Commissioning: Process and Benefits

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and
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Cx Associates LLC
Burlington, Vermont

Better Buildings By Design 2010

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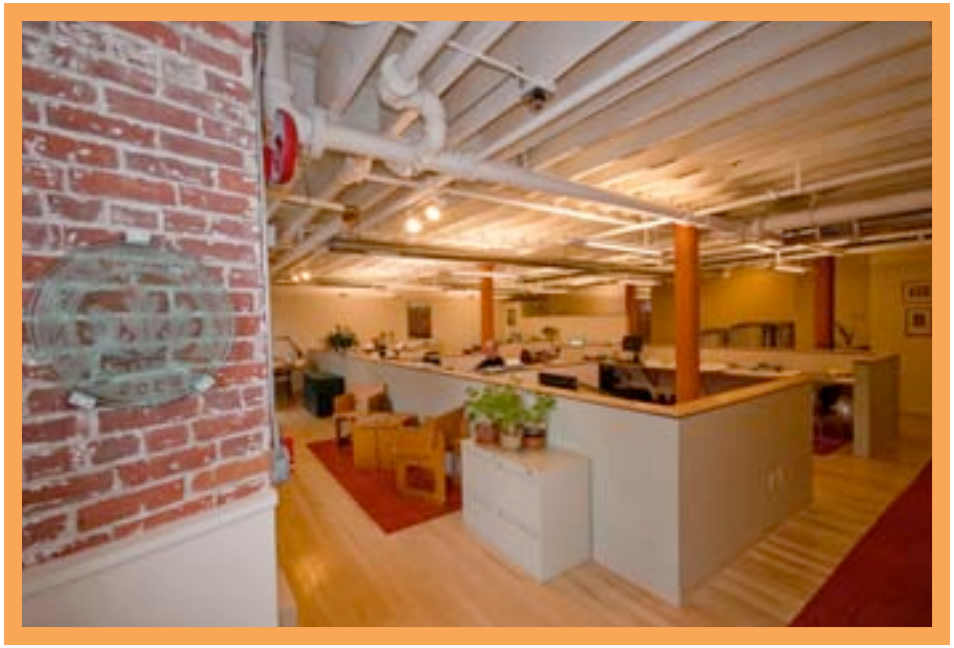
Learning Objectives

Lessons Learned While Commissioning

- At the end of this program, participants will be able to:
  - Examine real-world examples to learn how commissioning cost effectively identifies and resolves deficiencies
  - Utilize strategies to enhance energy efficiency in existing buildings
  - How to apply commissioning to existing buildings to prevent or resolve potential design and building flaws
  - Evaulate best approach to avoid potential operational problems prevalent in many existing buildings structures

Who is Cx Associates?

- ✓ Owners **Tom Anderson**, CCP & **Jennifer Chiodo**, PE, LEED AP
  - 50 years combined experience in the design, construction, commissioning and operation of high performance buildings
  - 16 years in business
- ✓ LEED Certified office, downtown Burlington, VT



Who is Cx Associates? (cont.)

- ✓ Building Commissioning
- ✓ Energy Analysis
- ✓ Energy Measurement & Verification

[redacted]

Who is Cx Associates? (cont.)

Commissioned over 11 million square feet and over $600 million in project costs since 1994

ECHO Vermont's first LEED certified building

The Davis Center at UVM, the first LEED Gold certified student center in the nation

Kemeny Hall and Haldeman Center, Dartmouth College, LEED Silver Certified

The Commissioning Process

- ✓ Commissioning (Cx) Overview
- ✓ Who Should Hire the Cx Authority?
- ✓ Commissioning Guidelines
- ✓ Fundamental Commissioning Metrics
- ✓ Design Review
- ✓ Field Verification
- ✓ Post-Occupancy Partnership

Commissioning (Cx) Overview

- ✓ The Commissioning Authority
  - Provides independent, third-party quality assurance
  - Identifies potential improvements
  - Ensures project goals are met

- ✓ The earlier, the better.
  - Ison's Rule of 10.

[redacted]

Ison's Rule of 10

The earlier problems are uncovered, the cheaper they are to fix.

Problem Uncovered	Relative Cost
During preliminary design	$50
During final design	$500
During construction	$5,000
Post-occupancy	$50,000

Not the $50 Fix!

Inadequate pull space

Discovered after unit was installed.

Plenty of pull space now!

[redacted]

Who Should Hire the CxA?

- ✓ Owners
  - Hiring a Cx provider directly ensures no conflicts of interest
- ✓ LEED Requirements
  - Must report findings directly to Owner
  - Fundamental Cx – May be hired by anyone
  - Enhanced Cx – Cannot be hired by any member of the construction team

[redacted]

Commissioning Guidelines

- ✓ No Cx "Standards" Exist (Not ANSI)
- ✓ ASHRAE Guideline 0 "The Commissioning Process"
  - Purpose "… to describe the commissioning process capable of verifying that a facility and its systems meet the Owner's Project Requirements."
  - Guideline "0" serves as basis for sub-system commissioning guidelines.
- ✓ BCA - Building Commissioning Association
  - Best Practices

[redacted]

Fundamental Commissioning Metrics

- ✓ Owner's Project Requirements (OPR)
  - Defines project objectives and sets expectations
- ✓ Basis of Design (BoD)
  - Aligns design with Owner's Project Requirements
  - Outlines how the objectives and expectations will be achieved.
- ✓ Not limited to MEP!

[redacted]

Commissioning Design Review

- ✓ Focus on ensuring design concepts meet OPR & BoD
- ✓ Identifies Opportunities for:
  - energy efficiency
  - simplified operation
  - better maintenance access

[redacted]

Design Review Matrix

Project	**Project Name** **Client Name**	**Reviewed by:**	Matthew Napolitan (Mechanical) 802-861-2715 xt 13	**Review Date**	
Phase	**CD Commissioning Review Comments**	**Response by:**	Note ALL responding parties here.	**Response Date**	

The following review comments are based on CD drawings dated 2008 and Addendum 1, Addendum 1 Rev 1& Addendum 2 documents dated September 05, 09 and 12, 2008 respectively, the design review meeting held Oct 06, 2008and the issue of Architectural Directive 005 dated Oct 17, 2008.

Item	Ref	Reviewer Comments	Consultant Response – Indicate vehicle for addressing comment e.g. SK, Addendum, Etc.	Contract Implications	Action By / Status
		MECHANICAL SYSTEM REVIEW COMMENTS			
1	General	There is no specification section for motors. We suggest including a motor specification section to clarify what the specific requirements of the project's motors are. For instance, motor enclosure types for various applications and motor insulation class. We also recommend not allowing shaded pole motors for small motor applications and encourage the use of ECM motors where available. All of this is usually captured in a motor specification section. *10/21/08 Addressed in AD-005 Spec Section 15970*	Motor spec to be added as addendum item.	Should be included before award	ME
2	P&ID-02	We suggest providing duct high and low static pressure safety switches on the supply and return ductwork respectively for MAU-1. *10/21/08 Addressed in AD-005 1-5.25*	Agreed, will be added as addendum item.	Should be included before award	ME

[redacted]

Field Verification

- ✓ Rigor via checksheets – developed from OPR, BoD, design drawings and submittal information.

- ✓ Two-step process
  - Initially carried out by responsible contractors
    1. Construction verification
    2. Functional testing

[redacted]

Sample Checksheet

Installation Checks			
Check if Acceptable; Provide comment if unacceptable	**Contractor**	**CxA**	**Comments**
Cabinet and General Installation			
Casing condition good: no dents, damage			
Access doors close tightly – no leaks			
Connection between duct and unit tight and in good condition			
Maintenance access acceptable for unit and components			
Thermal insulation properly installed and according to specification			
Cooling Coil is downstream of the heating / pre-heat coil to protect against freeze up?			
Fans and Dampers			
Supply fan lube points extended and/or accessible			
Return fan lube points extended and/or accessible			
Access doors open against pressure			

Post-Occupancy Partnership

- ✓ Training Scope Review & Verification
  - Ensure training will meet the needs of building operators *before* training occurs
  - Verify training was completed satisfactorily.
- ✓ Remote DDC monitoring
- ✓ Post-Occupancy site visit
  - Before contractor warranty period expires

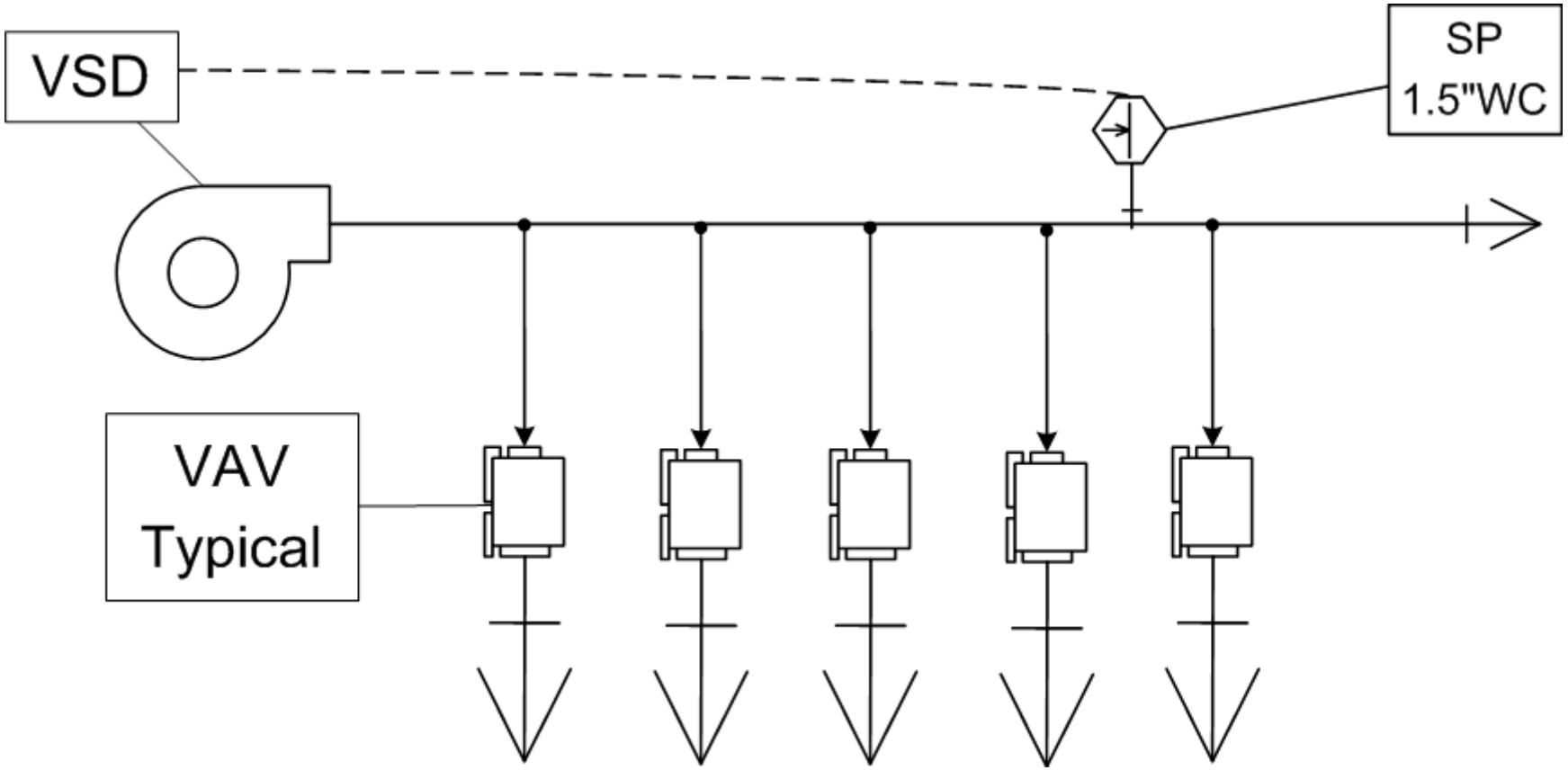
[redacted]

Commissioning in Practice

- ✓ Common HVAC Opportunities
- ✓ Common DHW Opportunities
- ✓ Common Lighting Opportunities
- ✓ HVAC Concepts

[redacted]

Static Pressure Control



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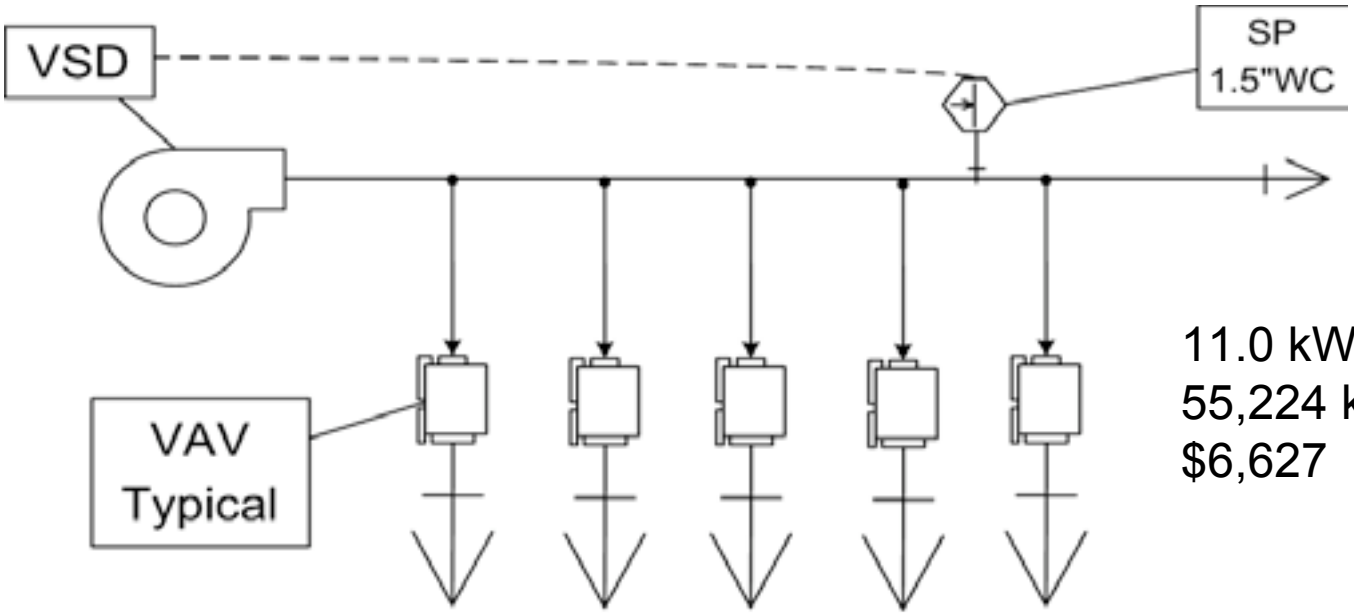
Static Pressure Control

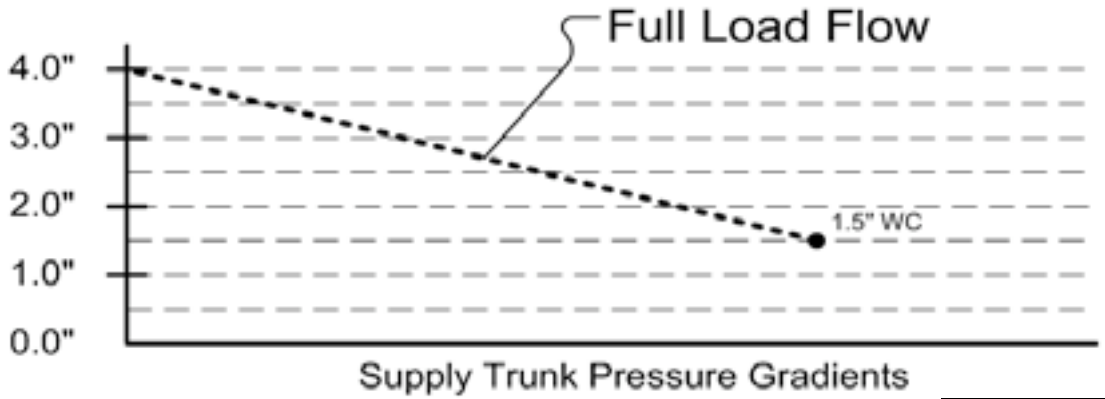
- ✓ Used For:
  - Variable Air Volume (VAV) Systems
  - Fan Capacity Controls
  - Maintaining Duct Pressure

[redacted]

Static Pressure Control



11.0 kW
55,224 kWh
$6,627



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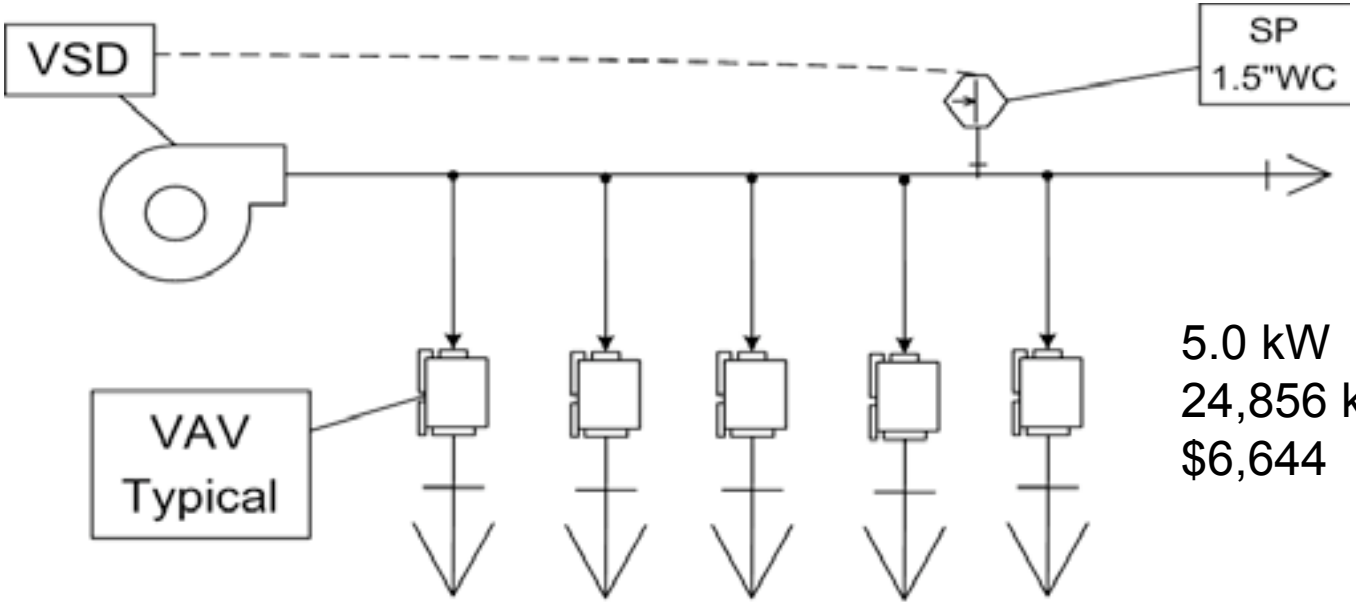
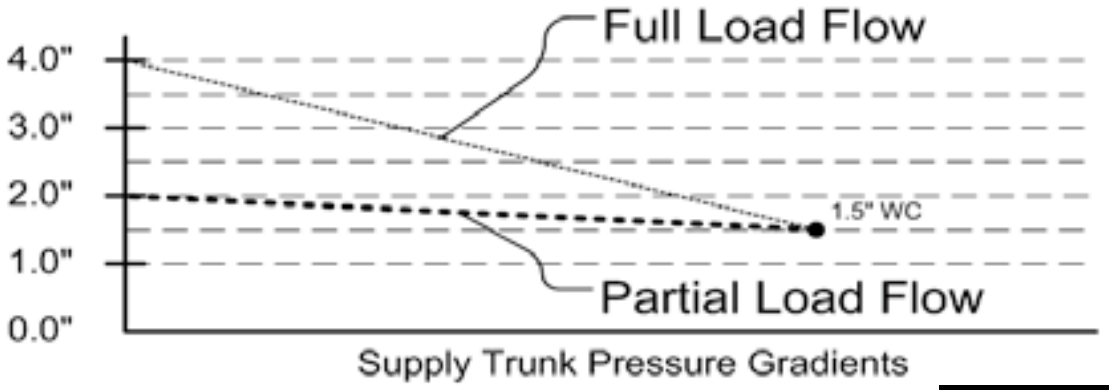
Static Pressure Control



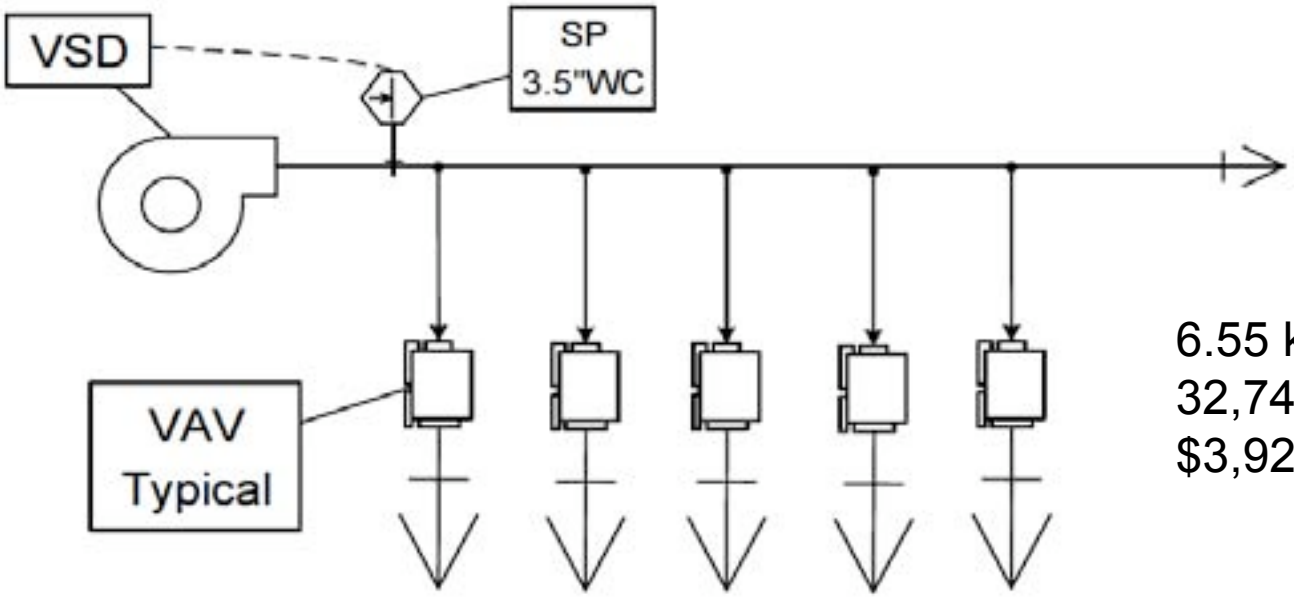
5.0 kW
24,856 kWh
$6,644



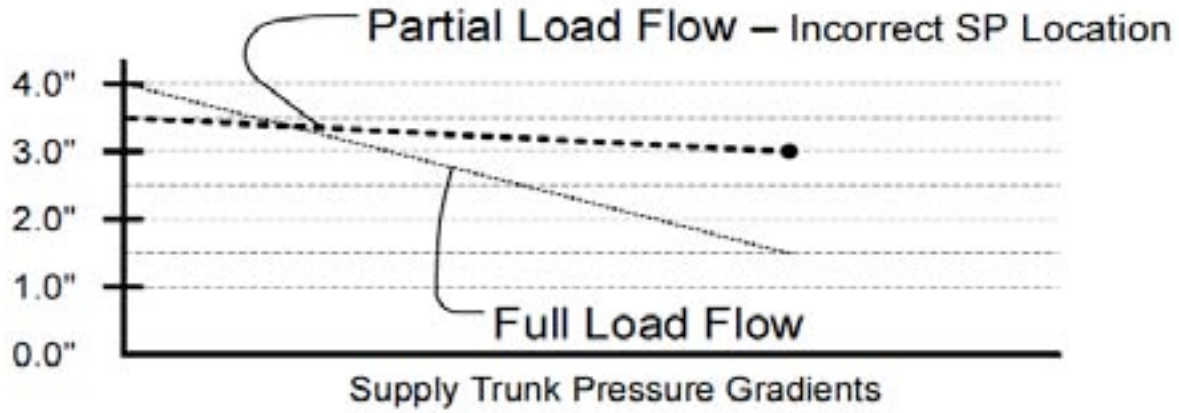
Supply Trunk Pressure Gradients

[redacted]

Static Pressure Control



6.55 kW
32,742 kWh
$3,929



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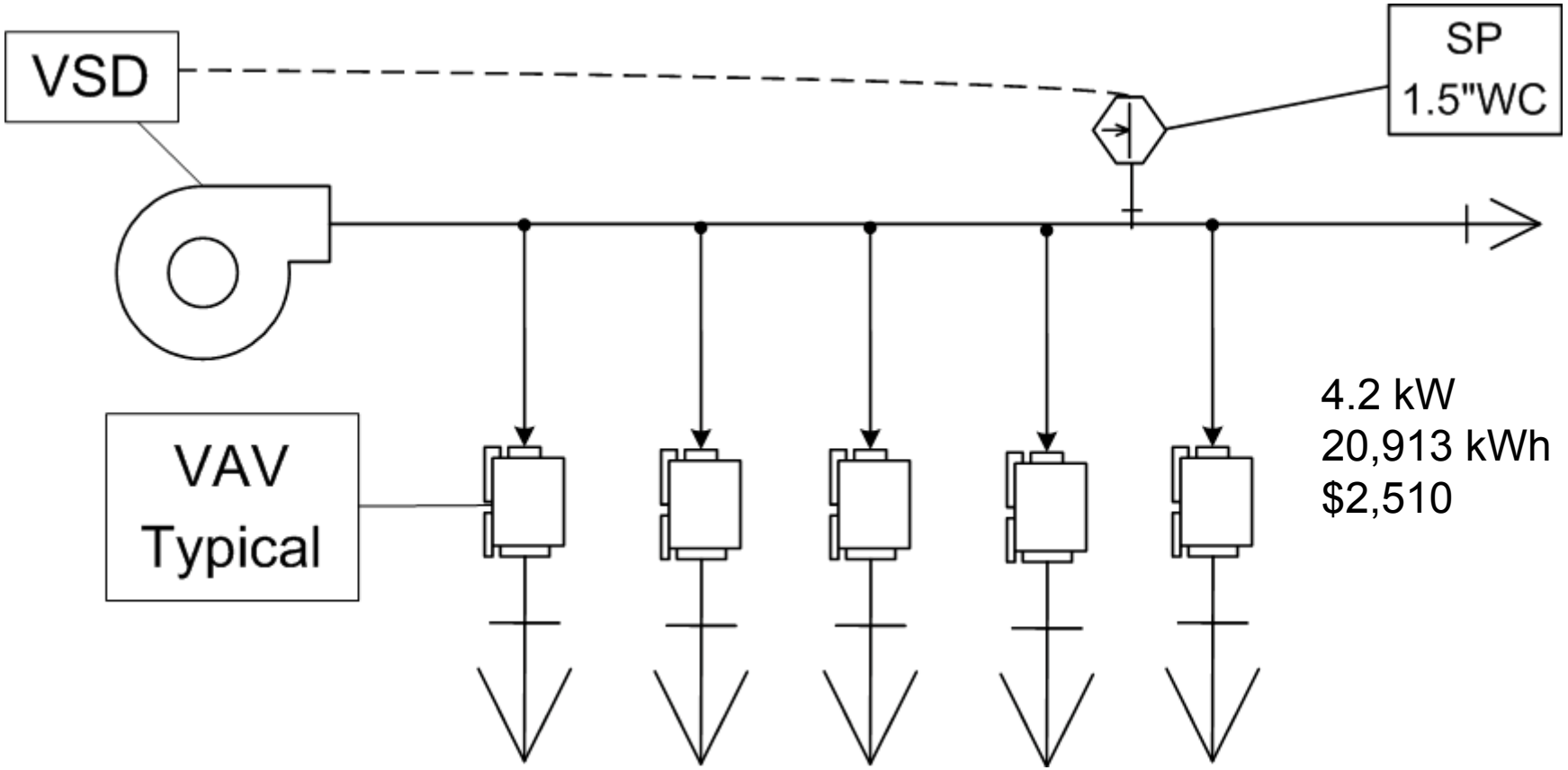
Static Pressure Reset



[redacted]

SP Control Consumption

METHOD	kW	kWh	$/Year
1.5” SP Fixed Setpoint	5.0 kW	24,856 kWh	$3,644.
1.5” SP Incorrect Location	6.6 kW	32,742 kWh	$3,929.
1.5” SP Reset	4.2 kW	20,913 kWh	$2,510.

10,00 cfm

6.0” TSP

70% average annual cfm load

5,000 hours per year

[redacted]

Static Pressure Reset

- ✓ Common “canned” sequence with most systems.
  - If added during design review: +/- $500. cost
  - If added during construction, additional programming time will be required
- ✓ Static Pressure Reset can be as low as possible (<.5” w.c.)

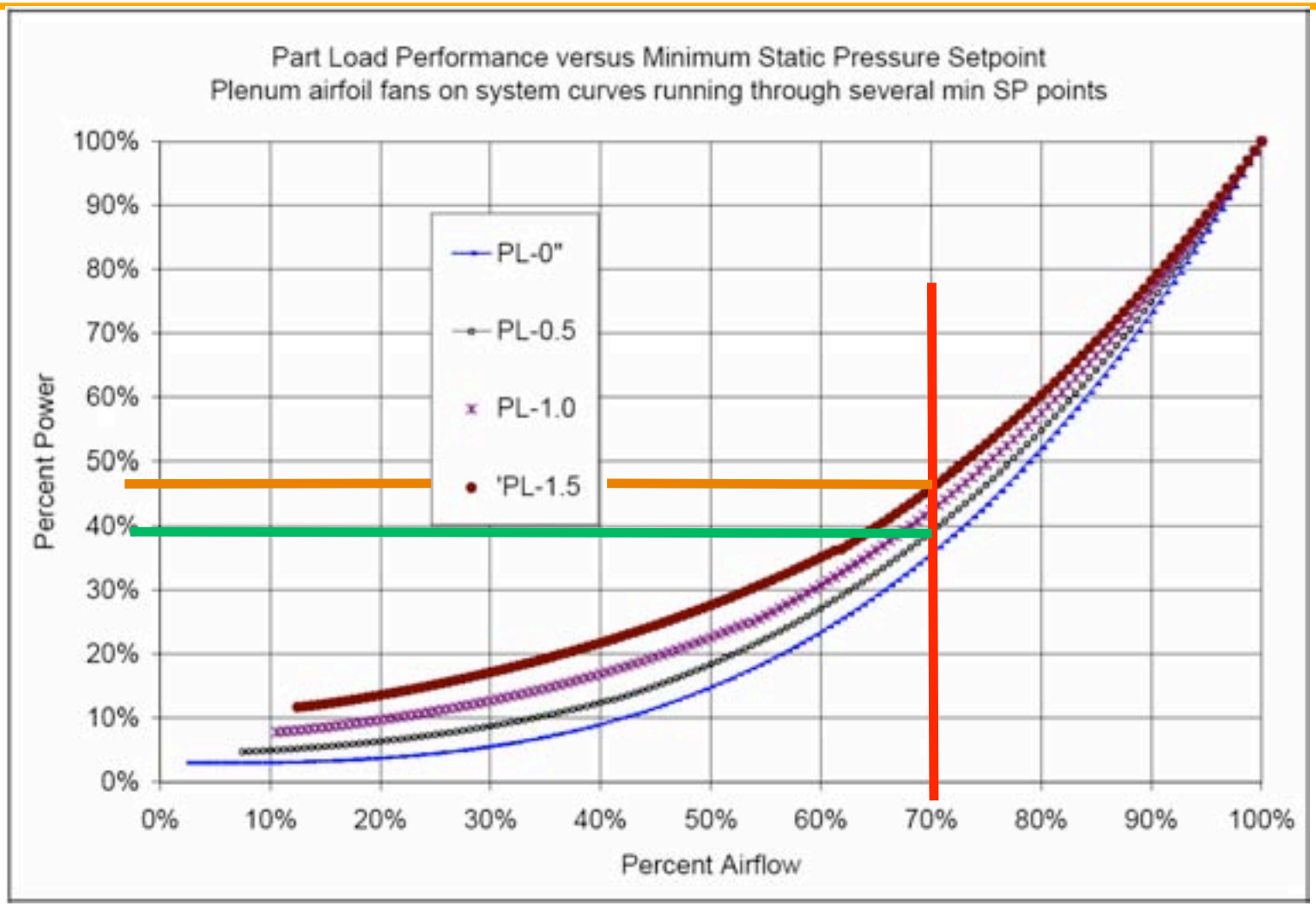
[redacted]

Static Pressure Reset

- ✓ Must specify correctly
  - Limit VAV boxes to 90% open
- ✓ “Rogue” VAV Boxes:
  - Number of Boxes Calling
  - User Defined Number

[redacted]

SP Set Point vs. Fan System Energy



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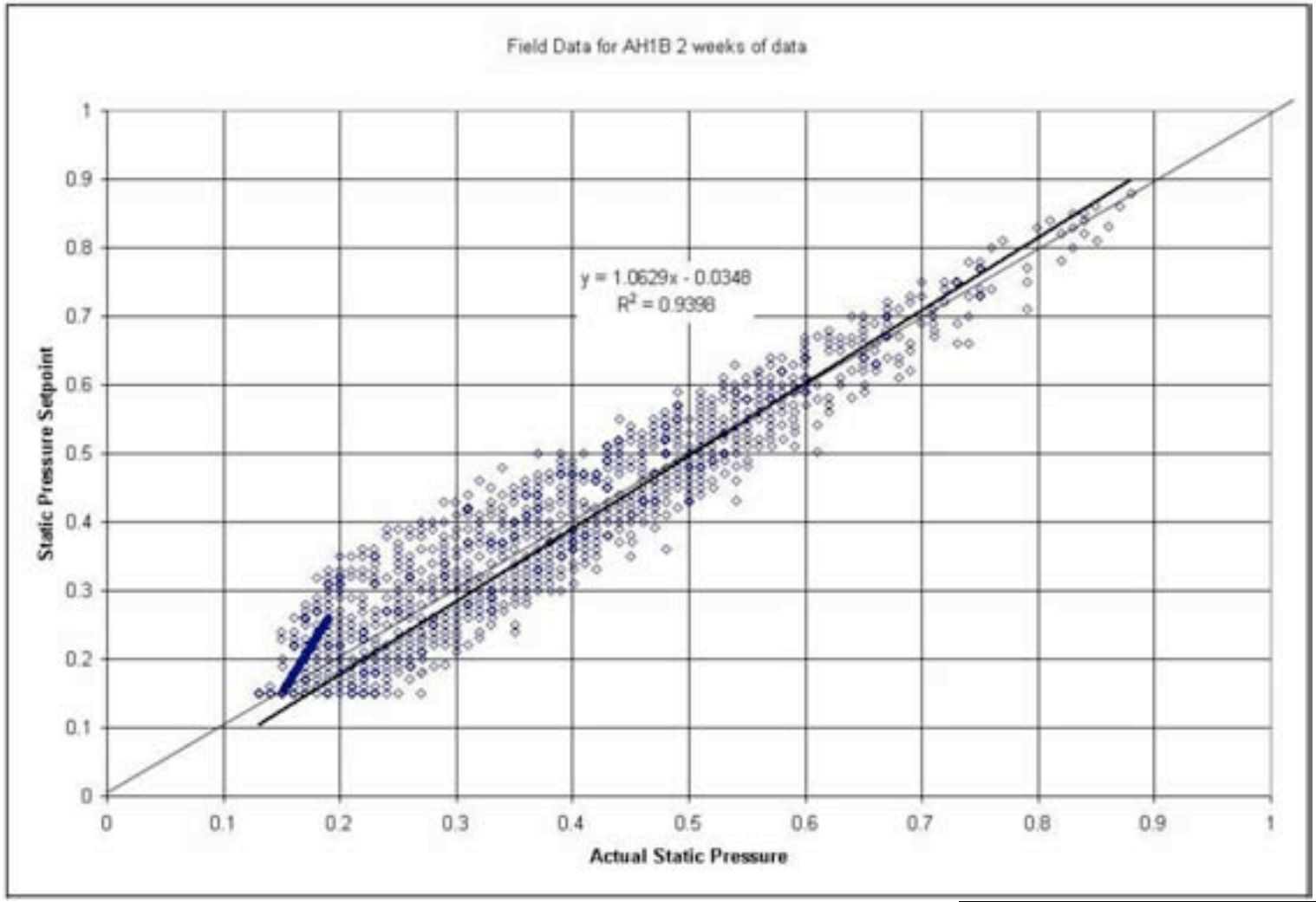
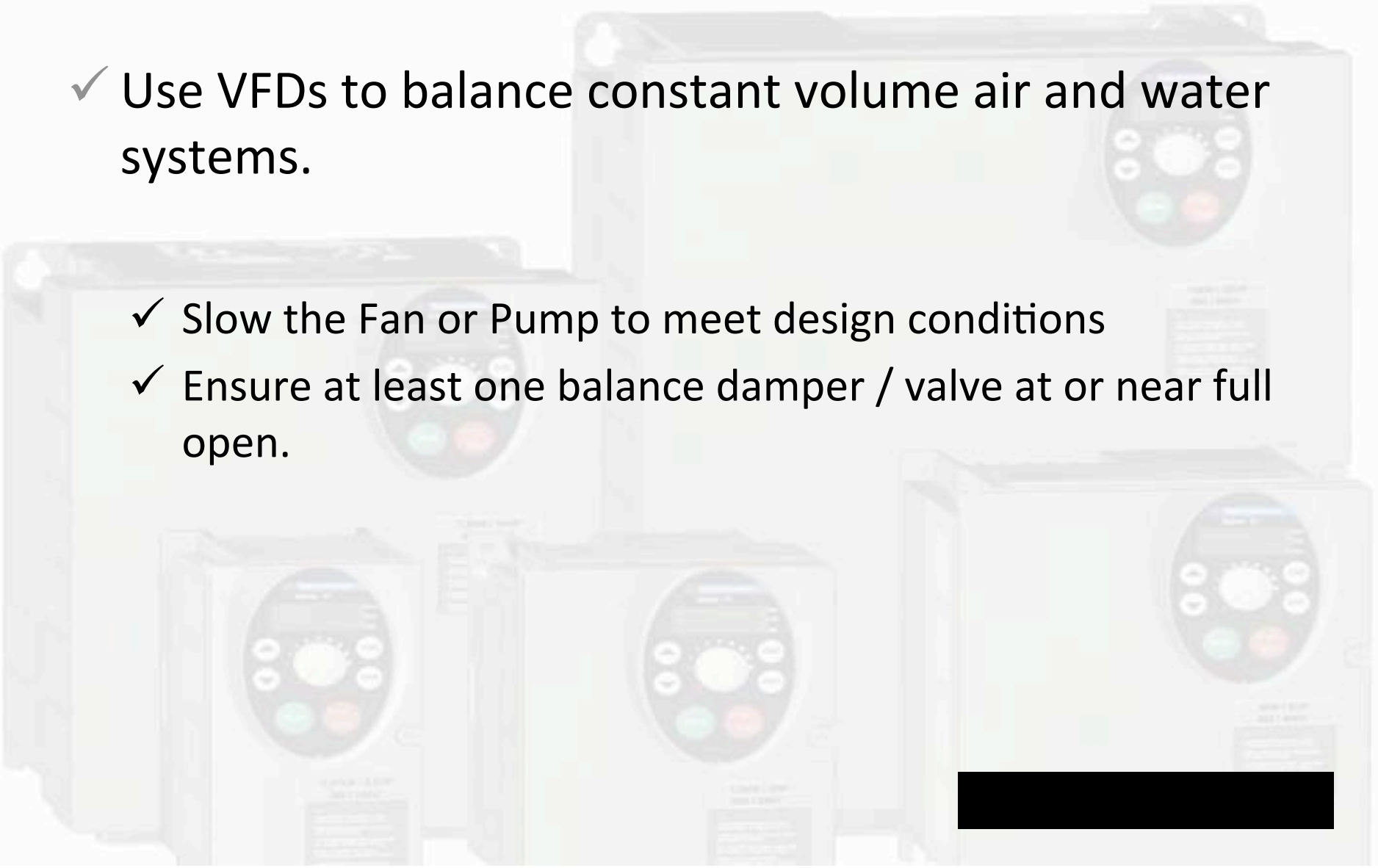
SP Reset Performance



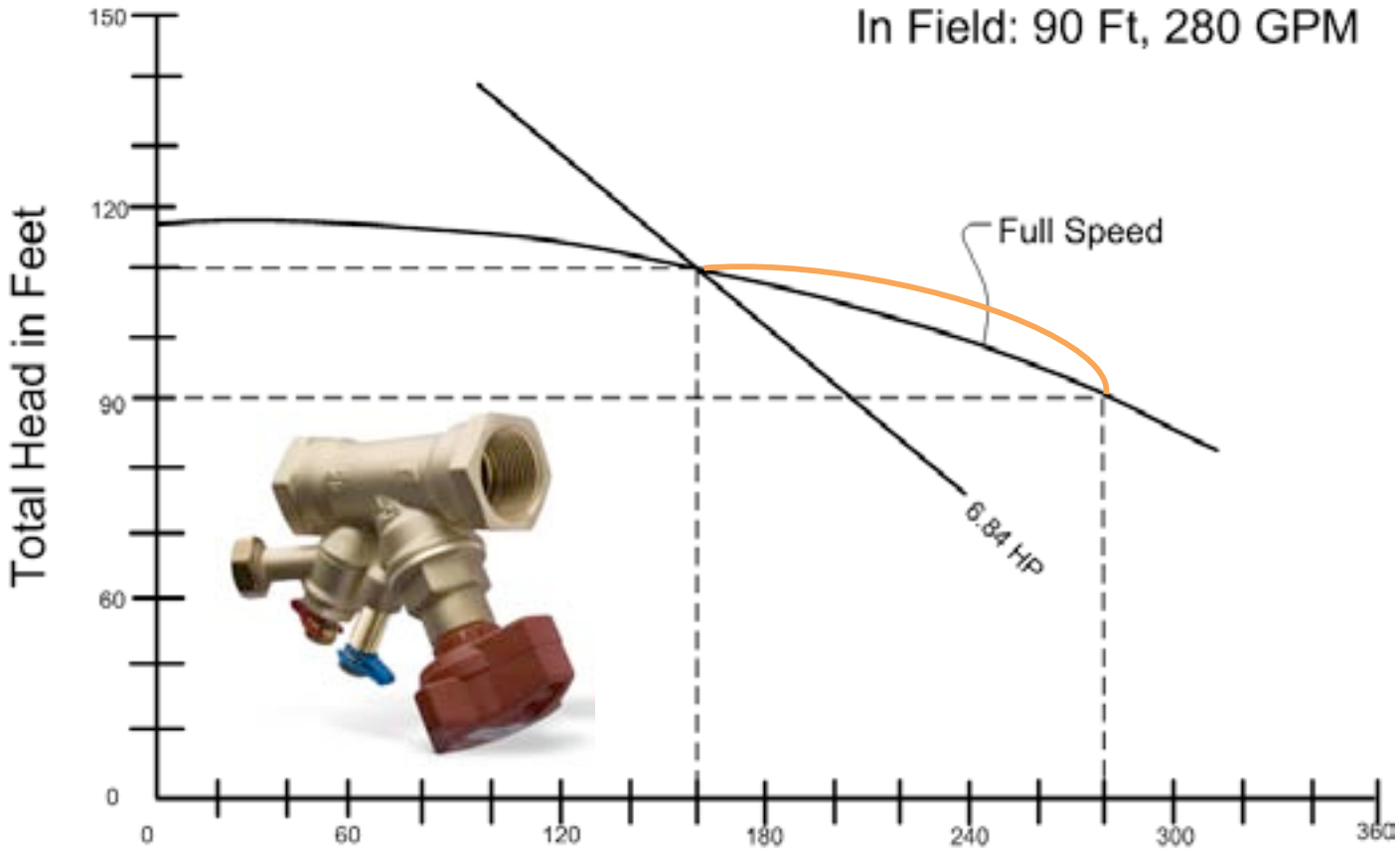
[redacted]

Variable Frequency Drives (VFDs)

- ✓ Use VFDs to balance constant volume air and water systems.
  - ✓ Slow the Fan or Pump to meet design conditions
  - ✓ Ensure at least one balance damper / valve at or near full open.



Design: 110 Ft, 160 GPM
In Field: 90 Ft, 280 GPM



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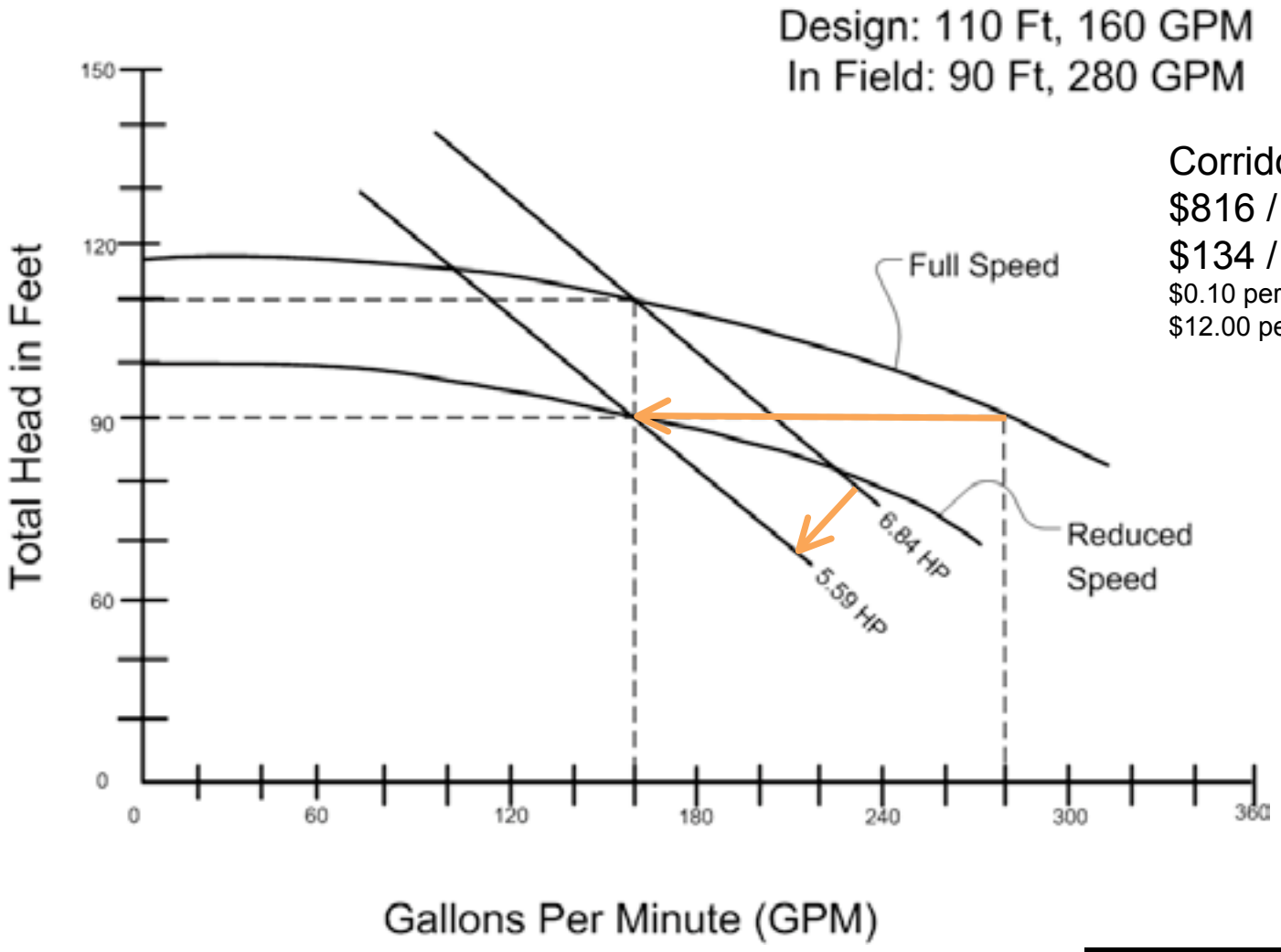
VFD used for balancing

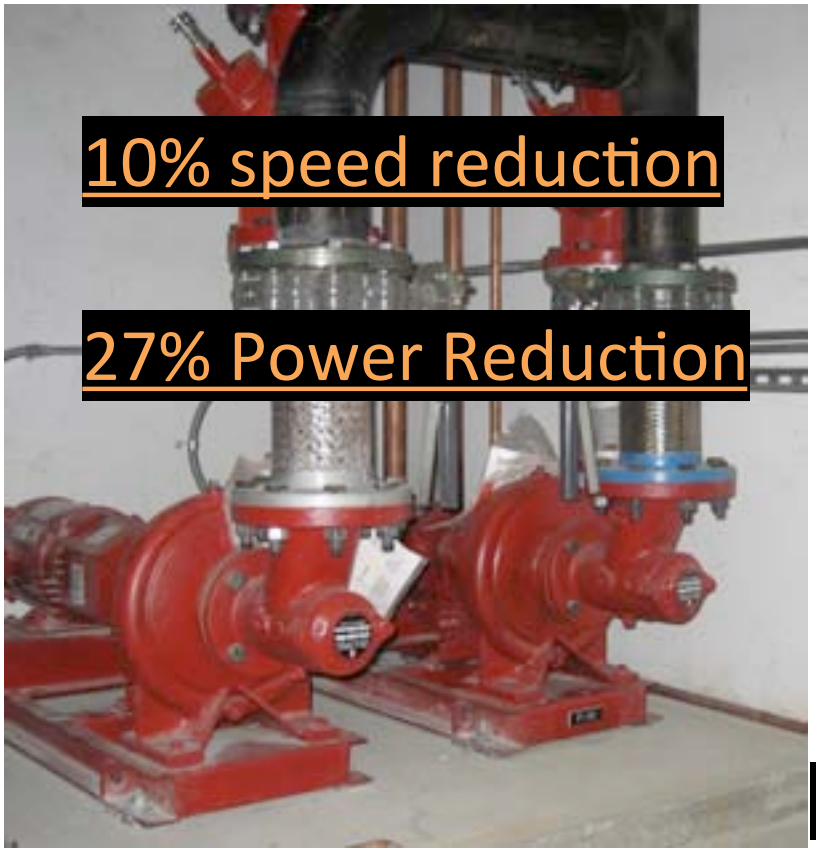


Corridor Ventilation:
$816 / yr energy
$134 / yr demand
$0.10 per kWh
$12.00 per kW

[redacted]

VFDs Continued

- ✓ Balance valves not necessary on VFD pumps
  - If used, open FULLY when done!

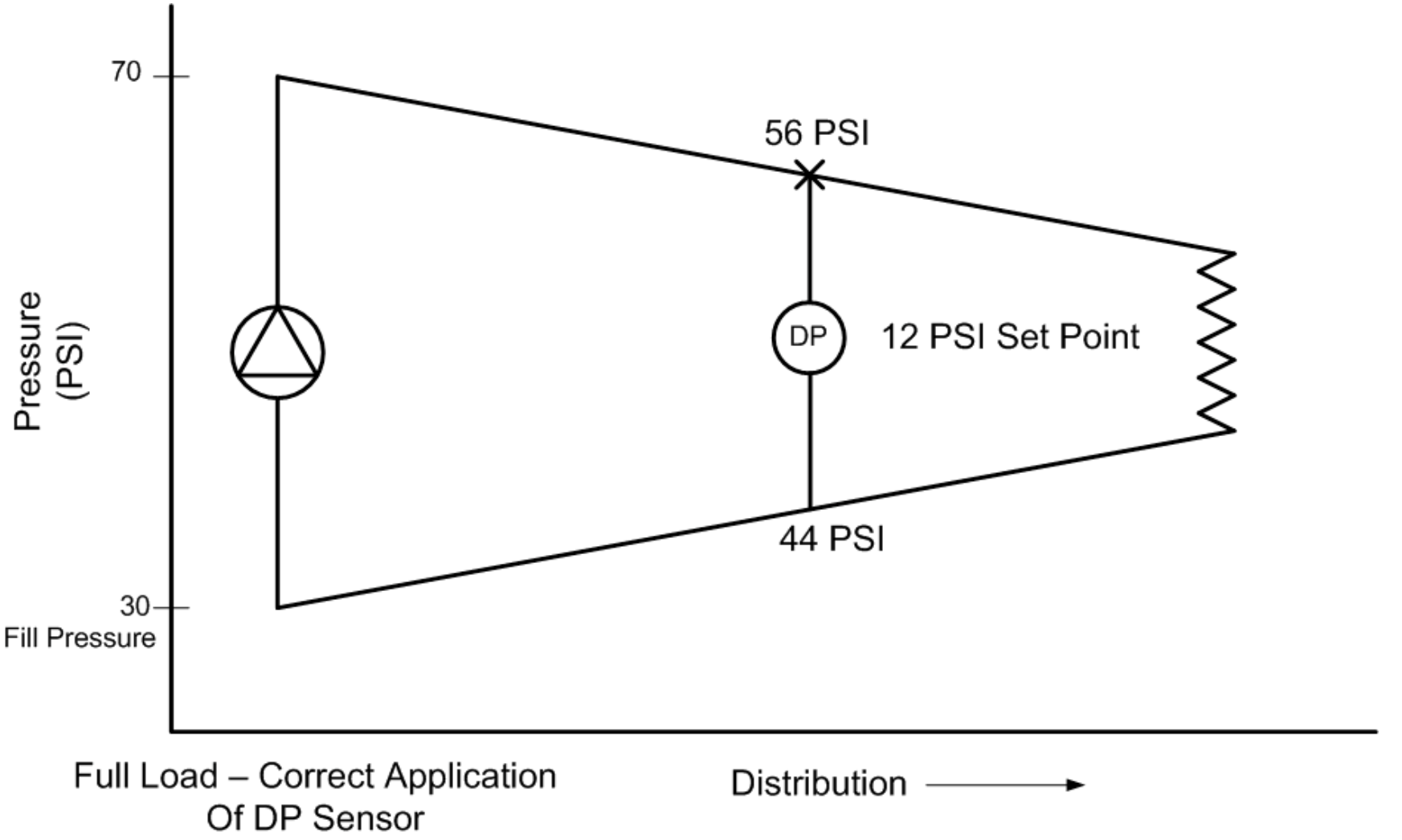


Pump Speed Control

- ✓ DP sensor (not P sensor) location
  - Roughly 2/3 downstream
  - Review balance report to ensure balance valves are as open as possible
  - dP across auto-balance is as low as possible.

[redacted]

Pump Pressure Control



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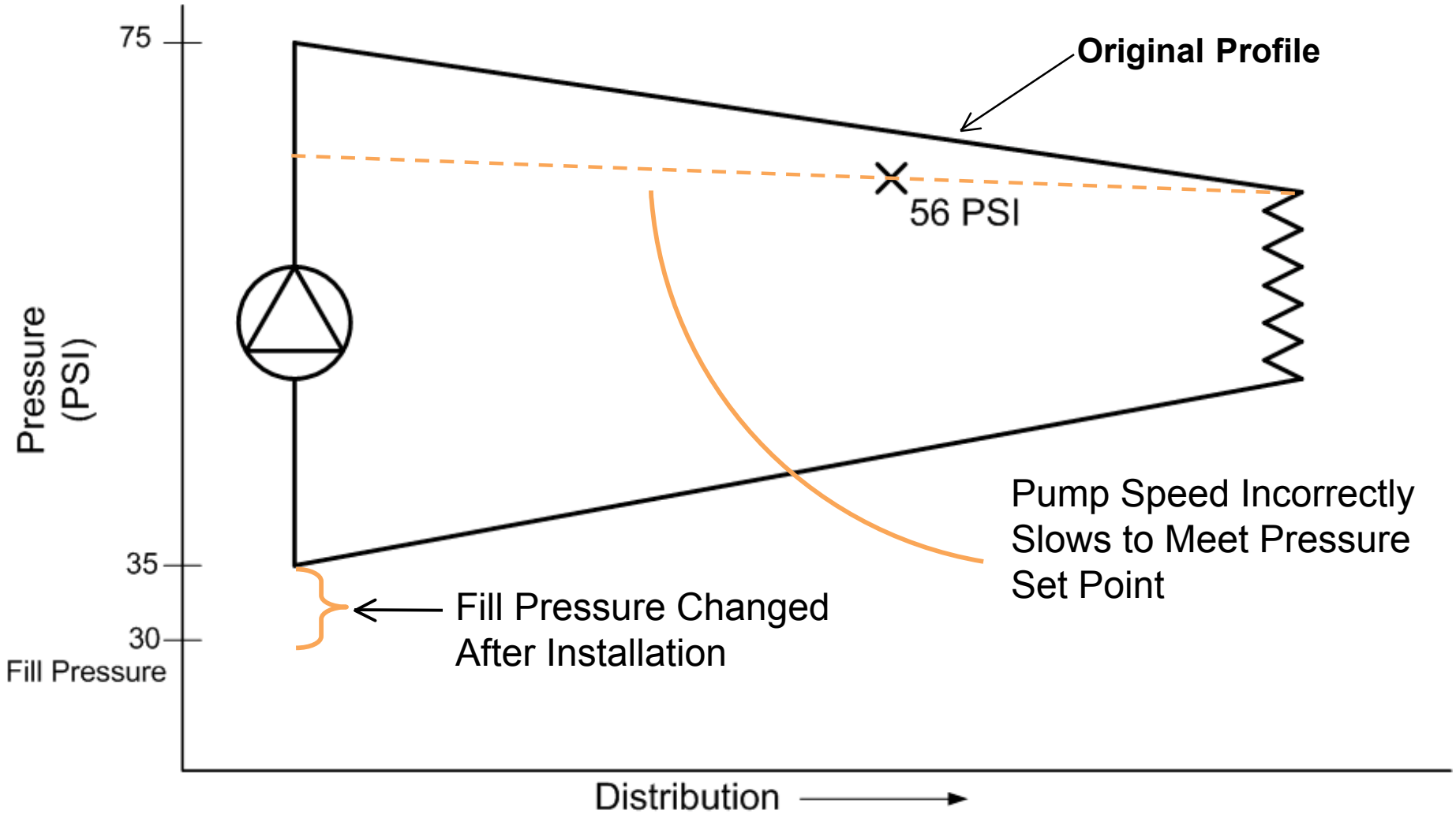
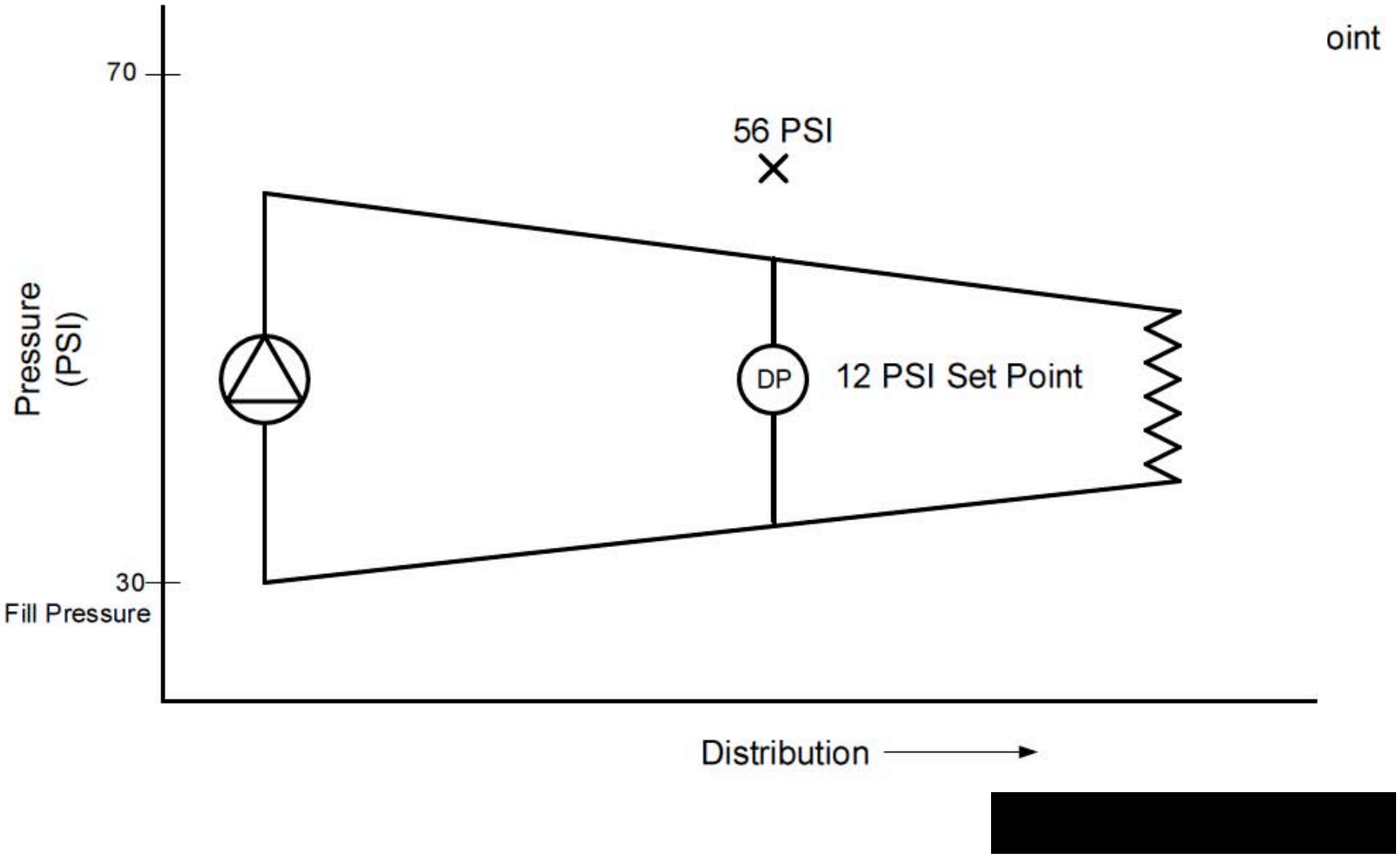
Pressure Set Point, not DP



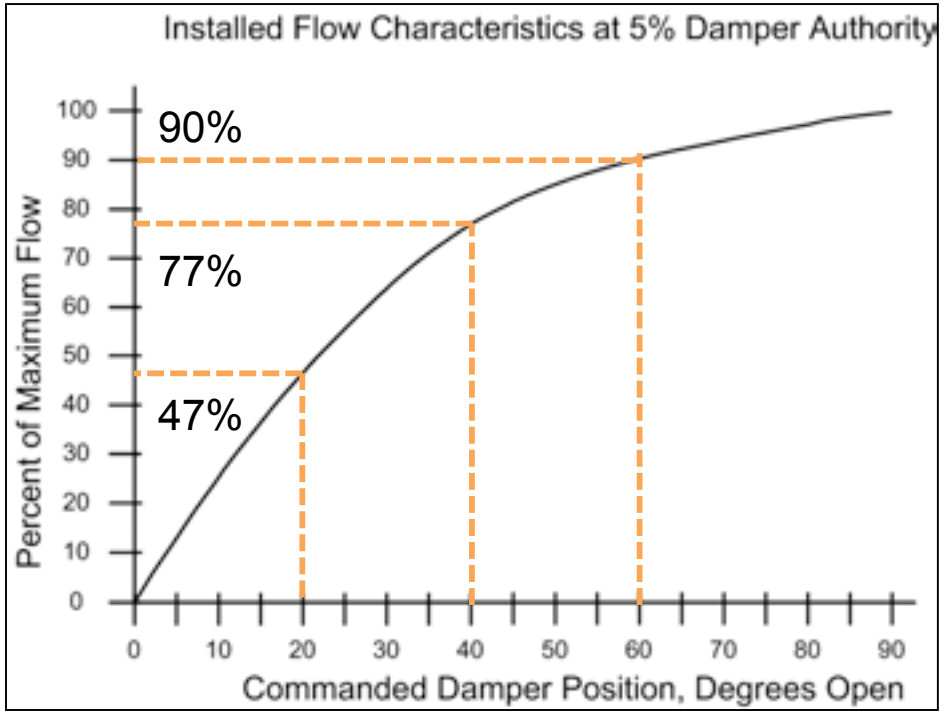
[redacted]

VFD Pump Using P Set Point Only

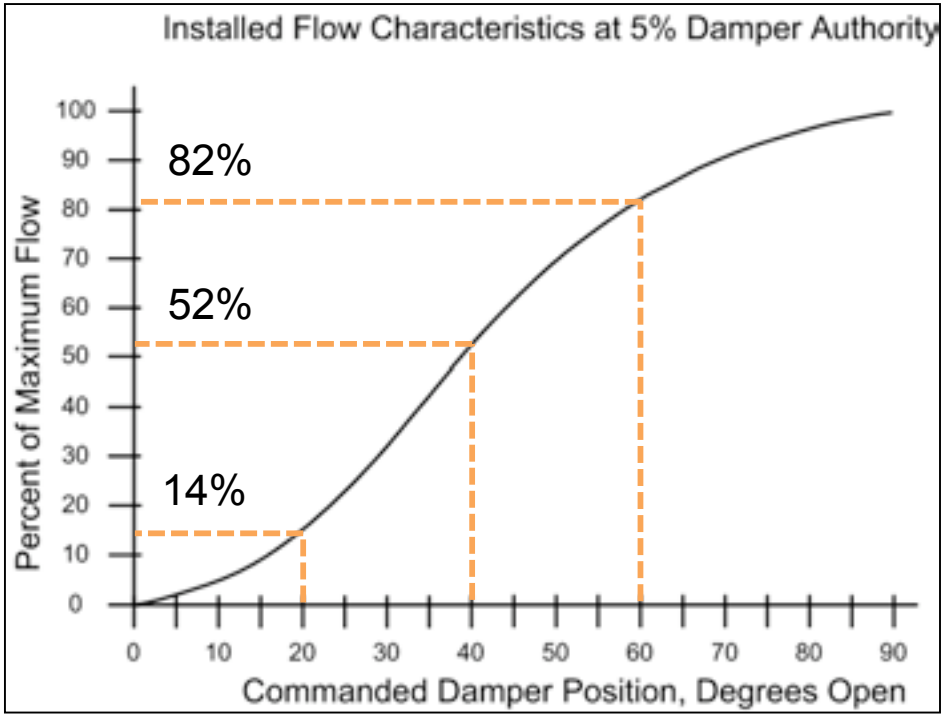


OA % (CFM) vs OA Damper %

Parallel Blade Damper

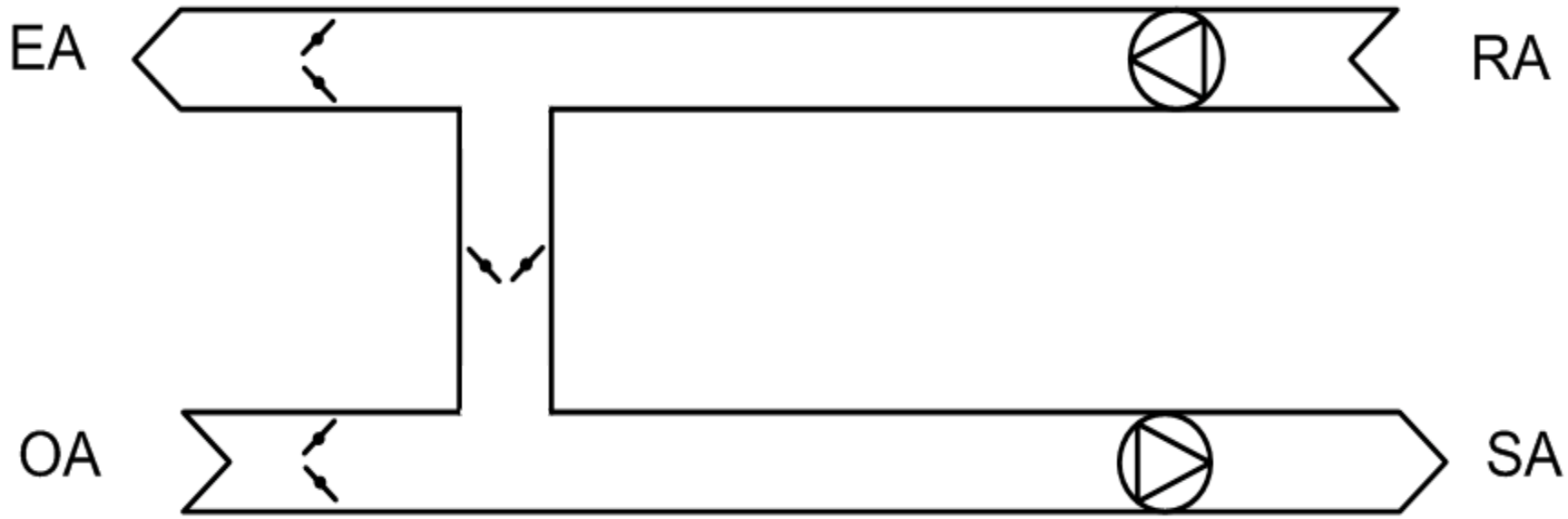


Opposed Blade Damper



[redacted]

OA Comparison



Expected: 4,000 CFM

Delivered: 3,200 CFM

10,000 CFM

[redacted]

LEED EQc2 – Additional Ventilation

- ✓ Non-CO2 controlled buildings
  - Higher First Cost
  - Higher Operating Costs
- ✓ Does it impact your energy model?

[redacted]

Common HVAC Opportunities (Cont.)

- ✓ Correct Economizer Specification
- ✓ CHW Coil Piping
- ✓ HW Coil Freeze Pump Piping

[redacted]

Economizer Specification

- ✓ Used in Airside Systems
- ✓ Economizer = Free Cooling
- ✓ Use cool outside air, not AC

[redacted]

Economizer Specification cont.

- ✓ Required if >65,000 BTUH (5.4 Tons)
- ✓ Capable of using 100% Outdoor Air

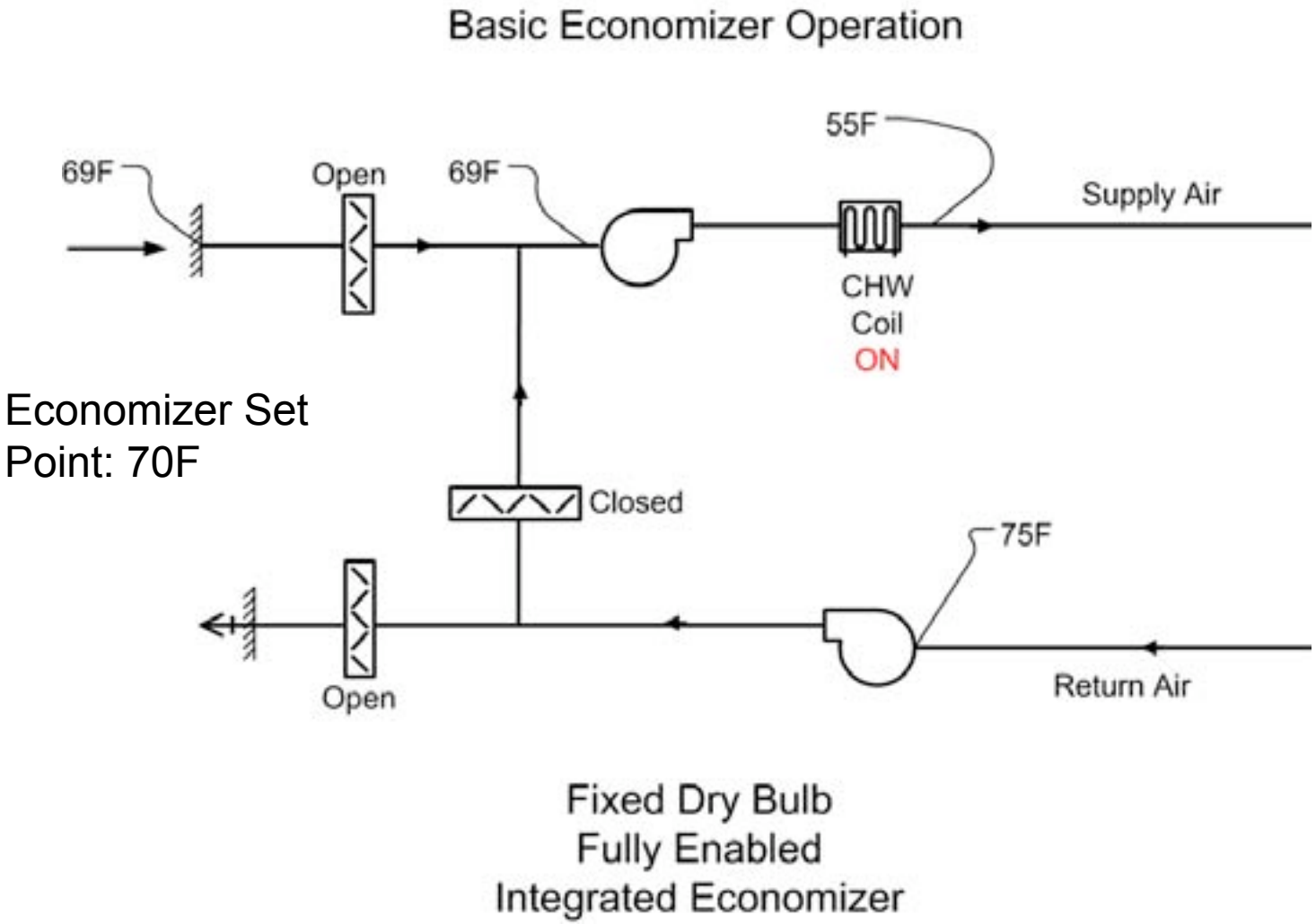
[redacted]

Economizer Specification cont.

- ✓ Fixed Dry Bulb
  - Enabled if Outside Air <70F dry bulb
- ✓ Differential Enthalpy
  - Enthalpy is heat content
  - If outside enthalpy is cooler than return air enthalpy

[redacted]

Economizer Specification cont.



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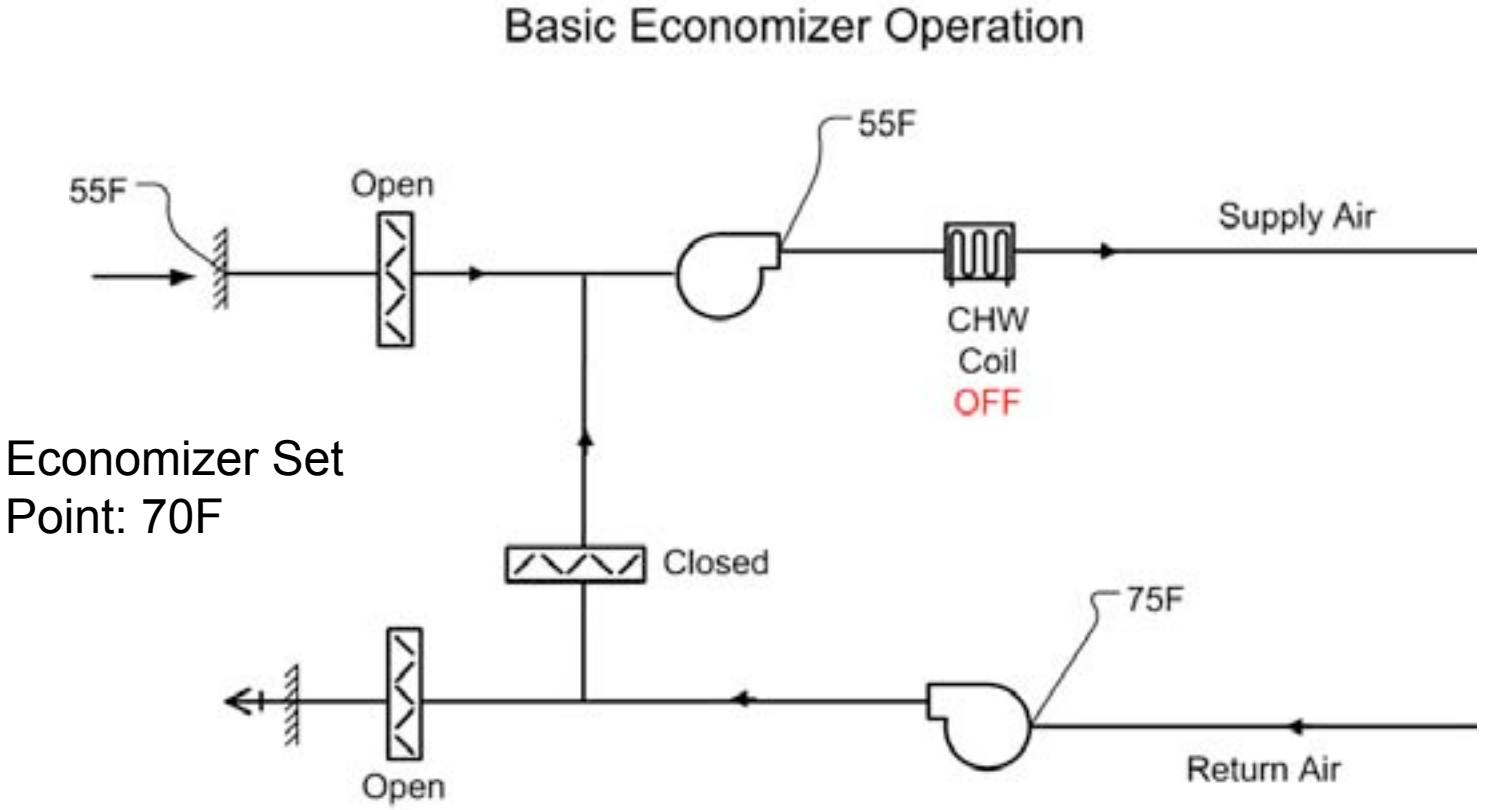
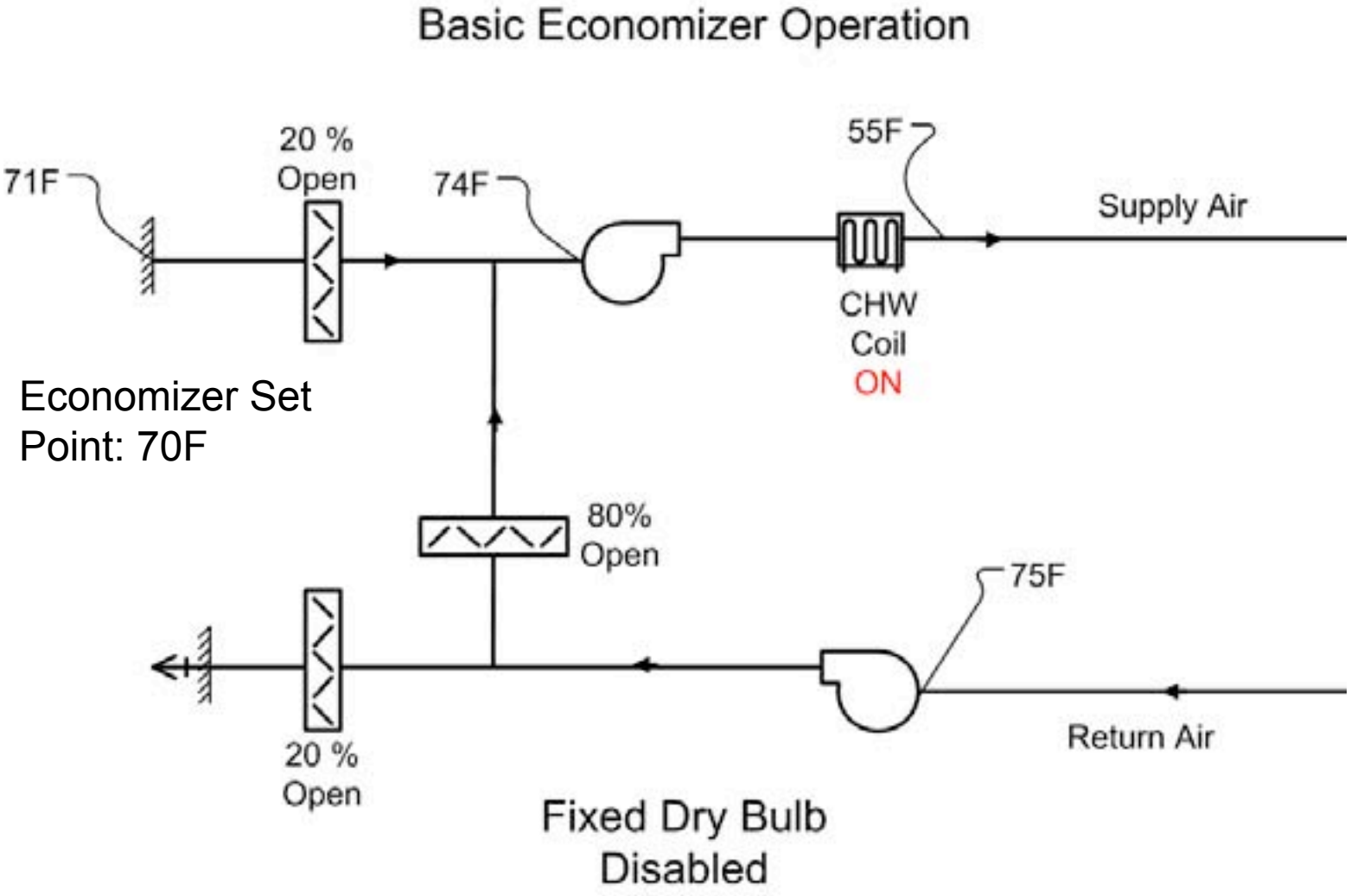
Economizer Specification cont.



Fixed Dry Bulb
Fully Enabled
No Mechanical Cooling

[redacted]

Economizer Specification cont.



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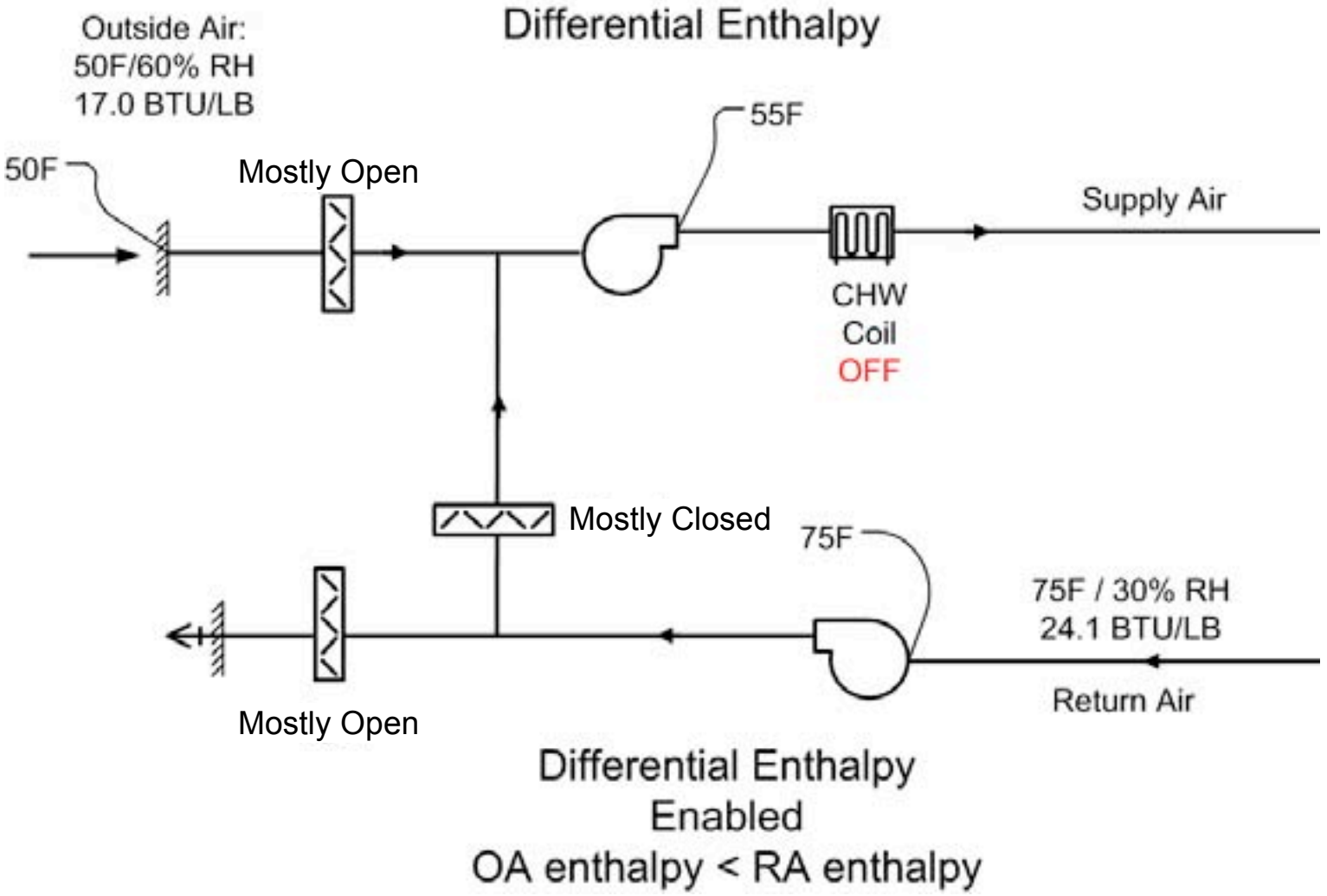
Economizer Specification cont.



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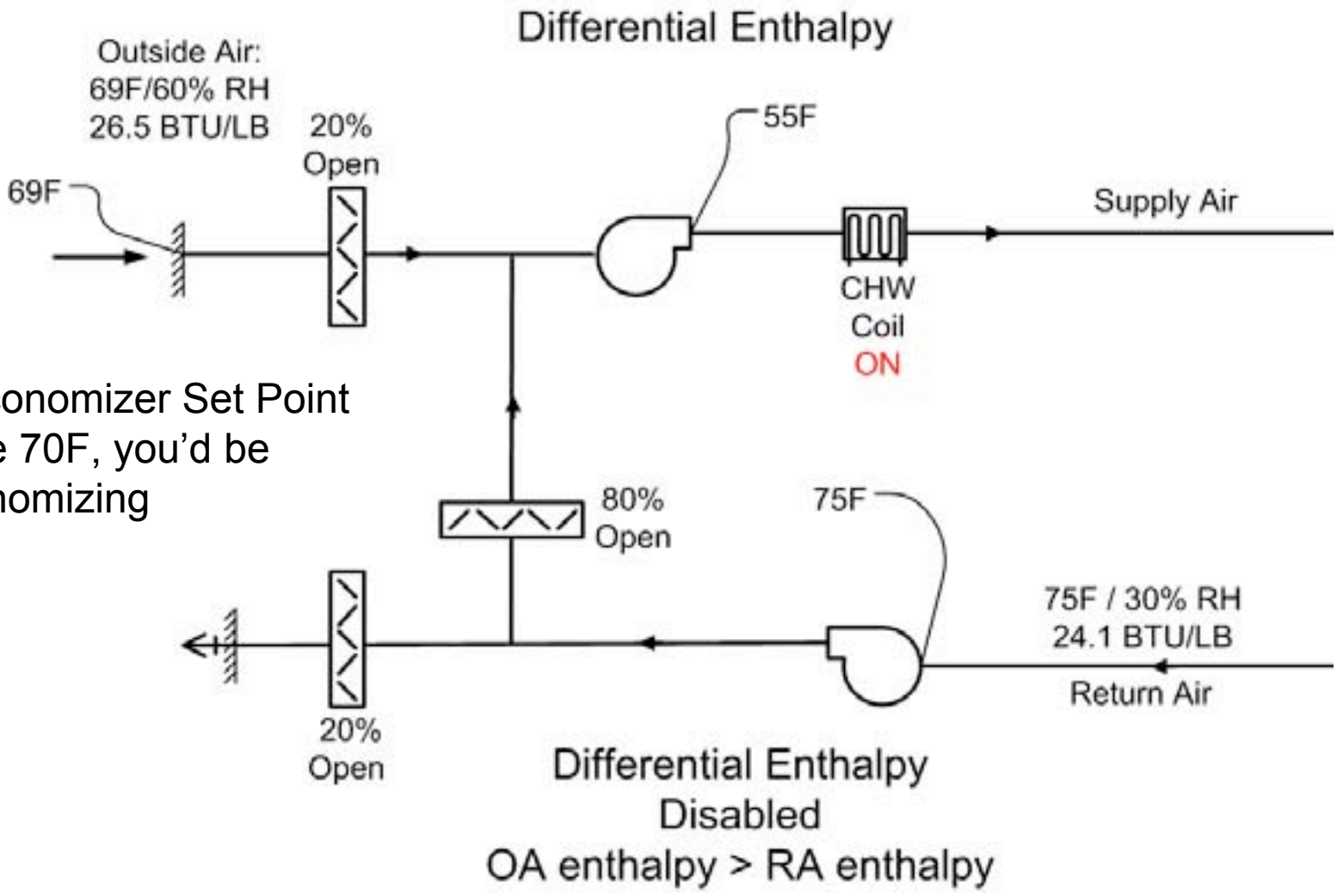
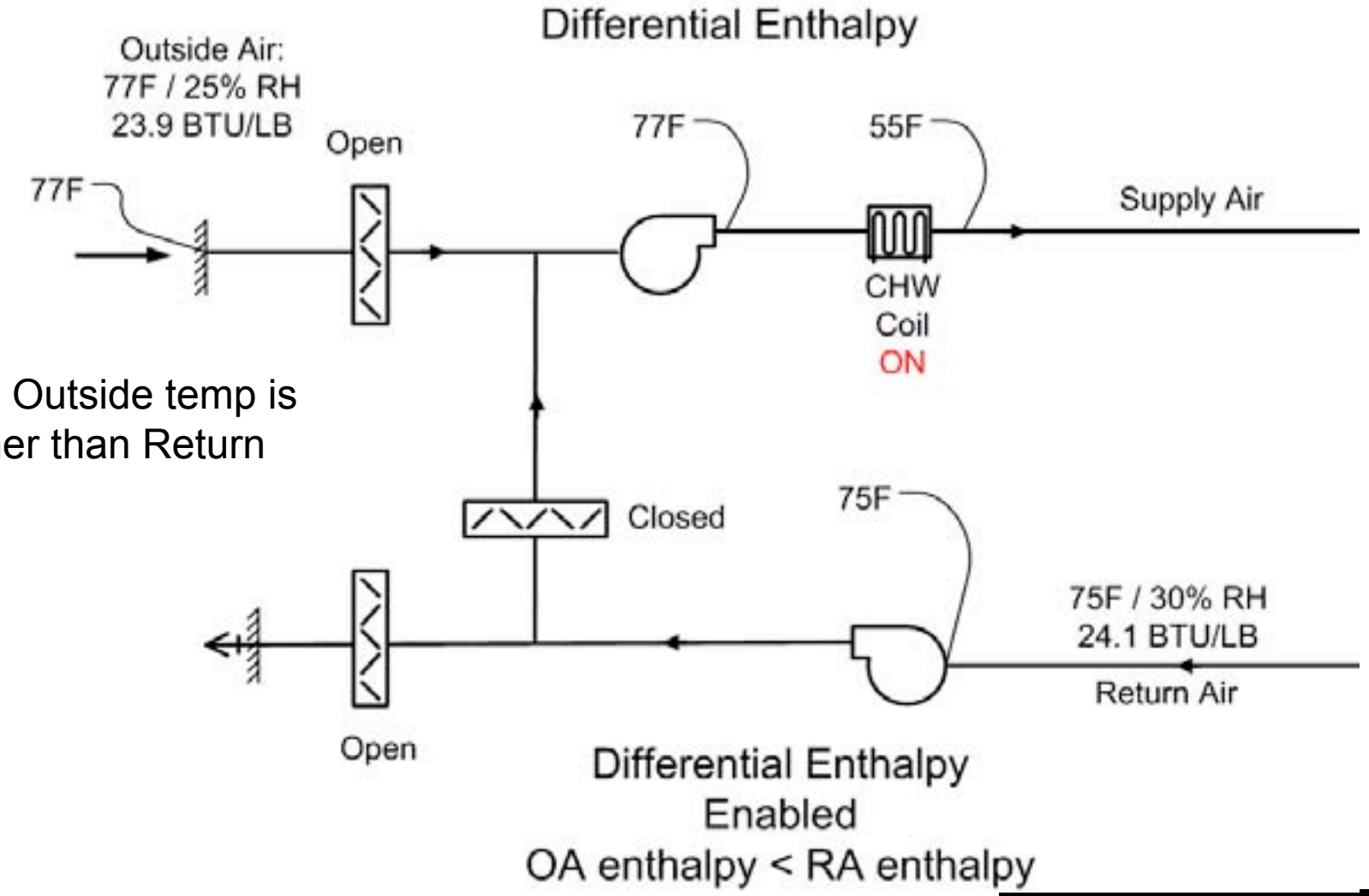
Economizer Specification cont.



If Economizer Set Point were 70F, you'd be economizing

[redacted]

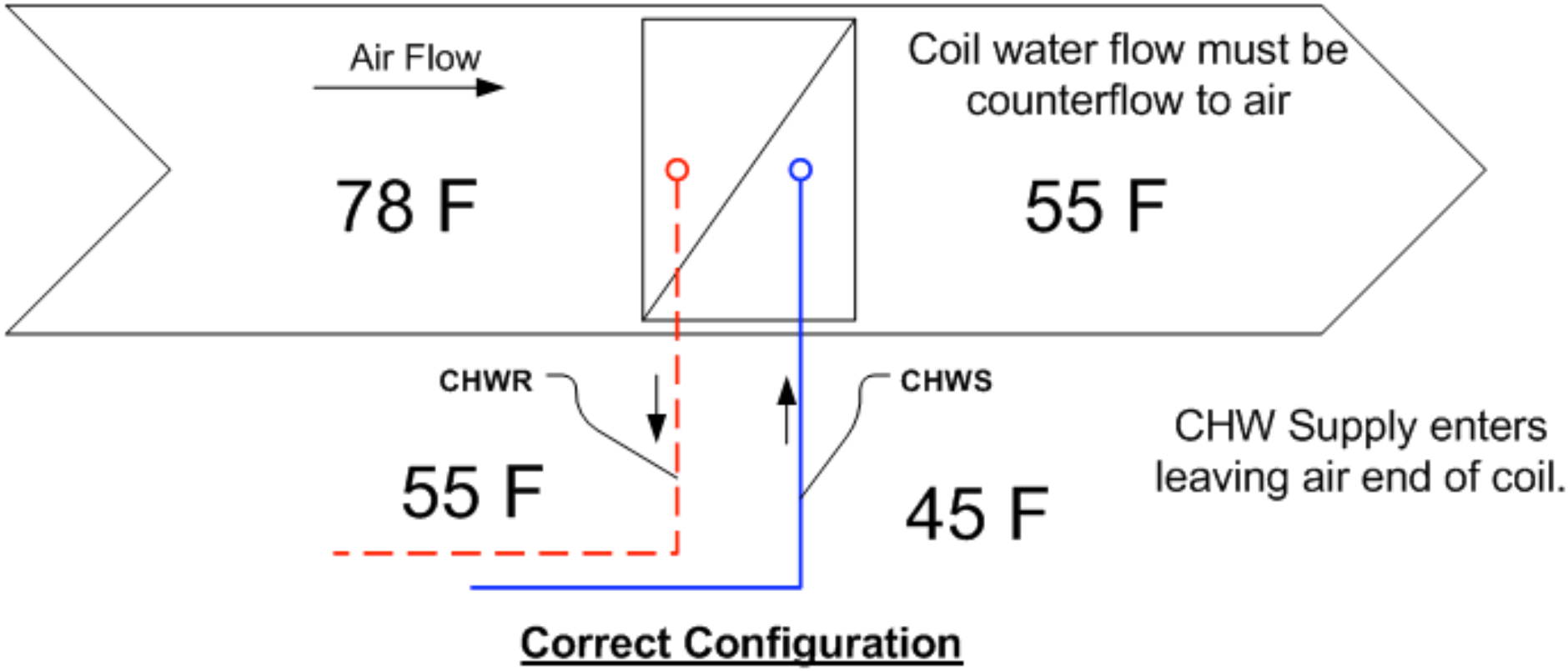
Economizer Specification cont.



Note: Outside temp is warmer than Return temp

[redacted]

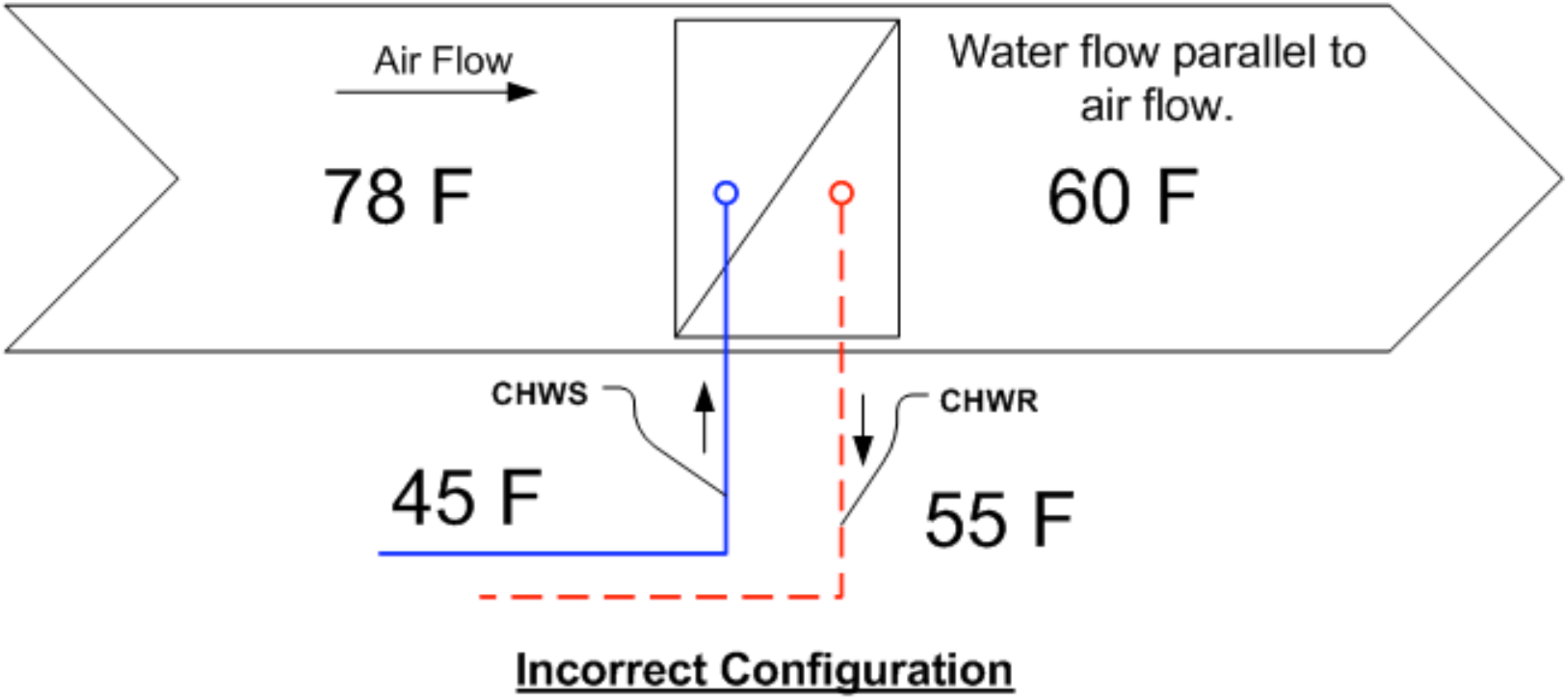
CHW Coil Piping - Correct



Correct Configuration

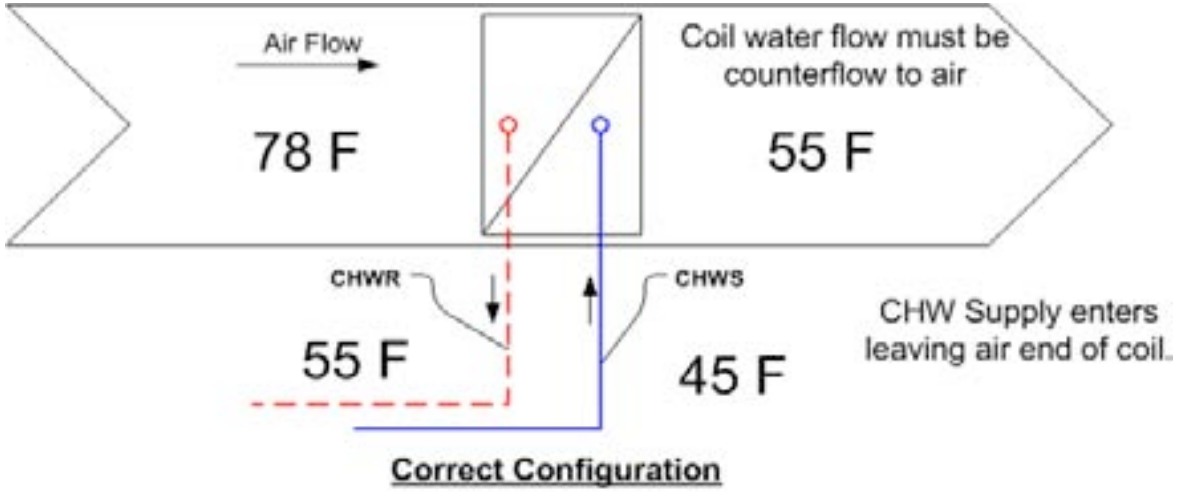
[redacted]

CHW Coil Piping – Incorrect

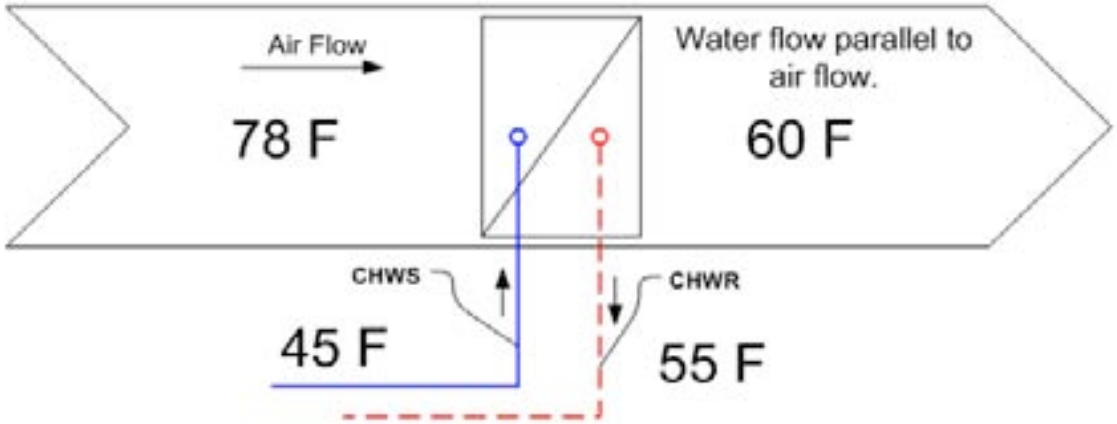


[redacted]

CHW Coil Piping – Both setups



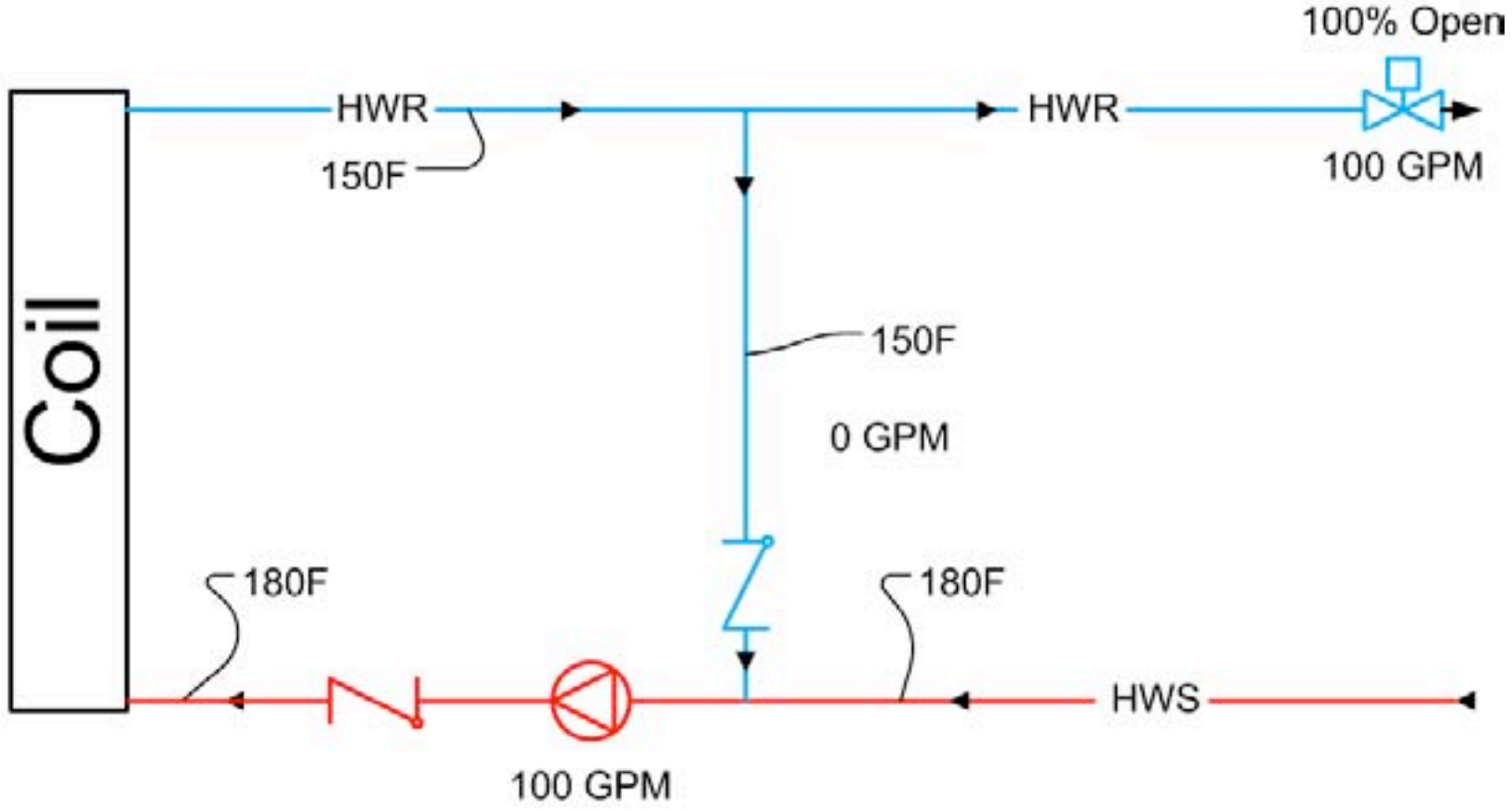
Correct Configuration



Incorrect Configuration

[redacted]

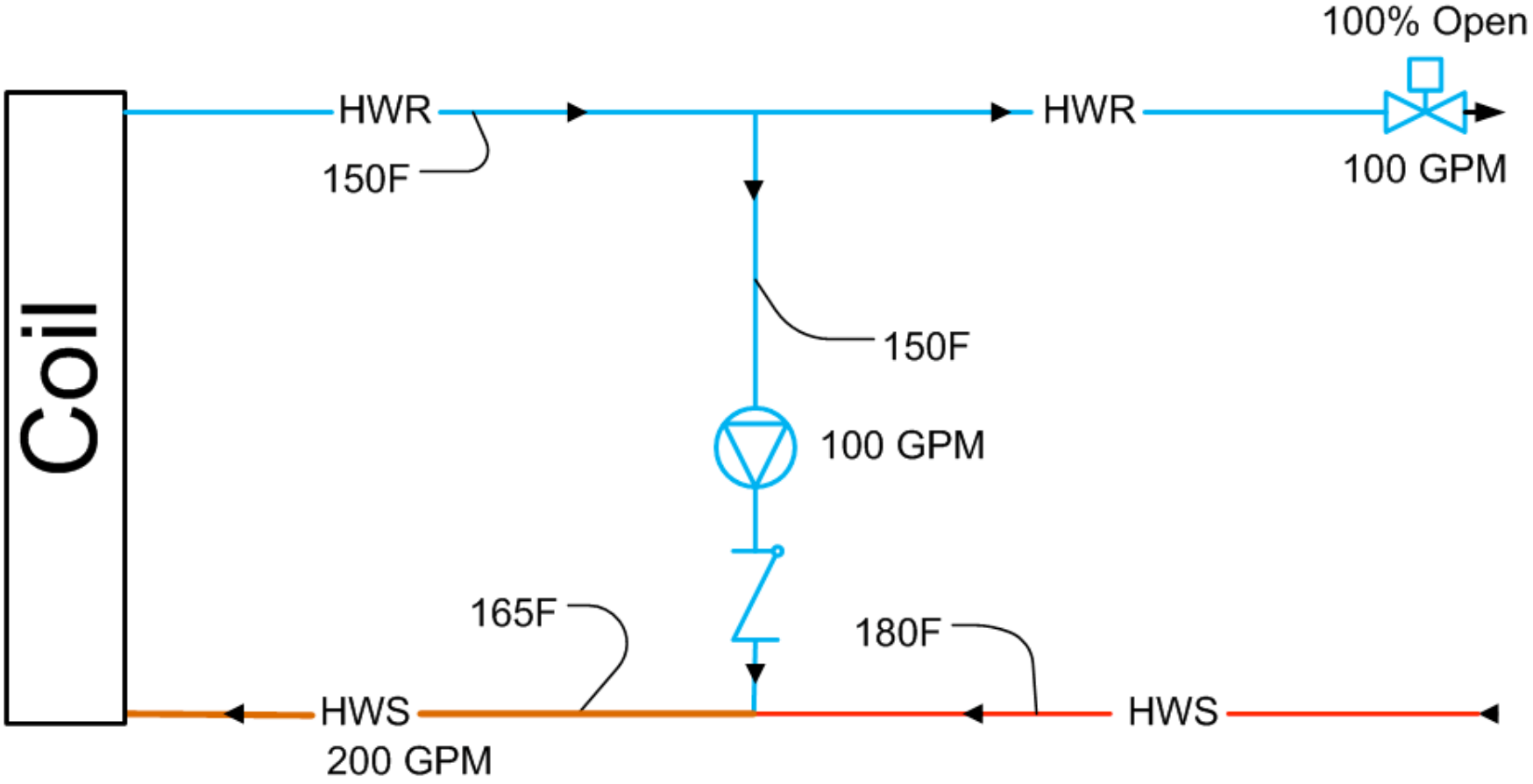
HW Coil Freeze Pump Piping



Coil Freeze Pump
Correct Installation

[redacted]

HW Coil Freeze Pump Piping



Coil Freeze Pump
Incorrect Installation

[redacted]

DHW Opportunities

- ✓ Point of Use vs. Central
- ✓ Considerations for Instantaneous DHW heaters

[redacted]

Central Vs. P.O.U. DHW Systems

Ground Floor

Central
DHW
Heater

Basement

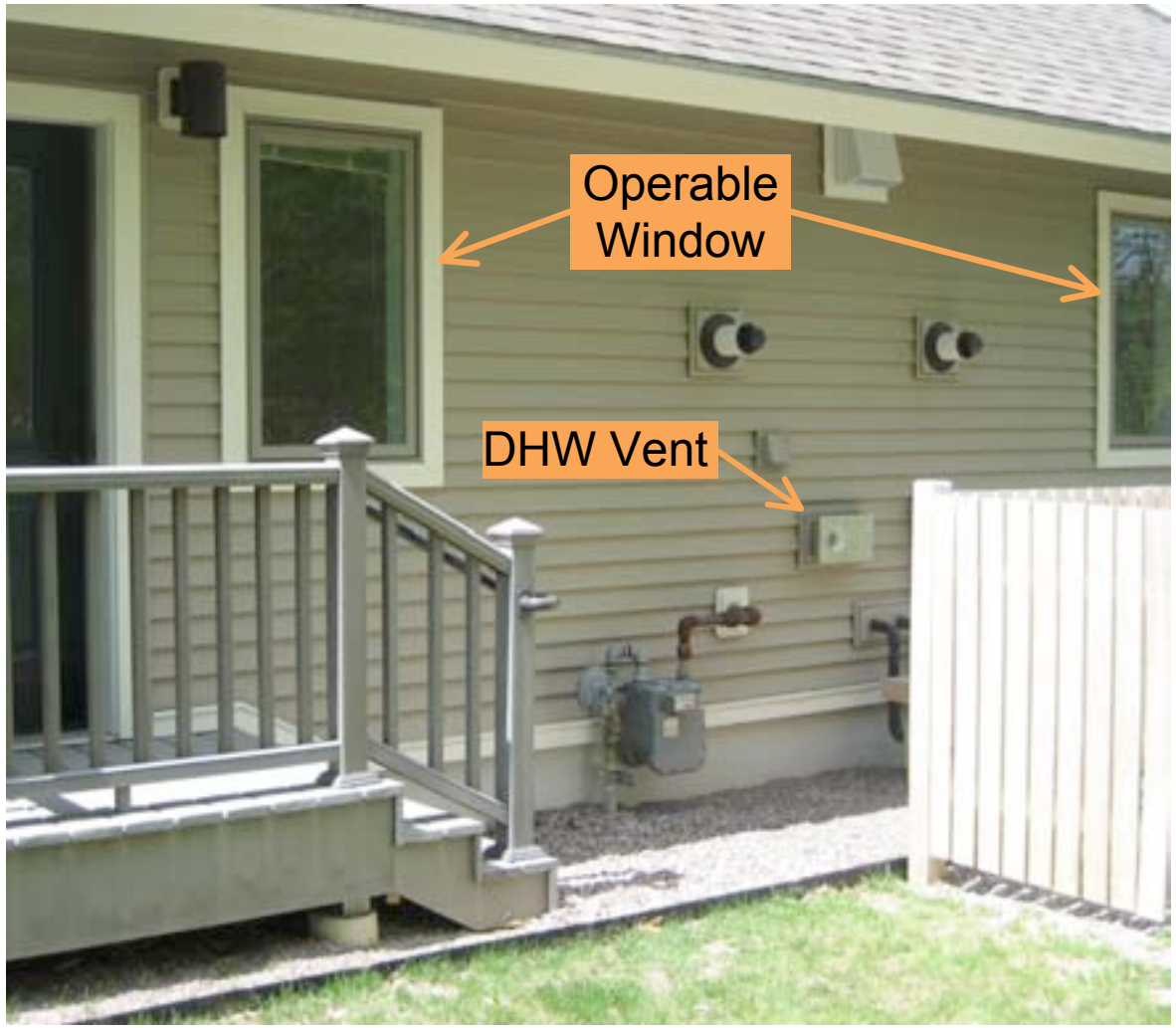
VS

P.O.U
Heater

Ground Floor

Basement

Instantaneous DHW Considerations



[redacted]

Instantaneous DHW Considerations

- ✓ Designers must consider building elevation.

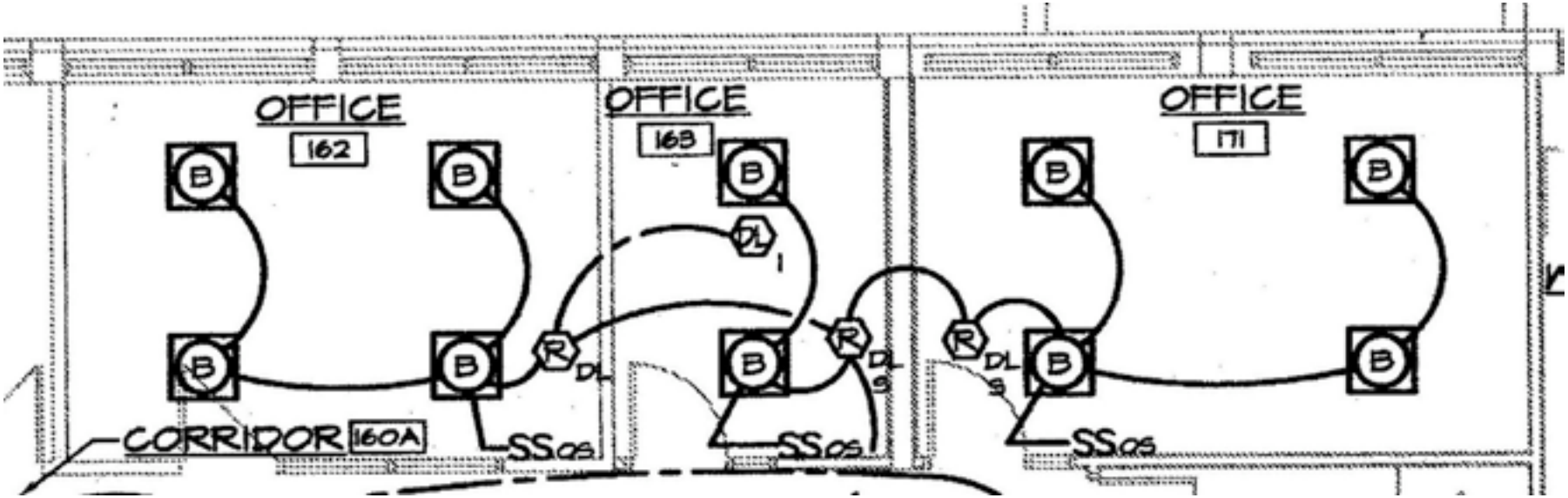
[redacted]

Common Lighting Opportunities

- ✓ "Learning" occupancy sensors learn to stay on
- ✓ Performance Specifications
  - Put burden on contractors
  - Engineer should specify:
    - Required light levels for dimming systems
    - Sequence of operation for dimming and day lighting systems
    - Occupancy sensor time delays.
      - NOT "Manufacturer's Standard"
    - "Sequence" for occupancy sensors

[redacted]

Example Reflected Ceiling Plan



Common Lighting Opportunities cont.

- ✓ Over / under lighting
  - Too much light from too many fixtures
  - IESNA requirements
    - 15 fc for use with computer screens, 50 fc task light as an option
    - 5-10 fc for corridors
  - Cx Assoicates commonly finds:
    - 30-40 fc ambient lighting in offices
    - 20-30 fc in corridors

[redacted]

Common Lighting Opportunities cont.

- ✓ Use of T5's
  - Lamps and Ballasts - Roughly 25% higher cost than ST8's
  - No appreciable efficiency gain
  - Easier to misapply – more opportunity for "hot spots" and glare.

[redacted]

HVAC Concepts

De-Coupled HVAC

De-Coupled HVAC

- ✓ HVAC consists of two processes:
  - Thermal Energy
  - Ventilation (Fresh Air)
- ✓ Conventional HVAC combines these
- ✓ De-Coupled HVAC isolates the two processes

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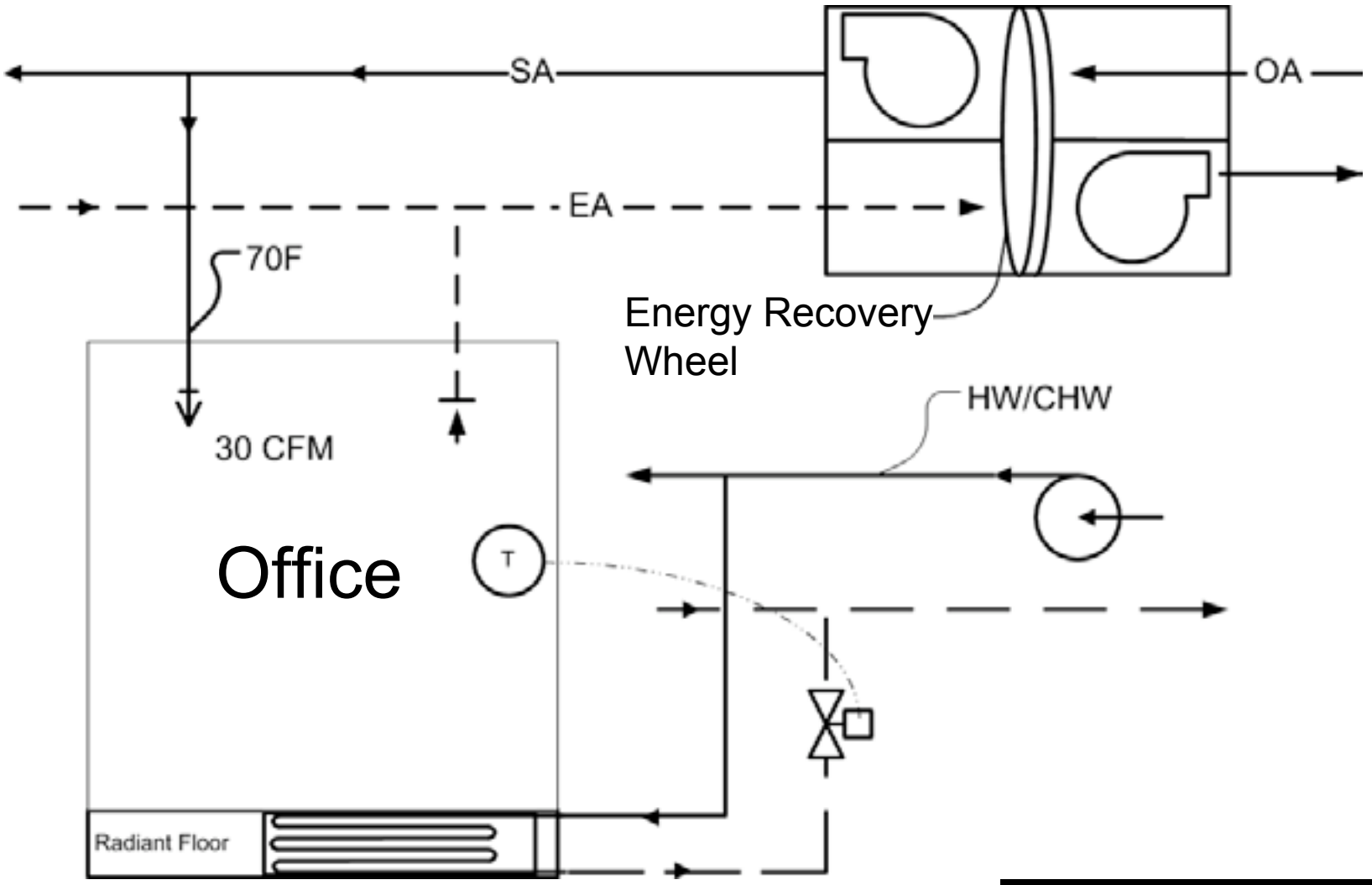
De-Coupled HVAC



De-Coupled HVAC

- ✓ Thermal process uses water
  - Much less transport energy than air
- ✓ Ventilation process uses 100% Outside Air
  - Delivered at thermally neutral temperature
  - Energy recovery wheel
    - ~70% to 80% thermal efficiency

[redacted]

De-Coupled HVAC

- ✓ Pros:
  - Water is more efficient medium for energy transport than air
  - Minimize ductwork and mechanical space in building (make friends with architects)
  - Simplifies ventilation calculations
- ✓ Cons:
  - Potentially slower response time
- ✓ Considerations:
  - Requires a good envelope
  - Requires realistic internal gains

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De-Coupled HVAC

- ✓ De-coupled HVAC is critical for:
  - High performance buildings
  - Net zero buildings
- ✓ De-coupled HVAC overcomes the limitations imposed by conventional HVAC

Conclusion

- ✓ Commissioning:
  - Starts during the design phase
  - Ensures project requirements are met
  - Identifies areas of improvement
  - Reduces overall project costs
  - Applicable to new and existing buildings

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Questions?

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