NEBBinar:
Managing Building Performance through Commissioning

March 28, 2013

Moderator

Jim Huber, NEBB Vice President and President of Complete Commissioning

Jim Huber is the President of Complete Commissioning. He has over 29 years of industry experience, is a Certified Energy Manager, and has extensive experience with BACNET, LON, MODBUS, and other building automation protocols and communication networks. He has programming, tuning, and testing experience with multiple systems and applications, as well as building systems commissioning, sound and vibration measurement, and testing and balancing.

Speaker

Jim Bochat

Jim Bochat is the President of Commissioning Concepts. He has been involved in the Arizona Engineering and Construction industry for over forty years. His experience includes Mechanical Design, Mechanical Construction, Controls, Test & Balance, Commissioning and Retro Commissioning. Jim is a former NEBB President. He is a Life Member of ASHRAE and serves on many technical committees. He also chairs the ASHRAE PMP Best Practices committee and recently served on the ABBA Whole Building Tightness Committee. He has been a NEBB Certified Professional since 1974 and has co-authored several standards regarding Commissioning for NEBB, ASHRAE and AABA. He has taught the NEBB certification program throughout the United States and in Australia. He has also spoken at events such as Greenbuild, ASHRAE, AHR Expo, PECI, NEBB, SMARCA, IFMA, Southwest Plant Engineers, RMA Chapter of APPA, Western Area Power Users, and AMCA of Australia regarding Commissioning.

Jim Bochat was presented the George Hightower Award for his distinguished service to NEBB. The George Hightower Award is NEBB's most prestigious honor and is presented to someone who has made significant contributions to the success of NEBB and the HVAC industry.

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Agenda

Energy usage in the United States

Building performance

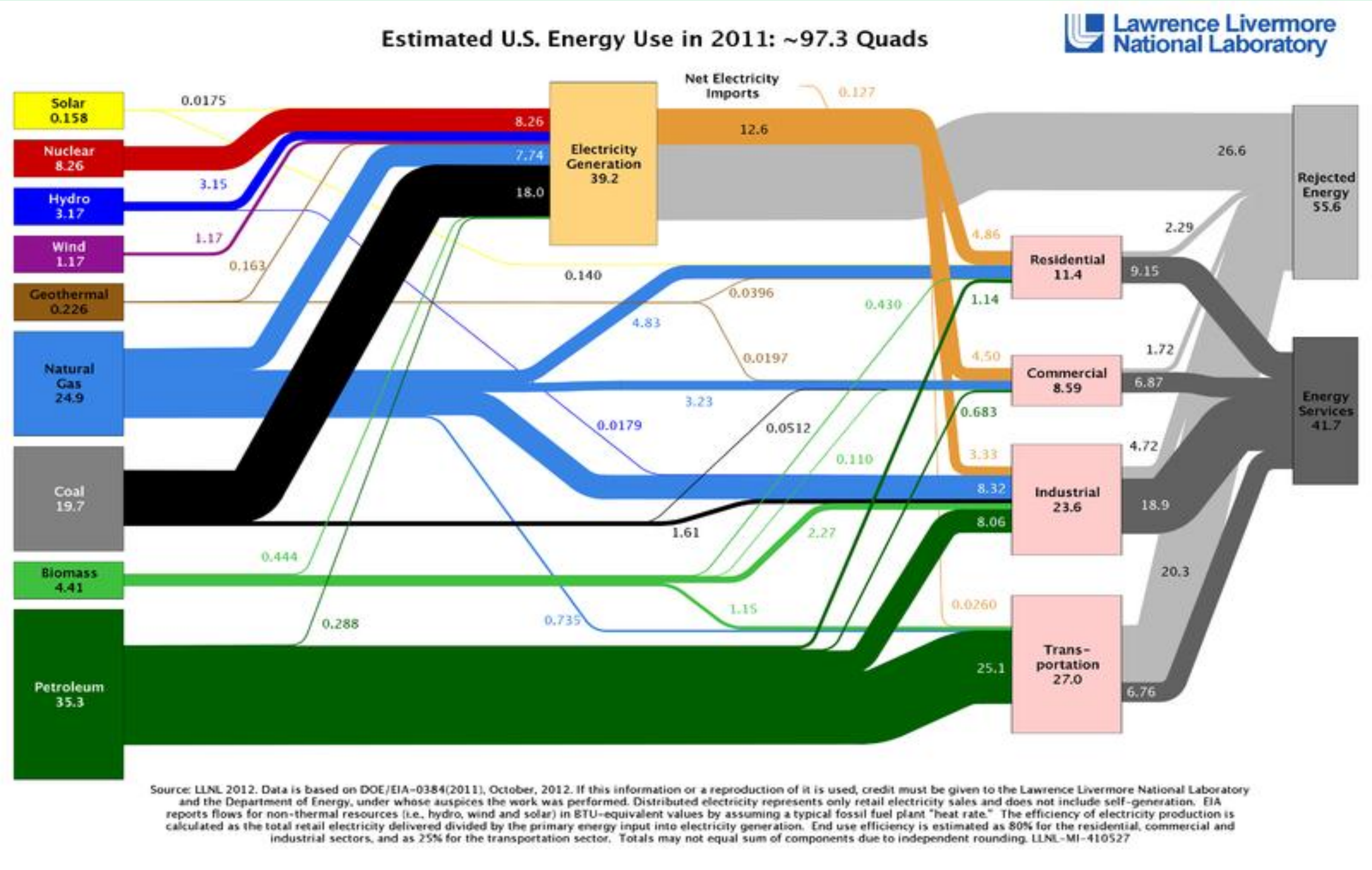
Achieving building performance

Mechanical systems

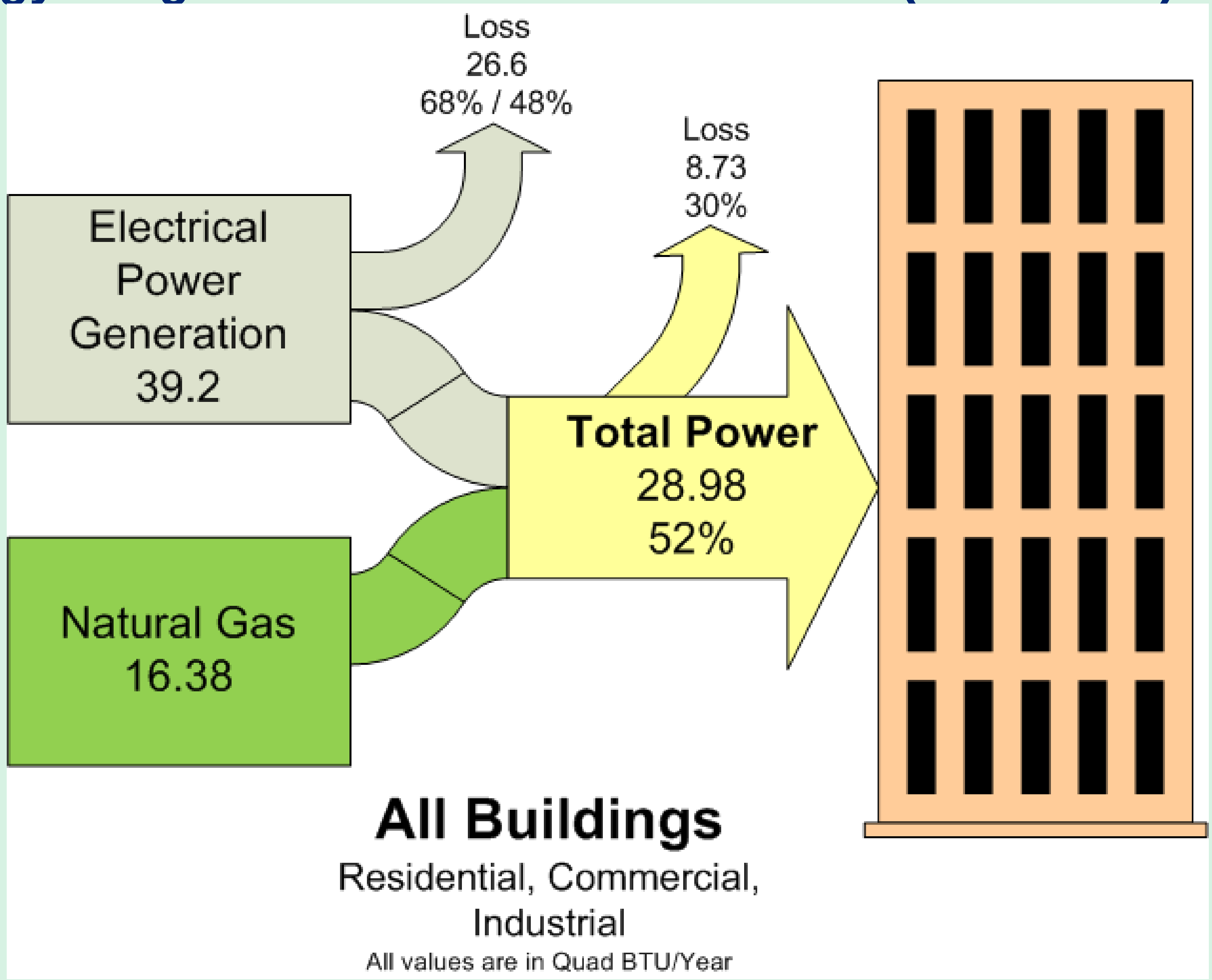
Control systems

Question and Answers

Energy usage in the United States



Energy usage in the United States (continued)



Energy usage in the United States: Commercial buildings

- 5,500,000 buildings[1]
- 81,100,000,000 (81 Billion SF)[2] 14,745 Square feet average
- 10,950,000,000,000,000 (10.95 Quadrillion BTU/Year)[3]
- Average consumption 135,000 to 217,000 BTU/SF/Year
- ASHRAE 90.1 (Energy code)
  - 1999 – 53,300 BTU/SF/Year
  - 2010 – 36,000 BTU/SF/Year

1. Interpolated from 2000 and 2010 data
2. Taken from 2010 data
3. End use power interpolated from 2010 and 2011 data

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Building performance: What is performance?

- **Systems work**
  - **Performance verification to design intent**
- **Environmental comfort (ASHRAE 55)**
  - **Occupant comfort**
  - **IEQ performance**
- **Utility performance**
  - **Electrical use**
  - **Water use**
  - **Gas use**

PERFORMANCE

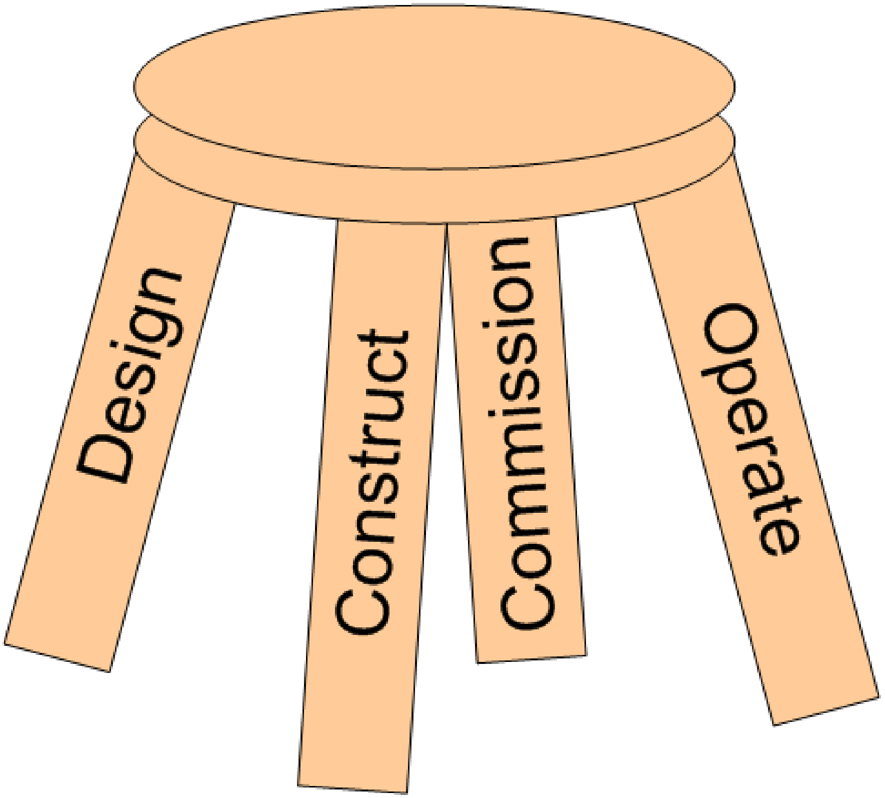
Building performance: How do we improve building performance?

- **Make new buildings work**
  - **Technical commissioning of systems**
- **Make what we have work**
  - **Retro-Commissioning of existing buildings**
- **Keep what we have working**
  - **Operations for performance**

PERFORMANCE

PERFORMANCE

Building performance is dependant upon four legs of the stool. Take one away and you have an unstable building.



Building performance: So what's not working…

- **Construction**
  - **Lack of performance knowledge**
- **Commissioning**
  - **Most buildings are not working correctly when they are turned over to the owner**
- **Operations**
  - **Most buildings do not measure performance so they do not improve**
- **Accountability**
  - **No one is held accountable for performance**

PERFORMANCE

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Building performance: What is the ultimate solution?

PERFORMANCE

- **Make performance contractual**
  - If new buildings were contracted with performance being a part of the contract then designers, contractors and commissioners could be held accountable.
  - The problem is operations is outside of the contract (key leg of the stool)
  - Suggestion: Make the first two years of operations a part of the contract with financial penalty for failure

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ACHIEVING BUILDING PERFORMANCE

Achieving building performance

- Performance verification
- Design for practical performance
- Construction for performance
- System testing for performance
- Commissioning for performance
- Operations for performance

Achieving building performance: Performance verification

- **Electrical Metering**
  - **Sub-metering - HVAC, lighting, and plug load**
- **Water metering**
  - **Sub-metering - Building, landscape, specific use**
- **Comfort verification**
  - **Occupant interviews**
- **Continuous improvement process**
  - **Ongoing verification**

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Achieving building performance: Design for <u>practical</u> performance

- Make performance the main design parameter
- Practical design
  - Proven performance understood by operators
  - Simple high quality designs in lieu of creative designs
- Design for performance verification
- Design for system testing

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Achieving building performance: Construction for performance

- Robust QC programs
- System testing
    - Envelope
    - HVAC and controls
    - Electrical
- Embrace technical commissioning
- Include operations verification

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Achieving building performance: System testing for performance

- **Envelope Testing**
  - Whole building pressure testing
  - Water intrusion testing
- **HVAC Testing**
  - Duct and pipe pressure test verification
  - Certified test and balance
  - Control system point to point testing
- **Electrical Testing**
  - Third party electrical system testing
  - Standby power testing

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Achieving building performance: Commissioning for performance

- **HVAC technical commissioning**
  - No sampling strategies
  - Onsite testing and verification
    - Installation inspection
    - Contractor testing observation
    - Controls point to point test
    - Functional performance testing

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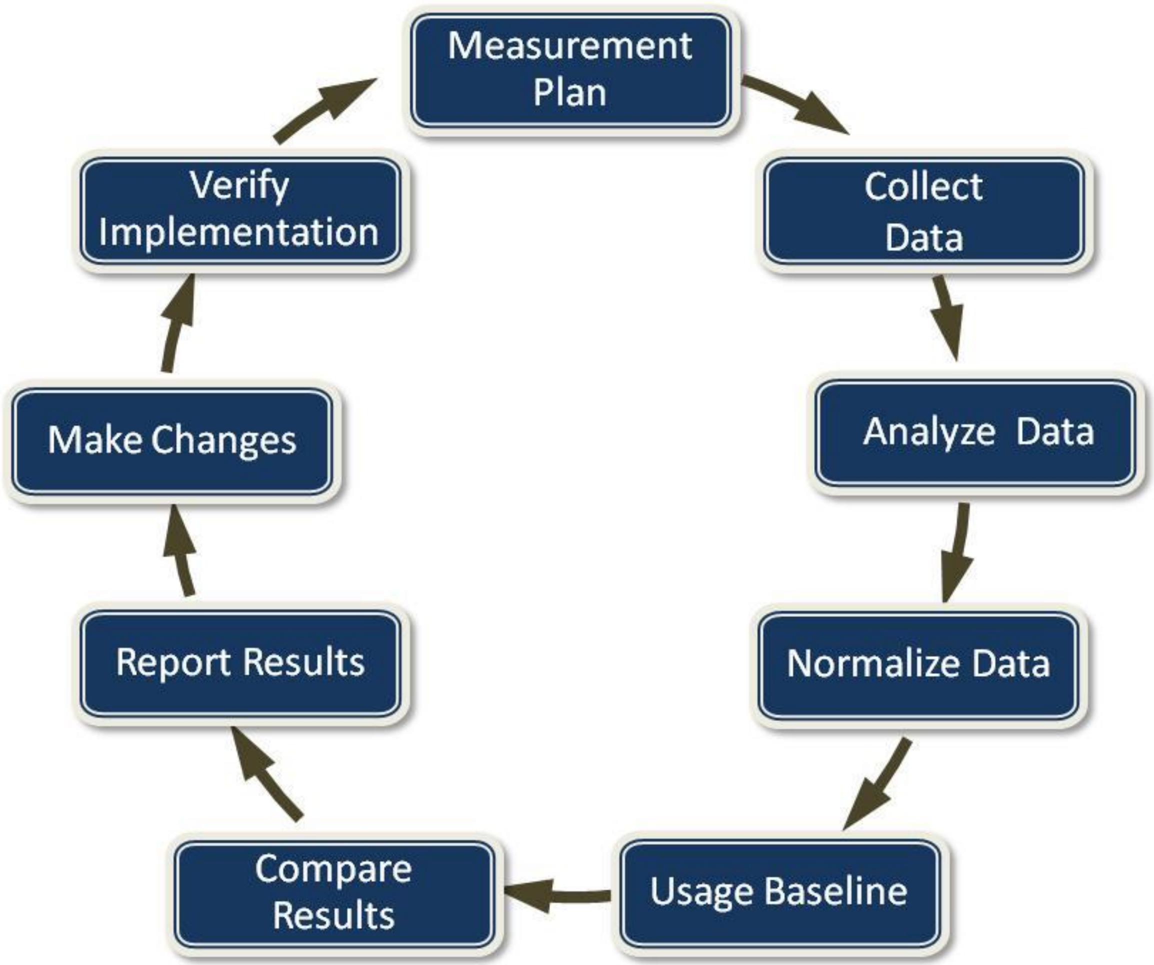
Achieving building performance: Commissioning for performance (continued)

- **Electrical technical commissioning**
  - On Site Testing & Verification
    - Installation Inspection
    - Contractor testing observation
    - Controls Point to Point Test

Achieving building performance: Operations for performance

- Continuous improvement process



Achieving building performance

- Devil is in the details
- Mechanical performance
- Control systems performance
- Electrical performance

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Question and Answers

Mechanical systems: Equipment efficiency

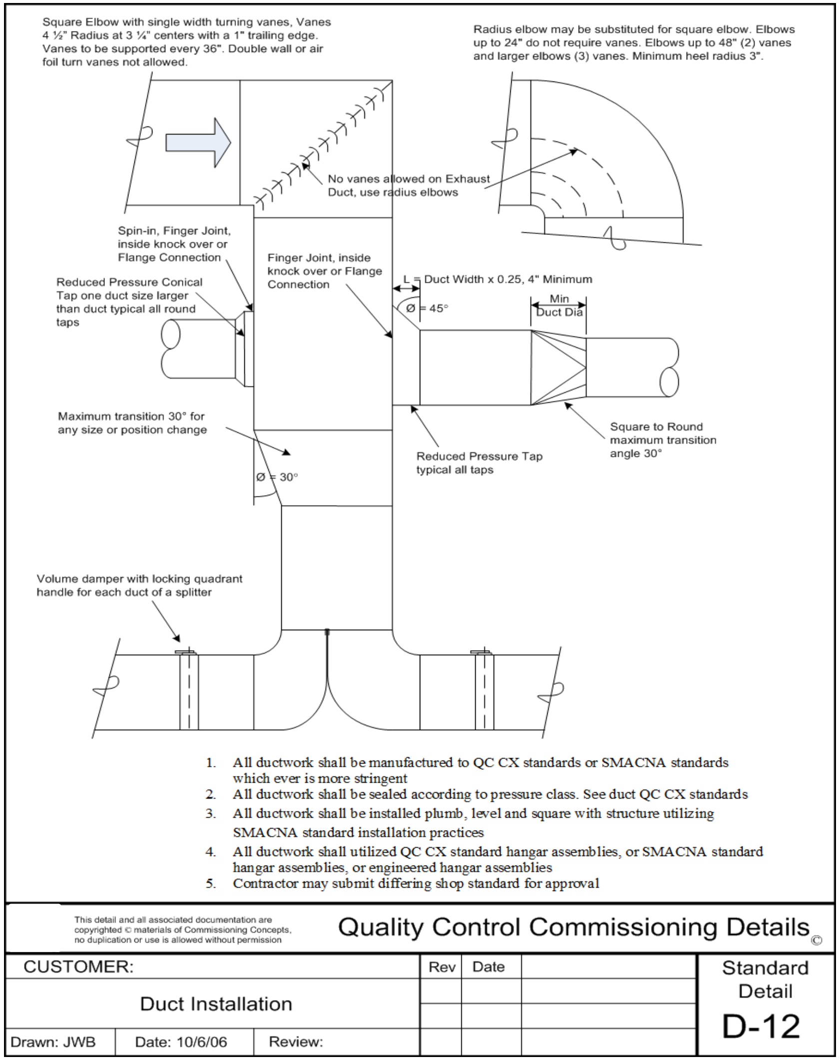
- SER and COP for package units
- Chiller part load efficiency
- Cooling tower efficiency
  - Fluid coolers versus towers with plate HX
- Motors premium efficiency
  - EF or other motors that run 24/7
- Fan and pump efficiency
- VFD on variable flow motors
- Boiler efficiency
  - Condensing boilers (high return temperature)

Mechanical systems: OSA flow and building pressurization

- **Minimum OSA flow**
  - **Building must be positive pressure (+0.02” to +0.05”)**
    - **(Total exhaust + envelope leakage)>(Ventilation rate)**
    - **Building leakage rate**
      - **Crack method calculation**
      - **Air barrier leakage rate calculation**
- **Envelope testing**
  - **Pressure testing (Leakage rate 0.16 to 0.25 $CFM/SF_{air\ barrier}$@75PA)**
  - **Not unusual to see (0.1 to 0.15 $CFM/SF_{floor\ area}$ @5PA)**
    Should be (0.05 to 0.075 $CFM/SF_{floor\ area}$ @5PA)
  - **Thermal intrusion testing (Thermal scan)**

Mechanical systems: Lowest practical operating pressure

- Liberal sizing
- Duct taps
  - Reduced pressure taps
- Duct transitions
- Duct sealing



Mechanical systems: Lowest practical operating pressure (continued)

- **Flex duct**
  - Liberal sizing
  - Maximum length 8'-6'
  - No kinks or sags
  - Joint seal

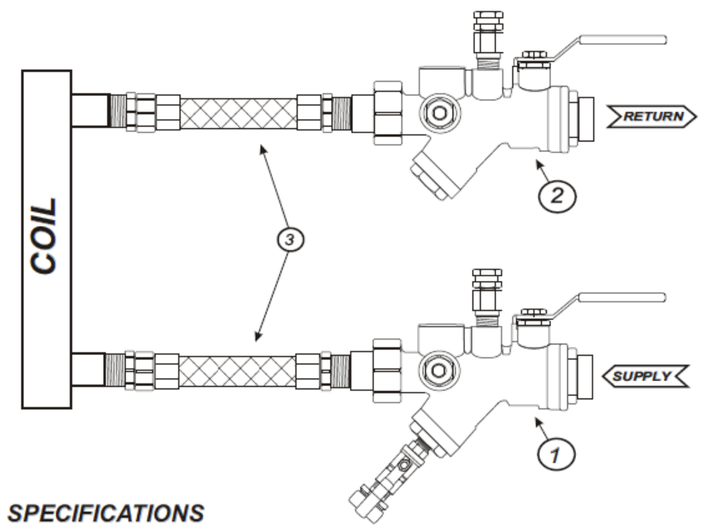
Low Pressure Flex Duct for Diffuser Run Outs			
Diameter	Maximum CFM	Velocity FPM	Maximum Length
4"	45	500	8'
5"	75	550	8'
6"	120	600	8'
7"	165	625	8'
8"	240	675	8'
9"	300	700	8'
10"	400	725	8'
12"	585	750	8'
14"	830	775	8'
16"	1200	850	6'
18"	1680	900	6'
20"	2200	1000	6'
24"	3450	1100	6'

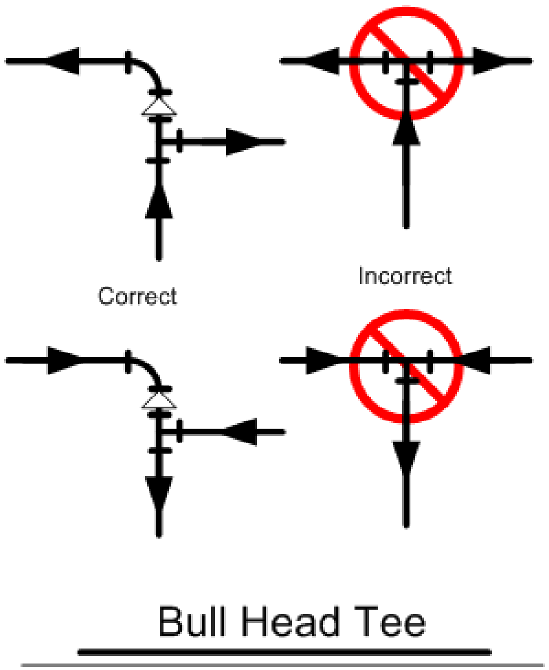
1. Flow based on the following conditions (14.7psi, 60°, 0.01 roughness factor)

Mechanical Systems

Mechanical systems: Lowest practical operating pressure (continued)

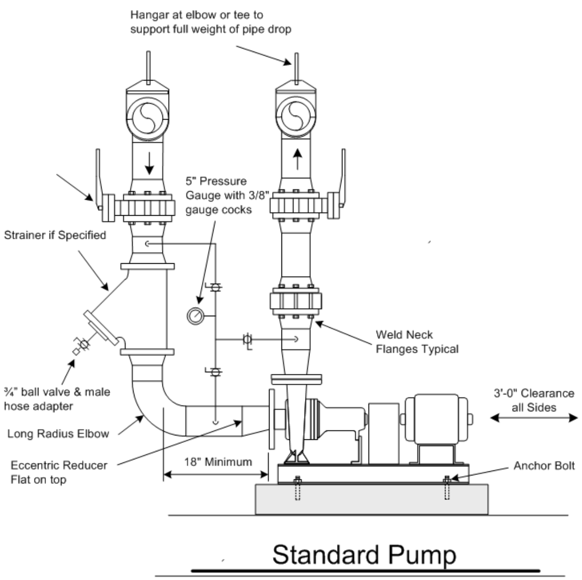
- **Pipe**
  - Lowest practical velocity
  - No bull head tees
  - Equipment run outs to design flow not unit connection size
  - Minimize coil valves

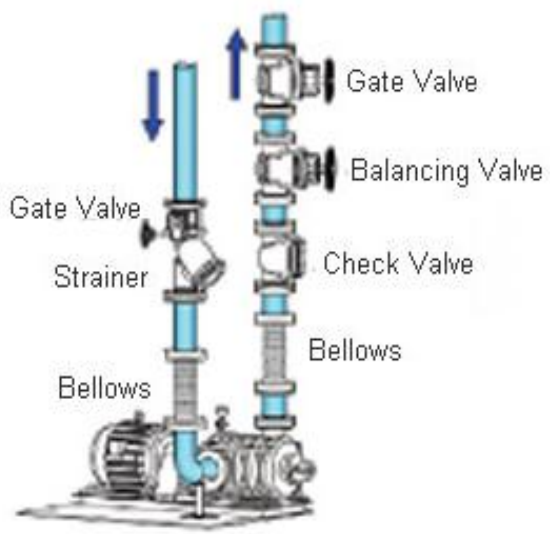


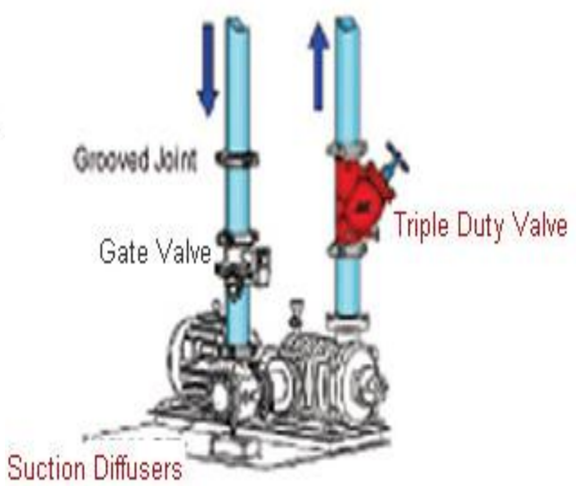


Mechanical systems: Lowest practical operating pressure (continued)

- **Pipe (continued)**
  - Multiple strainers
  - Multiple balance valves
  - Trim impellers
  - Condenser pump suction strainers



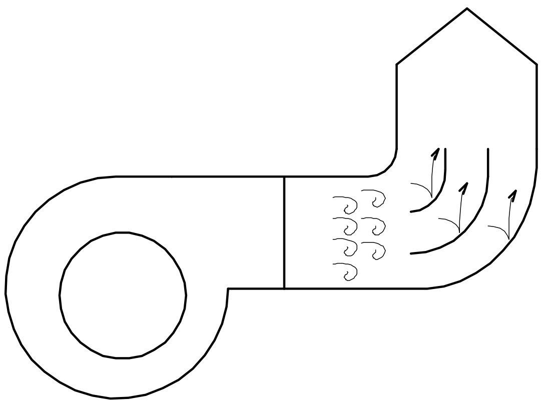


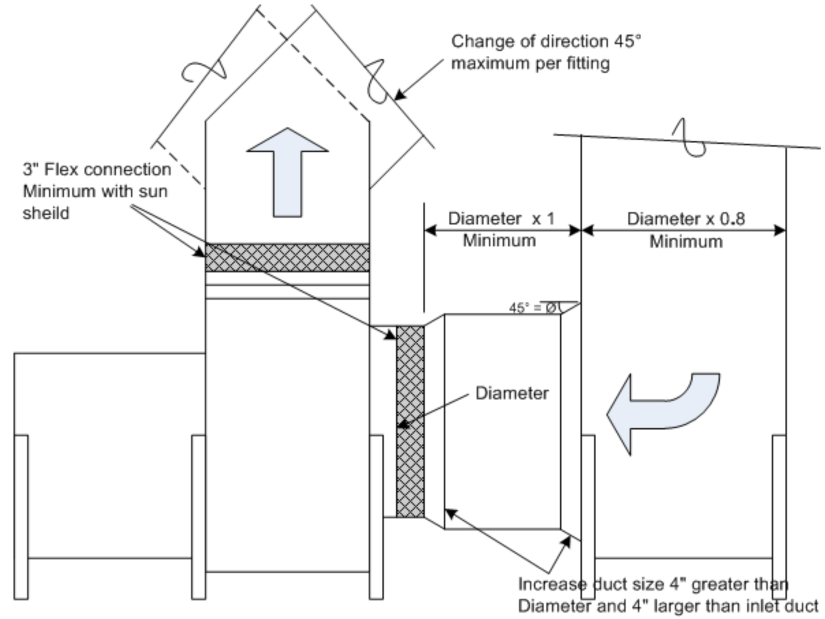


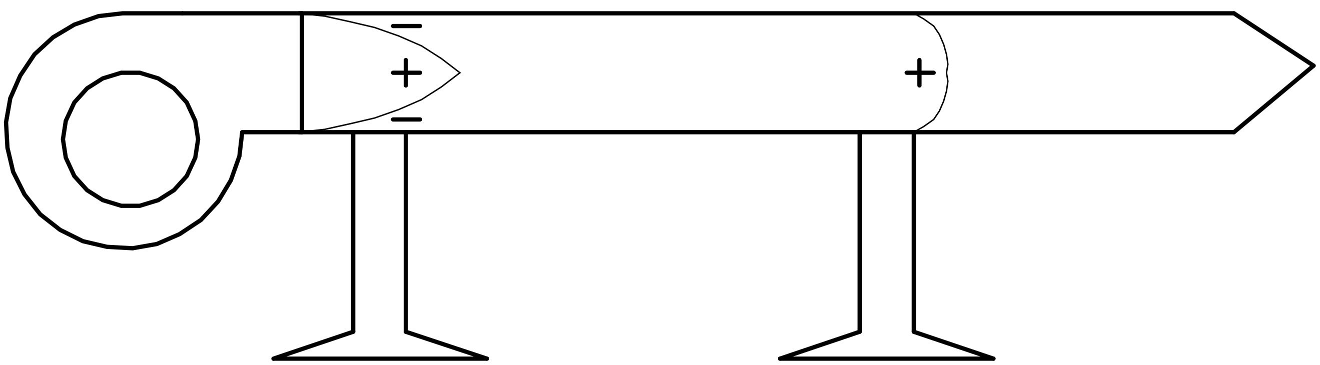
Mechanical Systems

Mechanical systems: System effect

- **High pressure due to system effect**
  - **Inlet Condition**
  - **Outlet Conditions**







Mechanical Systems

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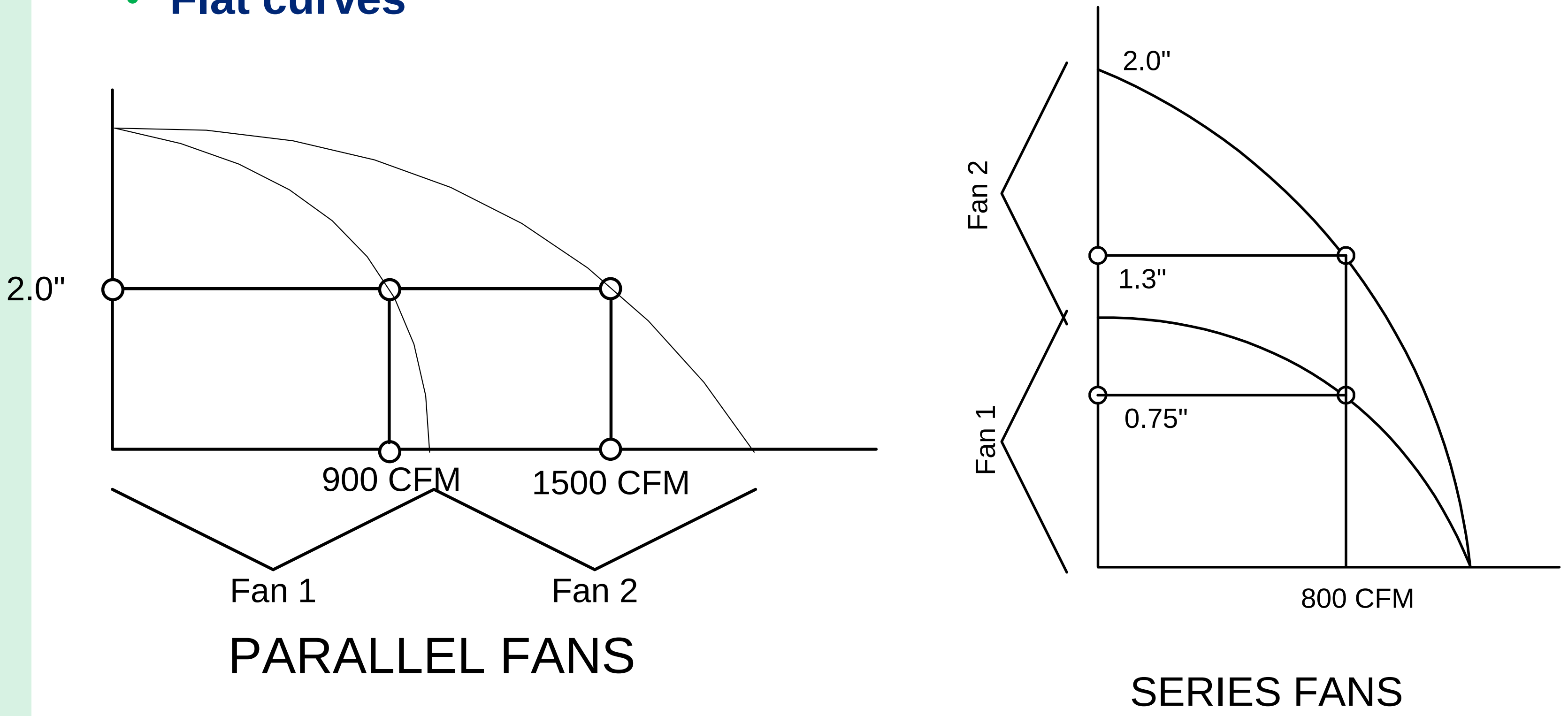
Mechanical systems: Flow performance

- **Fan or pump operation**
  - **Running multiple fans or pumps**
  - **Flat curves**



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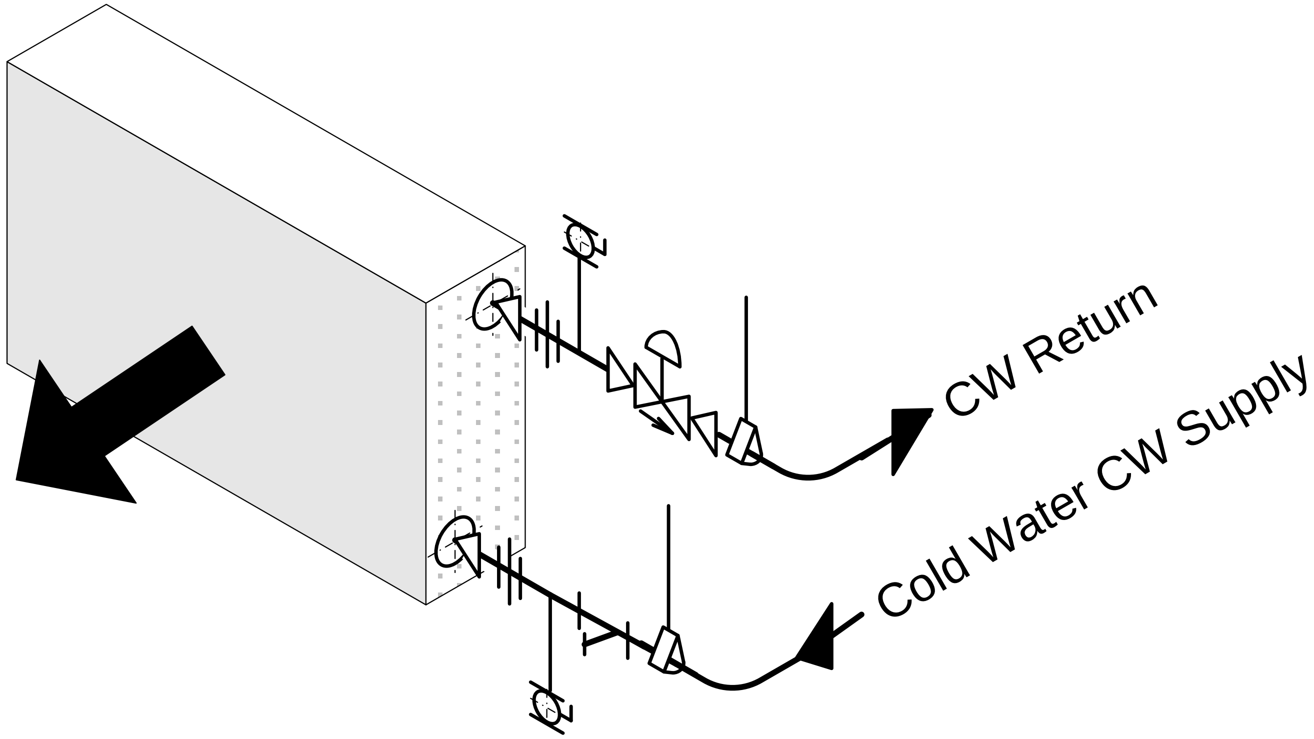
Mechanical systems: Temperature performance

- **Coil piping**
  - **Counter flow CW Coil**
    - **Coldest water enters at air leaving side of coil**



Mechanical systems: Flow performance

- **Air balance**
  - Low pressure balance
    - At least one grille should be 100% open
    - Proportional balance
  - Cooling diversity no lower than 75% of the total zone loads
    - % AHU CFM to total of all zone CFM
  - Heating diversity no lower than 100% of the total block load

Mechanical systems: Flow performance

- **Water balance**
  - Low pressure balance
    - Coil valve trains
    - Pump balance valves
  - Chilled water diversity no lower than 80% of the total of all zone loads
  - Hot water diversity should be 100% of the total block load
  - Hydronic HP condenser water should be 100% of the total of all zone loads (system start up)

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Mechanical systems: Maintenance performance

- Operations
  - Lowest possible filter drop
    - 300 FPM or less
    - Low pressure drop pleated material
  - Clean coils and condensate pans
  - Clean fan blades
  - Tight balanced fan belts
  - Lubricated and adjusted dampers
  - Seal all air leaks
  - Annual sensor calibration and point checks

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Mechanical systems: Maintenance performance (continued)

- Maintenance
  - Clean coil tubes
  - Clean strainers
  - Correct suction pressure
    - 12#-15# at pump suction (single story)
    - No air in system (auto vents)

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Question and Answers

Control systems: Sequence of controls

- **Schedule control**
- **CW leaving temperature / chiller ∆T**
  - **>10°**
  - **Lowest possible lift**
- **Condenser water temperature**
  - **Normal design 85° / 95°**
  - **Intel study recommends 5° above wet bulb**
    - **Cold water okay if lift is small or newer chillers**
- **CW or HW temperature reset control**
  - **Reset from valve position**
- **CW or HW pressure reset control**
  - **Make sure this does not fight temperature control**

Control systems: Sequence of controls (continued)

- Schedule control Set Points
  - Occupied / Unoccupied setpoints
    - Occupied 75°-78° / Unoccupied 84° - 86° summer
    - Occupied 70°-72° / Unoccupied 60° - 64° winter
- Dead band control
  - Difference between cooling and heating action
  - Dead Band 2° - 4°
- VAV supply air temperature reset control
  - Reset from terminal unit load
  - Not average load but low or high select
- Supply air pressure reset control
  - Make sure this does not fight temperature control

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Control systems: Sequence of controls (continued)

- Air side economizer Control
  - Verify operation
  - Db control
- Data trend analysis
  - Room temperature
  - Supply duct temperature
  - Supply duct pressure
  - CW differential temperature
  - Condenser water temperature

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Operations

- **Bad list**
  - Disable schedule to get space cool in the morning
  - Disable or override setpoint reset to make it colder
  - Override any automatic setpoint reset
  - Override control point output with manual switch
- **Good list**
  - Find the cause and fix it instead of reacting to symptom
  - Document any temporary measures taken and change them back as soon as issue is resolved
  - Measure performance often to see how you are doing
    - Energy
    - Comfort

Contact information

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