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Understanding the Selection and application of Hydronic Systems Control Valves
Why is the control valve important?

• It controls the flow;
  – How much flow is called for by the controller...
  – How well the valve flow is matched to the heat transfer and “theoretical” load is implied by the designer calculations
  – Delivered flow is directly related to electrical cost to operate the system; Pumps, Chillers/Boilers

• Efficient valve operation relies on predictability and repeatability of upstream system components
  – Entering water temperature needs to be stable
  – Differential pressure needs to be stable

• Are there other ways to do it?
87% Sensible Heat Transfer
50% Coil Flow

Chilled Water Coil Sensible Heat Transfer Characteristic

% Fluid Flow vs. % Coil Heat Transfer

NEBB NATIONAL MEETING: CONTROL VALVES
Typical Cooling Load Profile

- 80% of operational cooling uses less than 20% of design flow
- 97% of operational hours covered by 50% design flow
- 50% flow can be 12.5% design horsepower
Simplified Energy Analysis Method

- **Temperature Controller**: Proportional control signal to cooling or heating load
- **Equal Percentage Valve**: Makes non-linear coil heat transfer appear linear to controller

### Cumulative Hours Operation vs. Cumulative Percentage Load

<table>
<thead>
<tr>
<th>Cumulative Hours Operation</th>
<th>Cumulative Percentage</th>
<th>% Load</th>
<th>Hours of Operation</th>
<th>% Operation</th>
<th>Percentage Required Flow</th>
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**Valve Stroke**

**Equal Percentage Valve Flow**

- **Pump Curve Flow, Head Efficiency**
- **Calculate Pump Energy BHP, KWH**

*NEBB NATIONAL MEETING: CONTROL VALVES*
Typical Coil Connection

- Typically coil connections are on same side, supply low and return high
- Entering supply; Service valve, followed by strainer and union
- Leaving return; Union, followed by temperature control valve, balance valve and maybe a separate service valve
Typical Coil Connection

- Typically coil connections are on same side, supply low and return high
- Entering supply; Service valve, followed by strainer, union, measuring ports, drain valve
- Leaving return; Union, air vent, temperature control valve, balance valve, maybe a separate service valve, measuring ports
Globe Valves

- Globe valves are the “traditional” control valve
  - Several alternates
  - Characterized Ball
  - Flapper
  - Butterfly
- All styles have features and benefits
- All have similar construction features
- Water flows in to body, through a control orifice and leaves body
Globe Valves

- **Stem**: Connects globe or other throttling element to actuator so valve can be positioned and flow changed.
- **Packing**: Prevents water from following the stem path out of the closed system. The packing nut is used to adjust pressure to prevent the leak.
- **Bonnet**: Mechanically holds stem to body, and also gives actuator a place to connect to the body.
- **Body**: Contains the water and withstands the hydraulic forces.
Globe Valves

- Globe & Orifice; Do the work controlling the flow
- Seat may be separate material, or machined part of body
- Globe is machined to provide a calibrated characteristic of flow to the stem position, specific to being able to control
- Type of control matters
  - 2 Position; Flow On/Off
  - Proportionally Modulating; Traditional HVAC hydronic control
Valve Seat Configurations

- Many options available to seating and configuration to reduce internal forces on valve trim
- “Pressure Balancing” may also reduce the amount of actuating force required to open and close the valve
- May also see split range plugs for finer low flow control
Automated Control

Heated Room

Controller

Unit Heater

Control Signal

Actuator

Hot Water
Automated Control

Energy is lost proportionally to the outside temperature

\[ q = UA(T_i - T_o) \]

The controller output signal acts in a proportional manner to the difference in the actual from the desired temperature adding what is lost.
Theory

Disturbances

Heat Gains

- Solar
- Change Weather
- People

Manipulate Water Flow

Coil Blower Process

Control Temperature
A Fairly Simple Concept...

• We control for comfort as indicated by temperature
  – Humidity Control “Implied” By Coil Selection

• Various levels of implementation
  – Economic Criteria
  – Process Criteria
  – Paradigm Criteria
Proportional Control

```
SP + e K Ke MV -
```

“Control Theory”

Room Controller

Actuated Valve

0-10 VDC Control Signal

0-10 VDC

Control Signal

Output

Output

SP

MV

Ke

Ke

Output Signal

"Control Theory"
Proportional Control

Room Controller

Actuated Valve

0-10 VDC Control Signal

Linear Response

Output 0-10 VDC

e - Error

Error

SP

t
Proportional Control

(y - y_i) = K(t - t_i)

y = Valve Position
y_i = Initial Valve Position
t = Temperature
t_i = Initial Temperature
K = Constant (gain)
Traditional 2 Way Valve Temperature Control

- Controller controls because response is predictable
- Variable coil flow
- Variable system flow
- “Why” variable speed pumping can be used
Traditional 3 Way Valve Temperature Control

- Variable coil flow
- Constant/Variable system flow
- Really should be avoided
The coil performance is not linear.
A Subtle Control Issue: Flow Tolerance

- Note the interaction of flow and heat transfer
- Coil designed for 20°ΔT
  - 75% Design flow yields 97.5% Heat Transfer
  - ±25% Flow Tolerance
- However as design ΔT increases, flow tolerance decreases ±10%
- This is the core of hydronic balance. Systems need to achieve 97.5% heat transfer when operating in a design flow mode
- Minimum required flow tolerance is ±10%
Valve Characteristic

Quick Opening

Linear

Equal Percentage
Equal Percentage Characteristic

\[ C_v = C_{V_{\text{MAX}}} R^{(\ell-1)} \]

- Predominantly applied 2-way throttling control valve characteristic due to coil
- \( R \) is Rangeability... stick to valve body not valve and actuator
- Note: small percentage flow at “closed”...most valves are “modified equal percentage”

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• ASHRAE Research (RP-5) boiled it down to this
  – Just about every HVAC text on valves uses this type of figure
  – The coil gain (proportional band) isn’t the same as the controllers... why we use an equal percentage valve

![Coil Characteristic - Valve Characteristic - Controlled Relationship](image)

**Fig. 17** Heat Output, Flow, and Stem Travel Characteristics of Equal Percentage Valve

Source: ASHRAE Handbook
Controller Adjustment

- All control actions start with Proportional logic
- Adjustments can be made to the controller such that it becomes a 2 position controller

Graph showing the relationship between the controlled variable (% of controller scale) and the position of the controlled device (% of stroke) with throttling % on the y-axis.
Proportional Action

- Two Position

Diagram showing room temperature fluctuation and valve position.
Implication

• “Linear” control (coil and valve) is not an issue
  – Full Flow or No Flow
  – Less pressure drop required for valve
    • Bigger control ports (more potential balance issues)
    • Potentially bigger valve; More expensive
  – Potentially more overall energy use
  – Potentially more temperature swing

• Alternative control: Pulse Width Modulation
  – Proportional “on” to load
Pulse Width Control

• Pseudo analog control
  – 0%-100% Flow Rate, Proportional amount of on time
  – Exercise in control principles
    • Time constant (63% of response) of control process; Big Rooms: long time 20-40 or more minutes, Discharge of Coil: very short 4-6 seconds
    • 6-8 calculations per time constant or more

• Don’t overdo the calculations
  – Actuators have limited life
  – Heat transfer takes time...

• Applications
  – Long slow processes; Rooms, Auditoriums, Radiant Heating
  – Moderately combinable with other cascade control options; Outdoor reset of water temp; ΔP reset; All with moderation
Proportional Action

• Proportional Positioning

Offset Established
Why?
• Some change to the mass balance the controller was tuned at

Disturbance
(Imposed as Set Point Change)

Controller Reacts
(Valve is adjusted open and closed, changing temperature)
Proportional Integral Action

- Controller “Offset” occurs when the mass balance of the controlled system is different from what it was designed and adjusted for.

- Integral action is added to the proportional logic to reduce/eliminate offset.

\[
\begin{align*}
E &= m \\
&= K_i C \int e \, dt
\end{align*}
\]

Diagram showing the relationship between the error signal, proportional, integral, and control actions. The diagram illustrates how integral action reduces the offset by reacting to the disturbance imposed as set point change, resulting in the temperature stabilizing at the set point.
Linear Stem Valves (Globe)

To Select Properly;

- Required Flow Rate (GPM) / Flow Coefficient $C_v$
- Select Differential Pressure
  - Magnitude Depends On;
    - Control; Open-Closed/Modulating
    - Hydraulic Design Philosophy; Balanced, Unbalanced, Branch & Riser Pressure Drops
    - Pump Control; Constant vs. Variable Speed
    - Required Valve Authority
    - Fluid & Pressure characteristics (cavitation prevention)
  - Consider Characteristic Requirement
Valve Definition

- ISA 75 Series
  - Test & Performance Std.
  - Definitions
  - Calculations
- Many terms describe valves
- Flow Coefficient
  - $C_V$
- Rangeability
Flow Coefficient $C_v$ Is Used for Sizing

$$q = C_v \sqrt{\frac{\Delta P}{SG}}$$
Flow Coefficient

\[ Q = q \times 500(t_{\text{ent}} - t_{\text{lvg}}) \]  Heat Transfer

\[ q = C_v \sqrt{\frac{\Delta P}{\text{SG}}} \]  Units = PSI

Specific Gravity; Water = 1

Calculate Desired
Live with Available
Control Valve Integration

\[ C_V = C_{V_{\text{Max}}} \times R^{\ell - 1} \]

("\ell" is Percentage Valve Position)
Rangeability

\[ R = \frac{\text{MaxFlow}}{\text{MinFlow}} \]

- With & W/O Actuator
- Without Actuator, 30:1
- With Actuator, 100+:1
- Globe Valves “De-Facto” Standard
- Ball Valve...
The Goal; Make the red line straight and 100% to 100%
System Hydraulic Effect; Valve Authority, $\beta$

- Valve authority affects controllability
- The Controller cannot control properly
- Simplified index value is $\beta$ and is pressure drop of valve over “controlled” pressure drop

$$\beta = \frac{\Delta P_{\text{MIN}}}{\Delta P_{\text{MAX}}}$$

![Diagram showing system hydraulic effect and valve authority](image)
Valve Authority Based on Flow Coefficient Hydraulic Calculation

Constant Flow Coefficient
- Pipe
- Coil
- Service Valves
- Balancing Valves

Variable: Control Valve

\[ C_{V_{SYS}} = \frac{C_{V1} \times C_{V2}}{\sqrt{C_{V1}^2 + C_{V2}^2}} \]
General Equal Percentage Authority Distortion
Three-Way Control Valves

Body Styles for Mixing and Diverting Types

A. Mixing

B. Diverting
Balanced Three Way Valve Authority
Unbalanced Three Way Valve Authority

Diagram showing the flow paths and valve authority in a three-way valve system.
Controllability ~ Constants: One of the Mass Balances

- Constant $\Delta P$ keeps predictable flow characteristic (ISA Std. 75 Test Procedure)
- Constant $\Delta P$ keeps controller tuning parameters constant
A Note On Variable Speed Pump Application

- System pressure relationships imply how to set VS pump control set point, where to take $\Delta P$ reading and what you can and can’t do to pump operation
  - General Rule (2 Pipe Direct Return Symmetrical Coils); Measure $\Delta P$ at end circuit across what would be “common piping” for all branches.
  - $\Delta P$ Set Point is head loss of sensed branch piping, including coil and control valve
- As pump controller lowers pump speed proportionally to changes in flow, there is less system $\Delta P$, and all valve flow rates change (reducing flow)
- If pump speed reduces too much, the combined effects of authority (combined system hydraulics) and reduced head can cause the zone controller to hunt when there is a disturbance that it reacts to
  - No longer in control
Where does the sensor go? How much ΔP SP?

- Is there a right location? Where do you normally see it?
- There is a simple answer, there are complex answers
Other Common Valve Body Styles

• Three Way Valves
  – Have been applied for many years due to concerns over source flow rates
  – Theoretically “constant flow” (only)

• Simple Zone Valves (Flappers)
  – Tend to be “On-Off” flow action
  – Applied to slow responding rooms

• Ball Valves
  – Popular Globe valve alternative
  – Characterized
Globes vs. Ball Valves

• Each has benefits in application

• Globes have higher inherent losses
  – Not A bad thing... some “good” things happen as a result
    • Less if any correction factors, larger control orifices
  – Makes velocity head flow coefficient correction a non-issue

• Ball valves low inherent losses
  – Makes velocity head flow coefficient correction an issue
  – Should be tested for changes in pipe diameter
Characterized Ball Valve
Ball Valve Placeholder
Ball Valve Correction Factor May Be Required

- Flow Coefficients are developed with line size pipe into and out of valve by ISA test definition
- Ball valves are very “flow efficient”, low inherent losses
- Application of reducers in and out of standard ball valves changes differential pressure, reducing flow coefficient... this may effect characterized balls. Only lab testing can confirm if correction factor is needed
General Valve Concerns

- **Application Pressure**
  - Low rise buildings.... Generally not a problem
  - High rise buildings; high pressure body to match static head of building plus safety factor

- **Working Pressure & Differential**
  - Actuator sizing to move the valve & close off
  - Valve maximum differential pressure

- **Valve Packing**
  - Can it handle the pressure and temperatures
Other “Stuff” To Remember

• Valve Cavitation
  – Cavitation occurs if the static pressure in any part of the valve falls below the vapor pressure of the liquid
  – ROT: when valve pressure drops start to go above 10-15 PSI start to closely examine the valve critical pressure drop
Water Quality

• Leak Prevention
  – “Soft” Water; Trace Hard Water Leaks Create Calcium Carbonate Build Up On Outside Of Valve. On Stem Creates Scratches In Normal and Abnormal Operation

• Clean Water
  – New System Water Has Dirt, Solder, Flux, Weld, Pipe Scale. Flush Pipe To Clean
Water Quality

• Filtration: Check water quality regularly
  – Check flushed strainers
  – Perform a flush
  – Exercise Care if starting chemical treatment in an “old” system

• Water Treatment
  – Soften water if greater than 50 ppm Calcium Carbonate
  – Make Up water Iron less than 1 ppm
  – Bacteria less than 10000 CFU’s (Colony Forming Units)
An Example of Poor Water Quality

- 20-30 Years old
- 12” Pipe
- Built up crud ≈1”
- About 3” at bottom
- Believed to be condenser water
Guidelines on Proportional Control Valve Sizing

- Process is iterative
- Establish coil design $\Delta T$;
  - Remember, as waterside $\Delta T$ increases coil characteristic becomes more linear, implying less required $\Delta P$
  - If there is outside air in process, that may also linearize the coil
- Calculate hydraulically most significant circuit head loss
- Target authority index between 33%-50%
  - 50% Authority means that valve $\Delta P$ equals the path head loss
- Calculate target valve flow coefficient
  - Look up your favorite manufacturers valve and find closest
- Check valve maximum $\text{controlled}$ pressure drop (not close off)
  - Looking for potential cavitation issues
  - Look at maximum velocity or if velocity can cause noise in space
- Characteristic changes
- Evaluate required control valve operating characteristic (authority)
- Plus Side; Great turn down, big pump energy savings
Calculate Head Losses Sans Control Valve

• This is where the iteration comes in...
  – First Pass; How large is the total pressure drop (pump head)?, How close is the desired control valve $C_v$ and valve authority?
  – Second Pass; Resize pipes if necessary to reduce or re-distribute head losses, Select actual valve $C_v$, Select a pump, Evaluate energy use based on operation
  – Keep In Mind; Do loads on common pipe zones share same control characteristic?, Pressure control to zones, Should some loads be hydraulically isolated (Primary-Secondary),
  – If calculations are done, pre-setting the valve head loss is simple, makes the flows all close to equal and proportional
Why this extra care?

• Proportional control takes advantage of flow and heat transfer relationship
  – Approximately 80% of operational hours can be done at 50% flow or less...significant energy savings

• To work properly
  – Maintain constant supply water temperature to coil
  – Try to make sure that ΔP stays reasonably constant, particularly in Variable Speed pumping systems

• Understand
  – Flow & Heat Transfer sensitivity will probably not allow a standard valve to “automatically” compensate for overflows...you must balance
  – Your load calculation and distribution...is the system “thermally” proportional...use piping techniques to separate non-proportional loads

• Application Influence
  – “Rooms” are slower processes...tend to be less sensitive
  – AHU coil discharge are fast processes and very sensitive
In classically “balanced” systems:

• All flow paths have the same design head loss
  – Implication: Statically balanced
  – Proportional: Too little pump all get same percentage of flow, Too much pump is adjusted (trim impeller, adjust triple duty valve) to deliver design flow rate

• Pipe layout should be coordinated; All paths serve similarly demanding zones
  – Control valve interactions are minimized
  – All zones have the capability to get design heat transfer
  – When diversity exists, it is accommodated in a controlled manner
Traditional Valve Application

Controls using conventional valves rely on “flat curve” pumps to stabilize system pressure and make coil heat transfer response predictable.

Traditional throttled constant speed pump and control valve

Minimal pressure changes
Example: Proportionally Balanced 4 Unit x 3 Floor
## Calculate Head Loss & Flow Requirement

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### PATH TOTAL

- **A-1-2-3-4-6-7-12-F**: 5 3.35 7.75 26.4 7.75 7.75 26.4 26.4 7.75 5.35 4.9 5.1 37 92.6
- **A-1-2-3-5-6-7-12-F**: 5 3.35 7.75 26.4 7.75 7.75 26.4 26.4 7.75 5.35 4.9 5.1 37 92.6
- **A-1-2-8-10-11-7-12-F**: 5 3.35 7.75 26.4 7.75 7.75 26.4 26.4 7.75 5.35 4.9 5.1 37 92.6
- **A-1-2-8-9-11-7-12-F**: 5 3.35 7.75 26.4 7.75 7.75 26.4 26.4 7.75 5.35 4.9 5.1 37 92.6
- **A-B-1-2-3-4-6-7-12-E-F**: 5 3.1 3.35 7.75 26.4 7.75 7.75 26.4 26.4 7.75 5.35 5.1 37 100.8
- **A-B-1-2-3-5-6-7-12-E-F**: 5 3.1 3.35 7.75 26.4 7.75 7.75 26.4 26.4 7.75 5.35 5.1 37 100.8
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- **A-B-C-1-2-3-4-6-7-12-D-E-F**: 5 3.1 2.9 3.35 7.75 26.4 7.75 7.75 5.35 4.9 5.1 37 108.6
- **A-B-C-1-2-3-5-6-7-12-D-E-F**: 5 3.1 2.9 3.35 7.75 26.4 7.75 7.75 5.35 4.9 5.1 37 108.6
- **A-B-C-1-2-8-10-11-7-12-D-E-F**: 5 3.1 2.9 3.35 7.75 26.4 7.75 7.75 5.35 4.9 5.1 37 108.6
- **A-B-C-1-2-8-9-11-7-12-D-E-F**: 5 3.1 2.9 3.35 7.75 26.4 7.75 7.75 5.35 4.9 5.1 37 108.6
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NEBB NATIONAL MEETING: CONTROL VALVES
Design Problem Control Valve Selection

• Iterated component head losses to 66’
• We want 50% Authority, so size valve for ___ – 66’

\[ q = C_v \sqrt{\Delta P} \]

\[ \frac{20 \text{ GPM}}{\sqrt{\frac{66}{2.31}}} = C_v = 3.74 \]

28.6 PSI
Control Valve Selection

- Required \( C_V = 3.75 \)
- Pipe Size = 1½”
- Rules of Thumb
  - One pipe size smaller
  - 5 PSI; \( C_V = 9 \)

Control Valves are designed primarily to regulate the flow of water and steam in response to the demand of a controller in Heating, Ventilating, and Air Conditioning (HVAC) systems. These valves are available in Normally Open (N.O.), Normally Closed (N.C.), and three-way ways many configurations. Both electric and pneumatic actuators are available for factory or field mounting.

<table>
<thead>
<tr>
<th>Valve Size, in. (DN)</th>
<th>1/2 (DN15)</th>
<th>3/4 (DN20)</th>
<th>1 (DN25)</th>
<th>1-1/4 (DN32)</th>
<th>1-1/2 (DN40)</th>
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<td>Maximum ( C_V ) (Kv) Factor</td>
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<td>7.3 (6.3)</td>
<td>11.6 (10.0)</td>
<td>18.5 (16.0)</td>
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<td>28.9 (25.0)</td>
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<td>46.2 (40.0)</td>
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Valve Authority

- Components have constant flow coefficient
- Valve coefficient is variable
- Calculate equivalent coefficient at valve stroke using spreadsheet

\[
\beta = \frac{\Delta P_{\text{MIN}}}{\Delta P_{\text{MAX}}}
\]

\[
C_{\text{VE}} = \frac{C_{V-\text{Valve}} \times C_{V-\text{Comp}}}{\sqrt{C^2_{V-V} + C^2_{V-C}}}
\]
1" Valve

$C_v = 11.6$

$\beta = 9\%$

Closest $C_v$ Valve

$C_v = 4.6$

$\beta = 43.7/109 = 40\%$
Guidelines on Non-Proportional Valve Sizing

• When applying two position valves only, either
  – Economics of valve select size and pressure drop that minimizes losses and allows actuator to close off against system differential head
  – Apply line size valve, again noting actuator requirements
  – Evaluate controller/actuator cycle so that damage is prevented from over cycling
• Apply to thermally slow control processes (larger spaces)
• In pseudo proportional control actions (pulse width modulation) evaluate actuator cycling damage.
• PICV Valves integrate a differential pressure controller with a temperature control valve to stabilize flow versus valve position
Pressure Independent Control Valves

- Illustrative of concept
  - Numerous ways to do this functionally
  - Results can be the same or better

- Is it a “Balancing Valve”
  - Generally: No
  - Doesn’t have flow measurement
  - Flow Limiter
  - Proportional balance through control system programming

- Reportedly great variance in base body pressure losses

- Alternatively Zone $\Delta P$ Regulation
  - $\Delta P$ Valve
  - Pump (Think P/S pumping)
PICV: Good, Bad, ??

• No perfect solutions...
  – Proportional Balance implies same system pressure drops; Generally Static BV
  – VS Pump systems may have issues with Static BV application; Automatic Flow Limiter has benefits
  – PICV stabilizes pressure at TC valve, and can be AFL, but need software at controller level to deal with proportional balance.

• Lot’s of liberties taken on reporting required ΔP for operation
  – ΔP regulator may control 3-5 PSI across valve orifice, but “body” may need 15-20 PSI
Adding Variable Speed Pump Dynamics

- Proportional control dynamic is changed in conventional modulating valves
- Controller begins to hunt

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<tr>
<th>Load (Control Signal)</th>
<th>Flow Required</th>
<th>Conventional Valve</th>
<th>Regulated Valve</th>
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<td>10 GPM</td>
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<td>Get’s</td>
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<td>Need</td>
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<td>Get’s</td>
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Voltage Ramp
Flow “Stabilization”
Standard Valve

Set Point Change
Controller Hunts
Standard Valve

Load Change
Flow Changes
Standard Valve

Change To
PICV Valve

Set Point Changes To
PICV Valve
Control Valves & Balancing Are Misunderstood

- July & September 2009 ASHRAE Journal Article & Rebuttal
  - Predetermined bias against balance
  - Do not properly relate control or system hydraulics into calculations properly
  - Attempts to make economic case against balance
  - Faulty thesis of purposely oversized pumps and mismatched systems
  - Compares three way valves to two way variable speed variable flow

- Rebuttal re-examined the economics using the math and a real pump curve
  3-Way Valves vs. 2-Way Valves vs. PICV
  - Trimmed & Untrimmed Pump
  - Good & Poor Authority
  - Constant vs. Variable Speed
Summary of Results

- No surprises; Less flow, less head, less energy used

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<th>Scenario</th>
<th>KWH</th>
<th>Cost of Operation</th>
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<td>Base: 3 Way Valve, Poor Authority, Oversized Untrimmed Pump, No Balancing</td>
<td>58,000</td>
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<td>3 Way Valve, Poor Authority, Balanced &amp; Trimmed</td>
<td>42,000</td>
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<td>2 Way Valve, Poor Authority, Untrimmed Pump, No Balancing, Constant Speed</td>
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<tr>
<td>“PICV” with Max Flow Limit &amp; Variable Speed @ 5PSI Set Point (sort of attainable)</td>
<td>1,900</td>
<td>$145</td>
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Adding Variable Speed

These set points have an impact on operation of a variable speed pump:

- 40 Ft Across coil and valve limits, speed turndown to 80%.
- 30 Ft. Across valve limits, speed turndown to 70%.
- 11.5 Ft (5 PSI) for PICV allows speed turndown to less than 50%.

- Note: 5 PSI may not be realistic!

The lower the turndown, the greater the energy savings. The energy impact:
2000 KWH annual energy consumption, $150 energy cost.
Rules of Thumb

• We are not promoting use of Rules of Thumb but...
  – Control Valves should be at least one size smaller than pipe...
    • This should often happen, and valves could even be smaller
  – Use of 5 PSI for sizing (Not recommending)
    • Often found in control vendors quick sizing or engineering guides

• Worst case scenario for valve closure is pump shutoff head
  – Advent of variable speed pumping, generally makes valve actuation easier when properly controlled pump is applied

• Valve Quality
  – Generally speaking, HVAC globe and ball control valves for water are reasonable quality. Rangeability with an actuator is often greater than 100:1
  – Often some will substitute “valve quality” or “industrial grade” as an anecdotal substitute for proper sizing and good valve authority, those terms alone mean nothing.
  – When high pressure drops are unavoidable, then “Industrial Grade”, which often means a caged plug should be examined
Notes on Actuators

• Wide variety applied to HVAC
  – Fluid Power (Pneumatic), both linear and rotary action
  – Electric Power, gear driven rotary motors and linear action through linkage adapter
  – Electric thermal power, linear action thermally sensitive element expands and contracts pushing on stem

• Embedded actuator μP-controllers give many potential options (to manufacturers) to;
  – Scale signals, Do math based PICV, etc.
Other Application Styles: Primary-Secondary

- In this application, constant flow is kept on the coil by the load pump
  - Maintains 100% coil heat transfer (full flow)
  - Hydraulically isolates high loss terminals from main system pump
- Temperature control by changing coil entering temperature through valve modulation
- Especially useful on Outdoor Air coils in cold climates
Effects of Changing EWT In Coil

- 160°F EWT
- 180°F EWT
- 200°F EWT

Percent Heat Transfer (WRT 160°F Baseline)

Percent Water Flow

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Changing Entering Water Temperature

- Coil characteristic becomes more linear
- Coil always delivers 100% heat transfer due to 100% flow rate, just not full coil potential heat transfer
- Advantage in heating coil always hot and no potential for freeze up
- Advantage in cooling coil 100% latent capability
Primary-Secondary With Check Valve in Common
Primary-Secondary: Valve in Common / Differential Pressure Transmitter
Primary-Secondary: Temperature Sensors in Bridge
Terminal With Face-Bypass Control
Terminal With Face-Bypass Control and Conditioned Bypass Air

- Outside Air
- Mixed Air
- Return Air
- Control Valve
- Discharge Temperature Controller
- Cooling Coil
- Face-Bypass Dampers and Actuators
- Low Temperature Thermostat
- Fan
- Supply
Alternative to Control Valve

- VFD or Pulse Width On/Off control of circulating pump instead of control valve provides control ±0.5°F
- BSRIA/ASHRAE Research (R.H. Green) Transactions 1994 New Orleans Meeting
Optimizing Strategies

• First rule of optimization: design so that control valve functions as intended

• Water temperature reset control
  – Not too much reset... changing entering water temperature too much will drive heat transfer down and the zone controller will want to open the valve

• System differential pressure control
  – Stabilize system differential around the control valve, or apply separate differential pressure control valves to stabilize several temperature control valves on a common branch

• Variable speed pump control
  – Apply to system, but evaluate when loads occur with respect to each other and the hydraulic effects of sensor location
  – Applying “diversity” criteria to pump selection and pipe sizing can have significant detrimental operating effects...be very careful
Thank You

Questions will be answered now or whenever you want to ask (after session or meeting... pick up the phone)