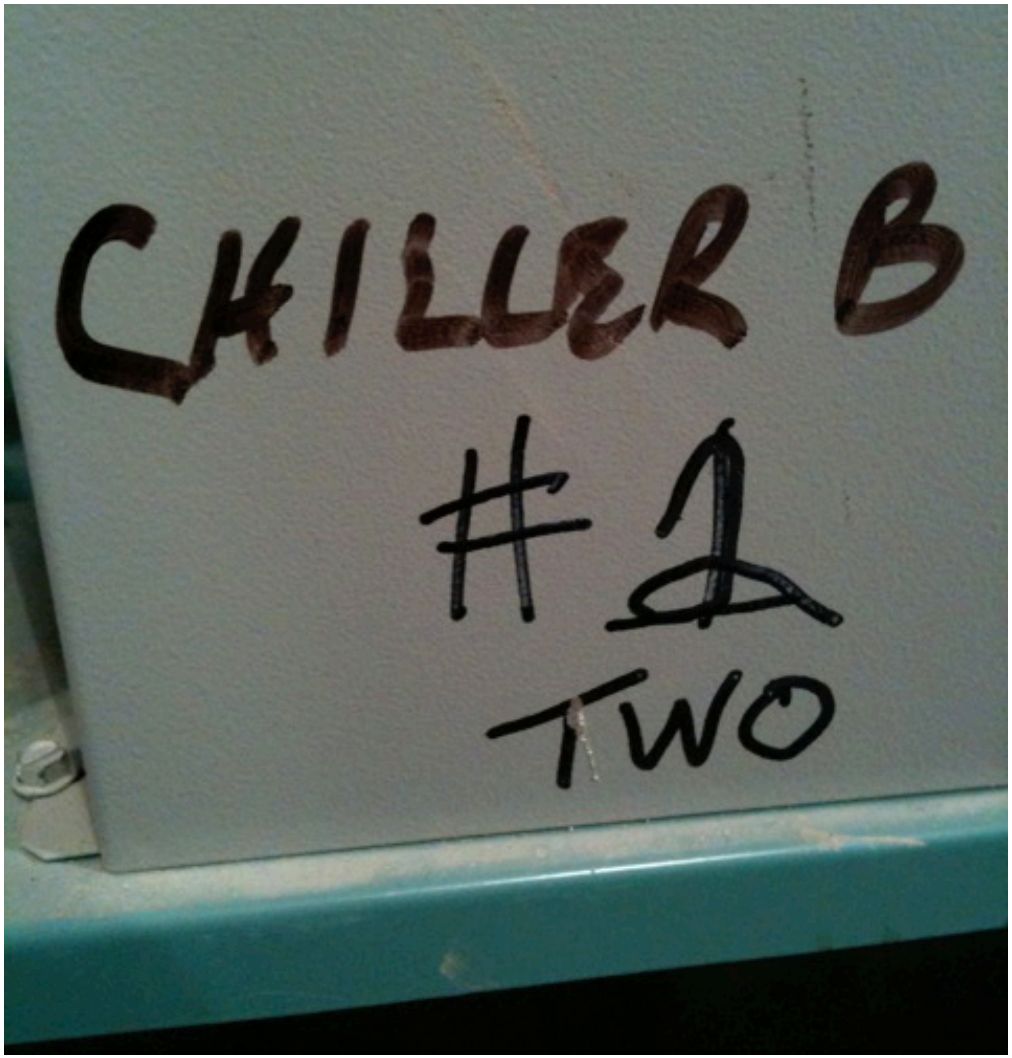

Labeling/Tagging

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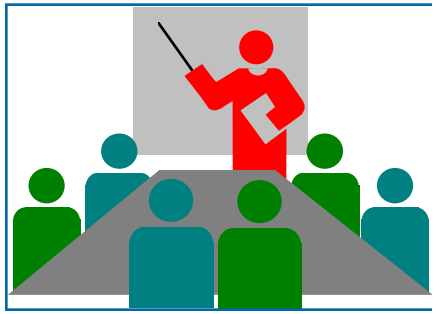

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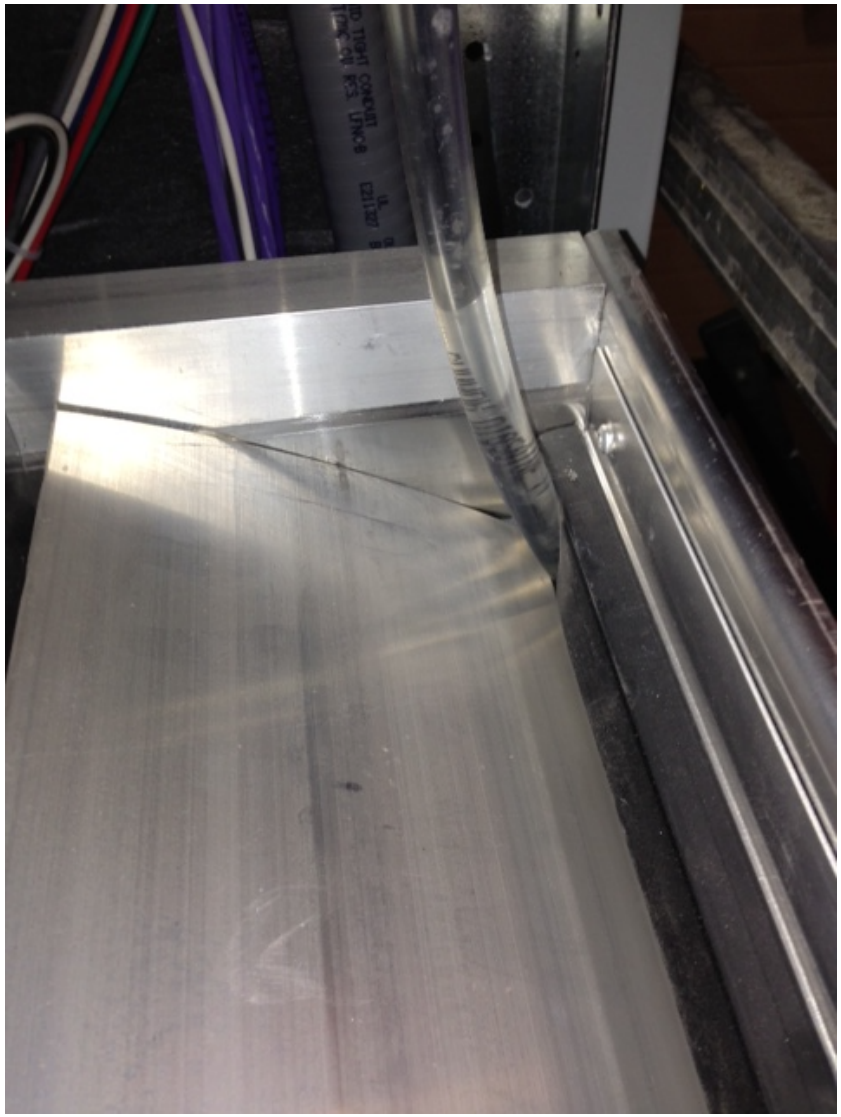

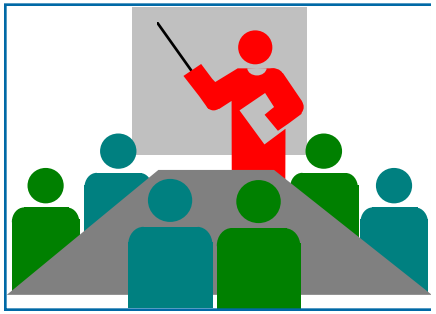

Condensate Line Routing

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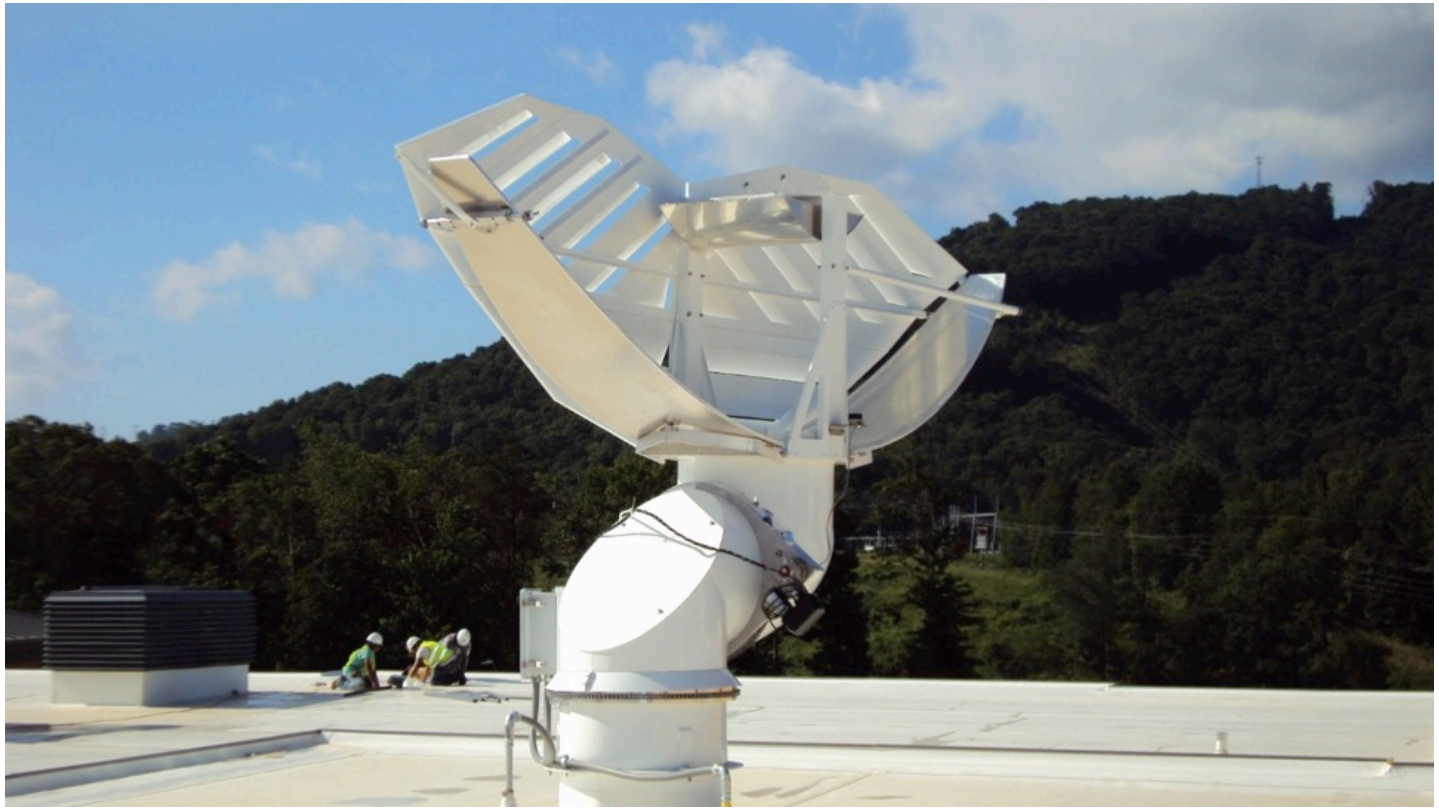
Quiz of the Day – What is this?



Thank You!

This concludes The American Institute of Architects
Continuing Education Systems Course

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