

# Hydronic System Performance

**Why design and modeling data  
cannot always predict a  
building's actual performance**

Presented by Belimo

# Learning Objectives

- Explore the design and modelling assumptions regarding hydronic systems
- Identify the system performance issues that are caused by improperly sized control valves and poor valve authority
- Understand how variances in coil performance affects thermal heat transfer efficiency
- Discover how advanced control valves offer potential solutions for all these issues

# **Design and Modeling Assumptions**

An aerial photograph of a city skyline, likely New York City, featuring a prominent skyscraper with a glass facade in the foreground. The background shows a dense urban landscape with various buildings and a hazy horizon.

# Design / Modelling Assumptions

A vertical grey arrow pointing upwards, indicating a hierarchy or progression of assumptions.


**Perfect Valve Authority**

**Stable System Pressures**


**Proper Valve Sizing**

**What is a  
Design  
Day?**



An aerial photograph of a city skyline, likely New York City, featuring numerous skyscrapers and a dense urban landscape. A prominent blue circle is overlaid on the right side of the image, containing white text. A vertical, textured bar with a grid-like pattern of blue, green, and orange colors runs down the center of the image, partially overlapping the city view.

**How  
Many in  
a Year?**

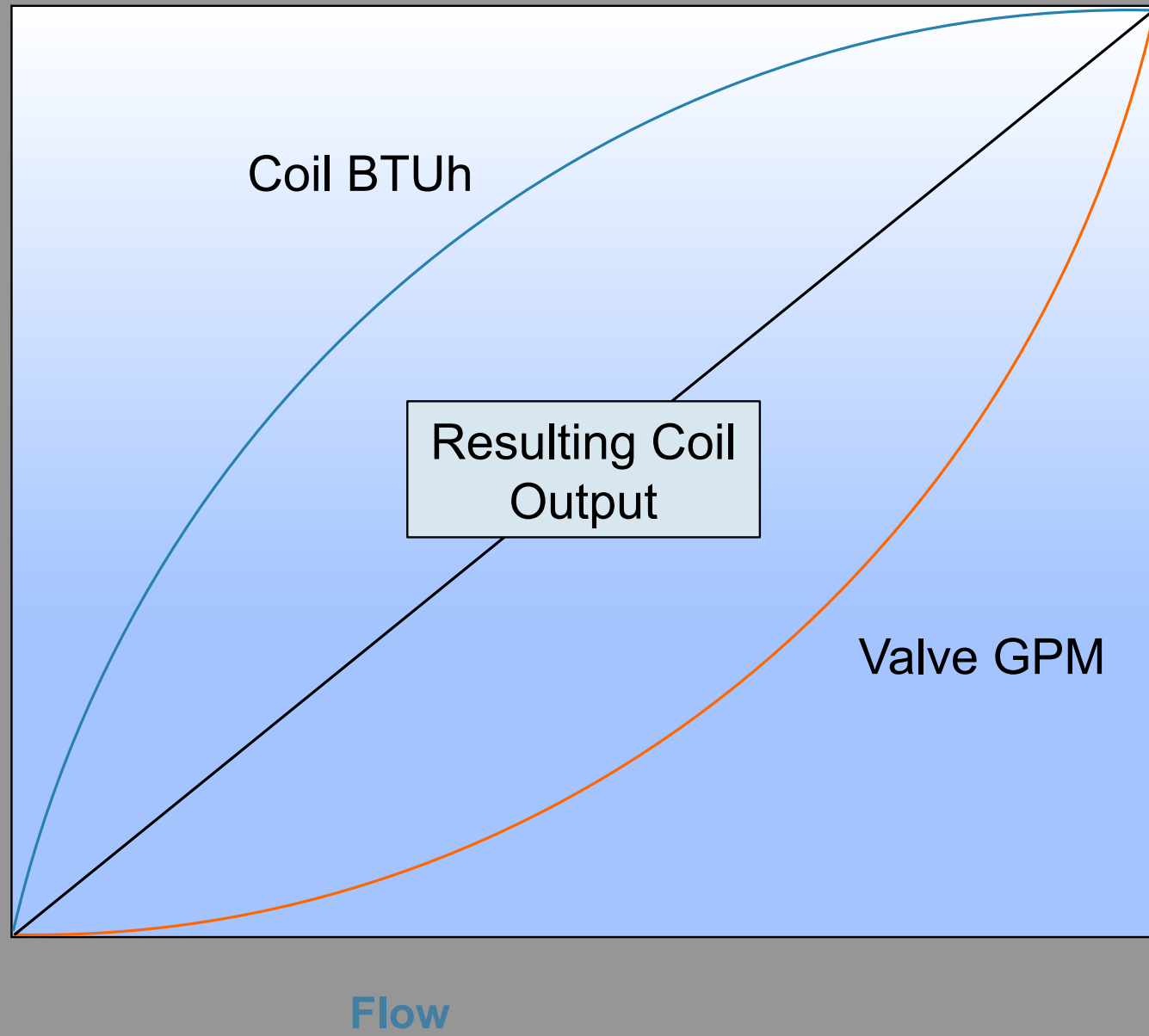
An aerial view of a city skyline, likely New York City, with a prominent skyscraper in the center. A blue circular overlay is positioned in the lower-left quadrant, containing white text. The background shows a dense urban landscape with various buildings and a hazy horizon.

**What  
Happens  
Rest of the  
Year?**

# System Performance Problems

Valve Sizing

Coil Power



ACTUATOR PART #

Control

2-Way

Model #	Cv	Size [mm]
G665CS	65	2½" [65]
G680CS	90	3" [80]
G6100CS	170	4" [100]
G6125CS	263	5" [125]
G6150CS	344	6" [150]

3-Way Mixing

G765S

68

3" [80]

$$Cv = \frac{GPM}{\sqrt{\Delta P}}$$

- Coil Requires 250 GPM
- $\Delta P = 4\text{psi}$

$$Cv = \frac{250 \text{ GPM}}{\sqrt{4}} = 125$$

ACTUATOR PART #

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3-Way Mixing

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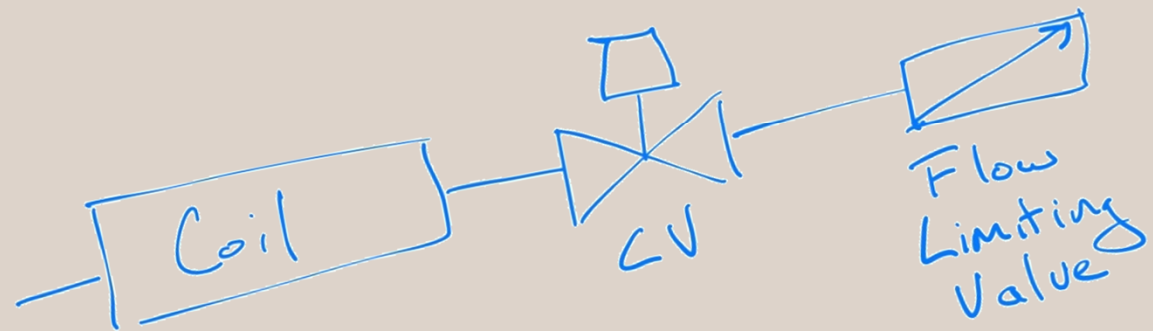
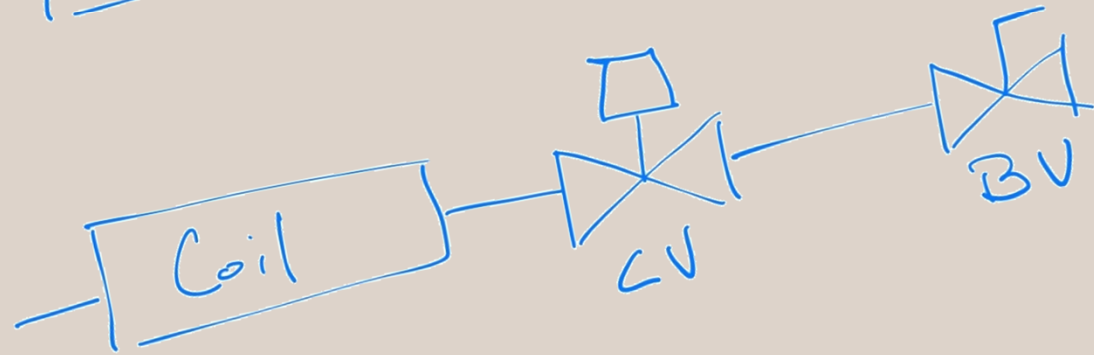
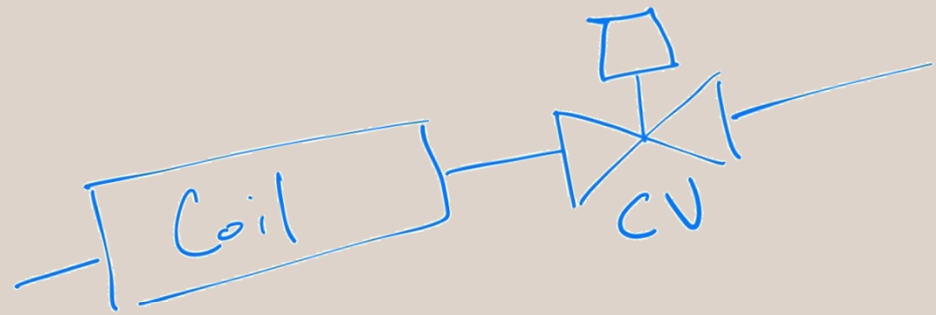
68

3" [80]

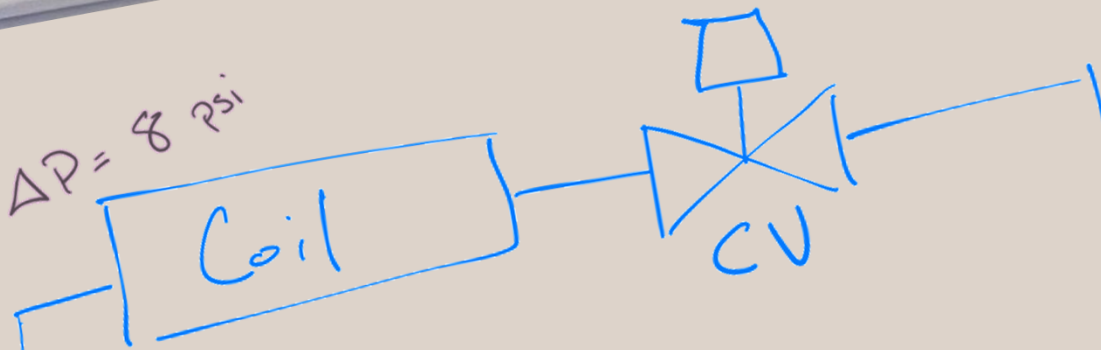
$$\Delta P = \left( \frac{GPM}{Cv} \right)^2$$

$$\Delta P = \left( \frac{250}{90} \right)^2 = 7.7 \text{psi}$$

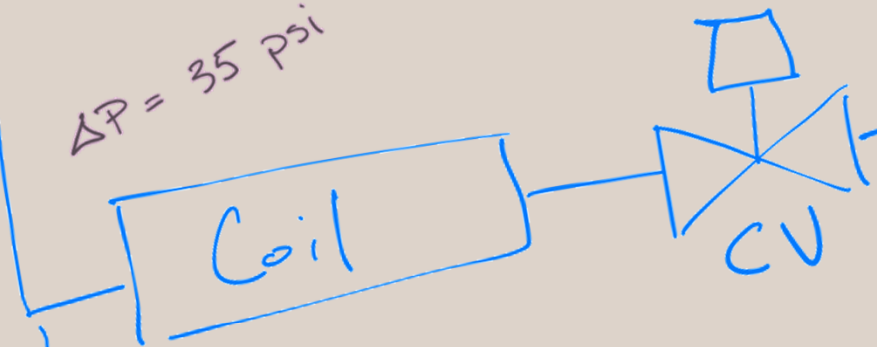
$$\Delta P = \left( \frac{250}{170} \right)^2 = 2.2 \text{psi}$$



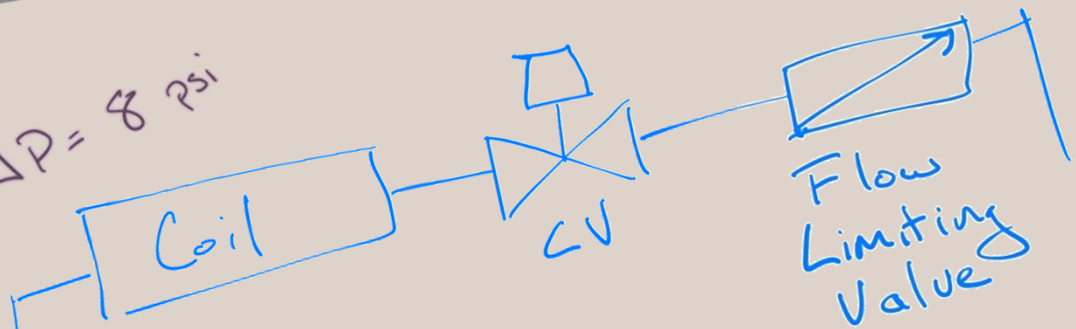
$\Delta P = 8 \text{ psi}$



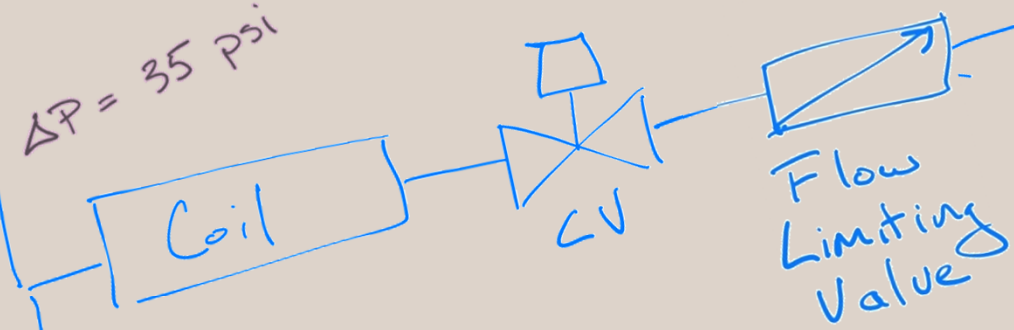
$\Delta P = 35 \text{ psi}$



$\Delta P = 8 \text{ psi}$



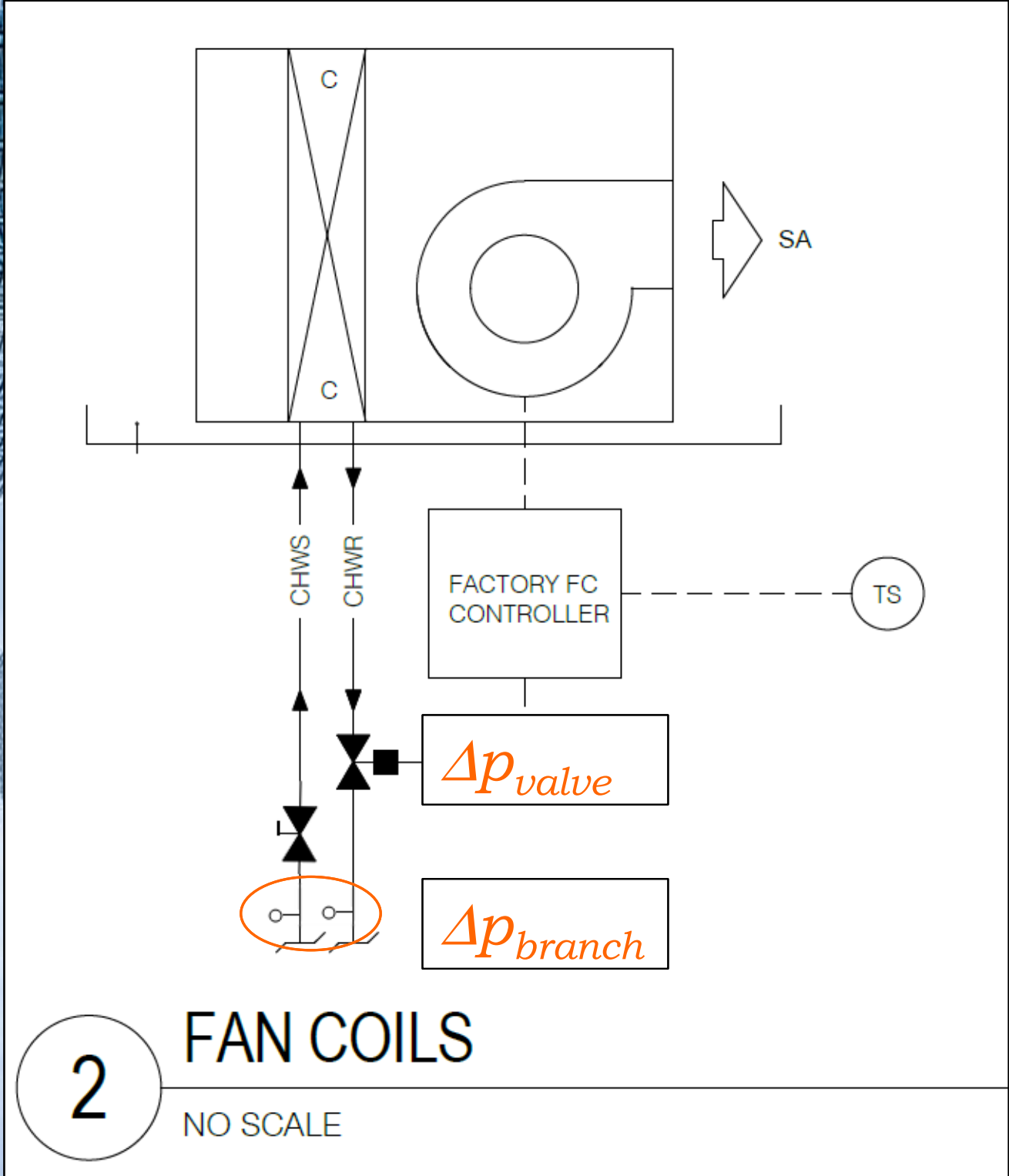
$\Delta P = 35 \text{ psi}$



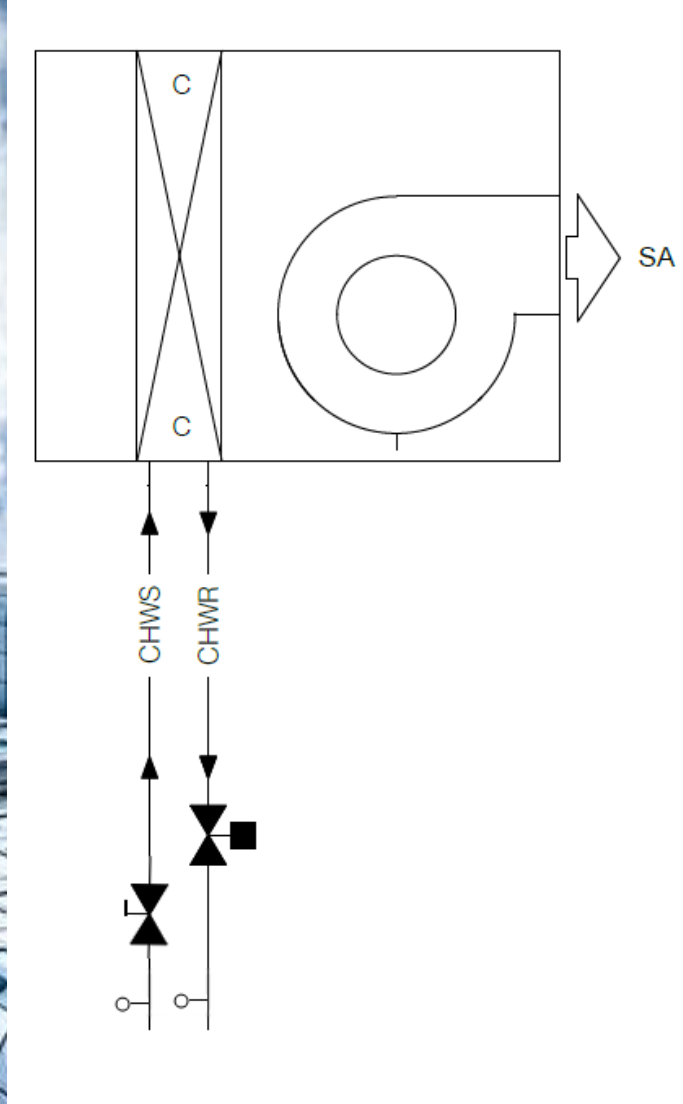
# System Performance Problems

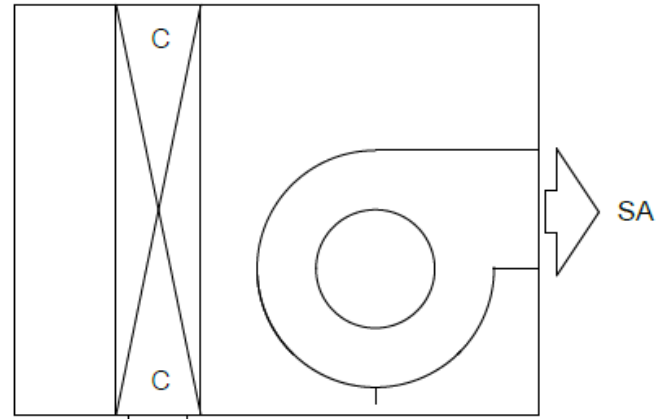
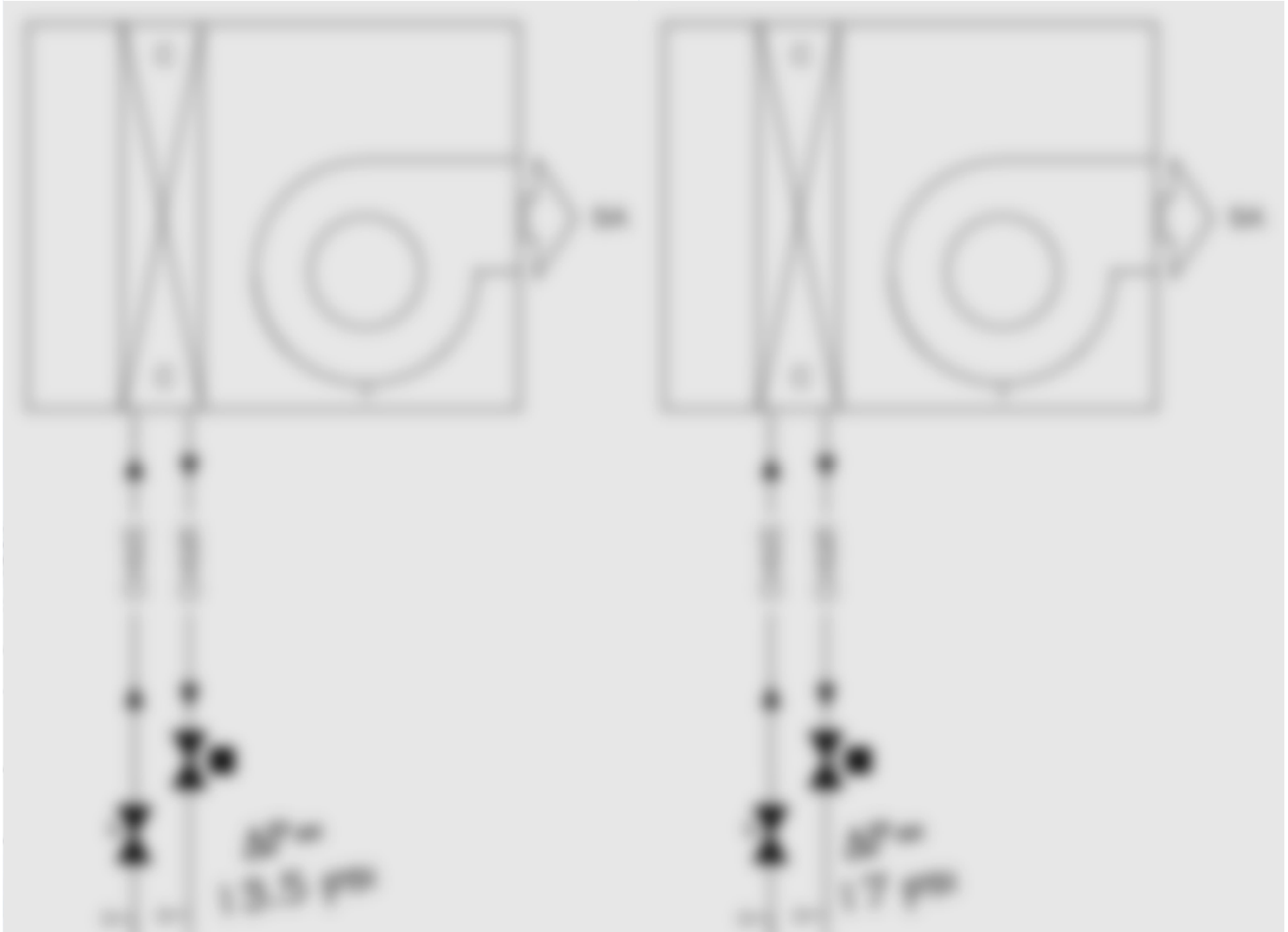
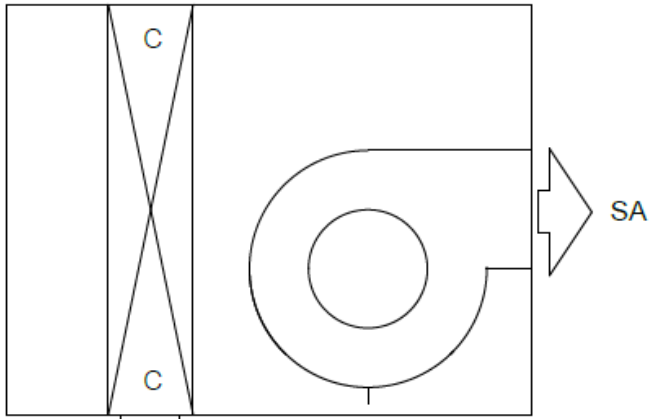
**Valve Authority**

$$A = \frac{\Delta P_{valve}}{\Delta P_{branch}}$$



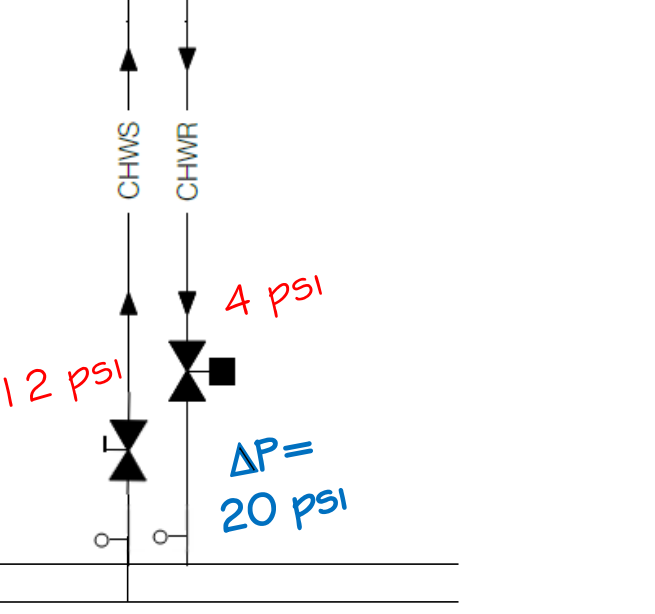
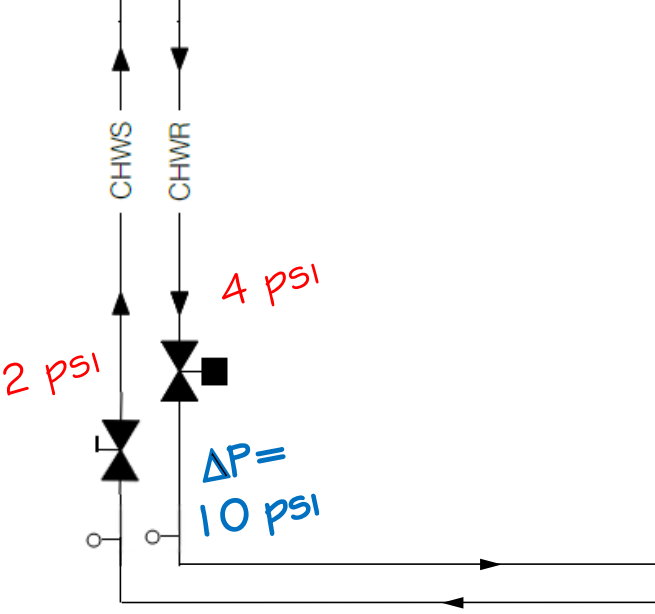
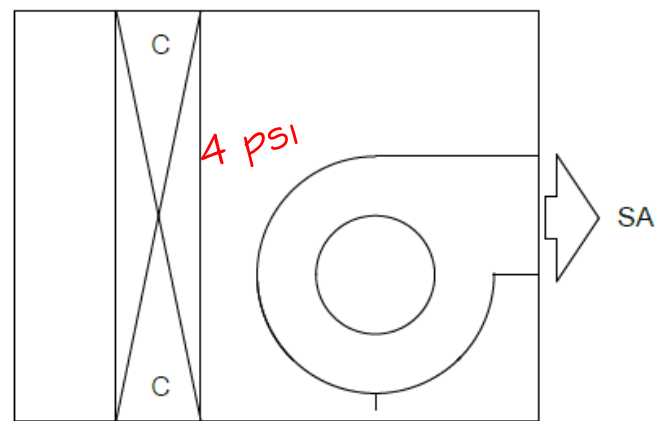
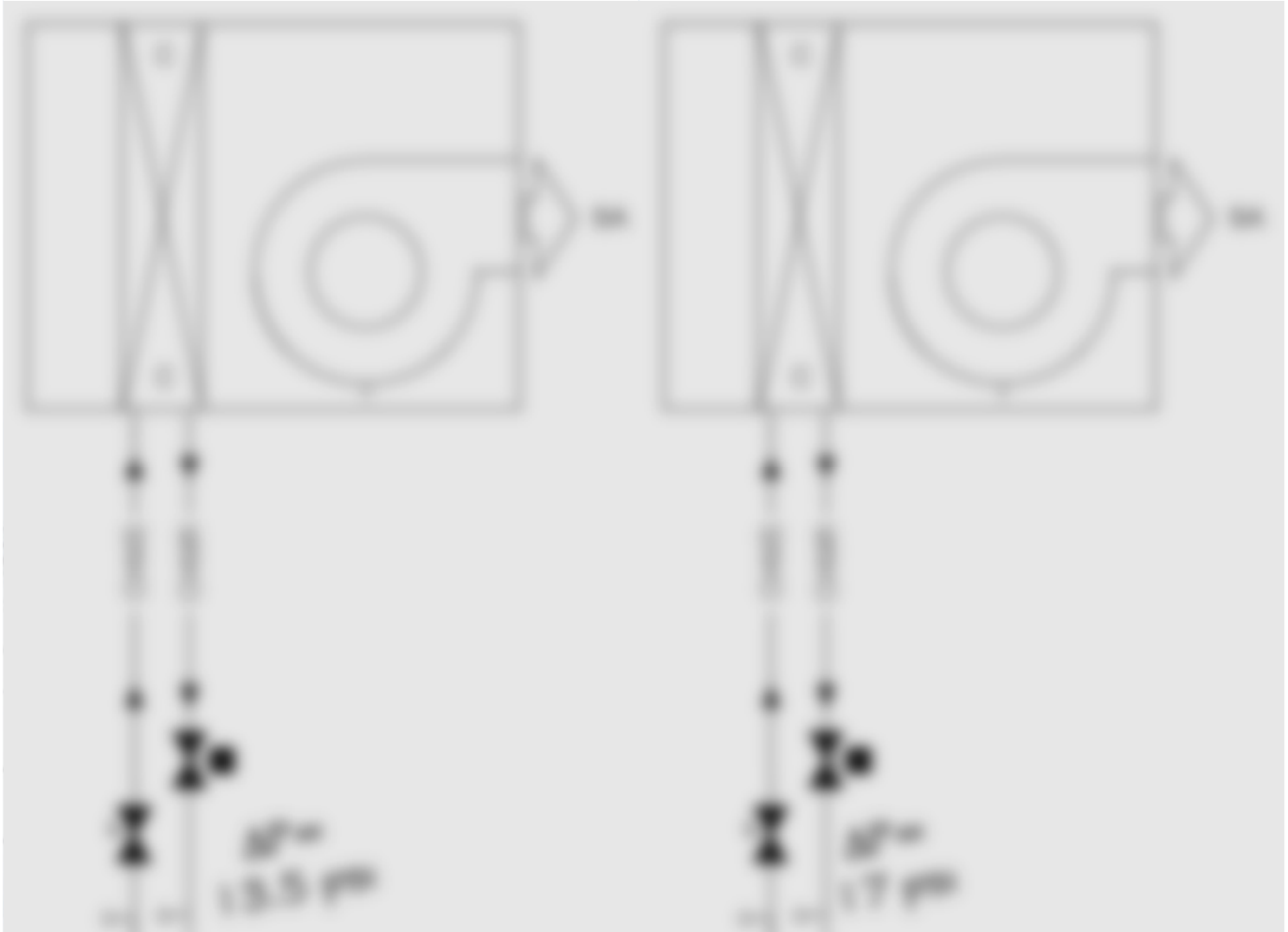
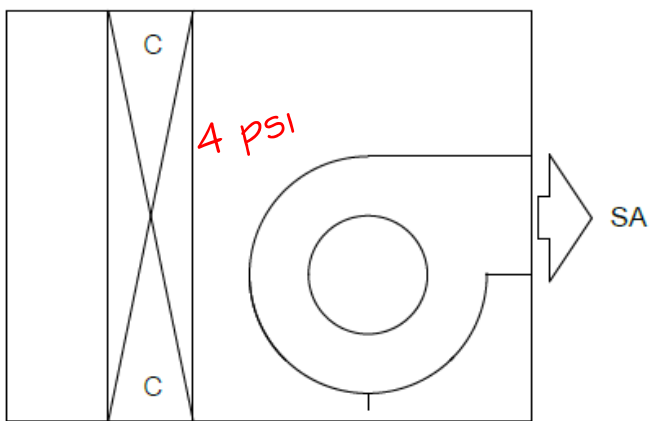
# Static Balancing

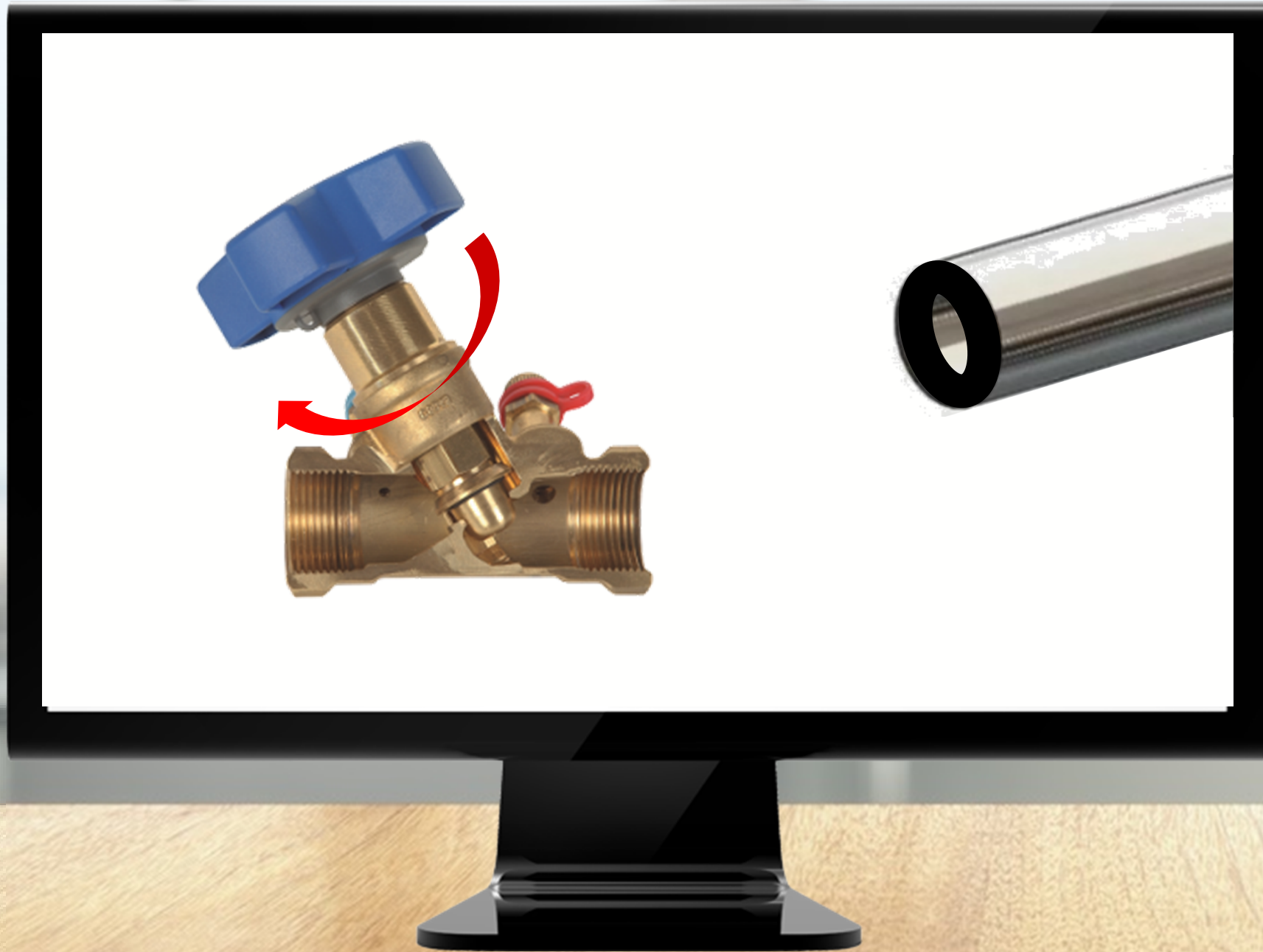




$\Delta P = 10 \text{ psi}$

$\Delta P = 20 \text{ psi}$





the Legal Pad

Tops.

## Manual Balancing Valves

(Full Open)

100% flow

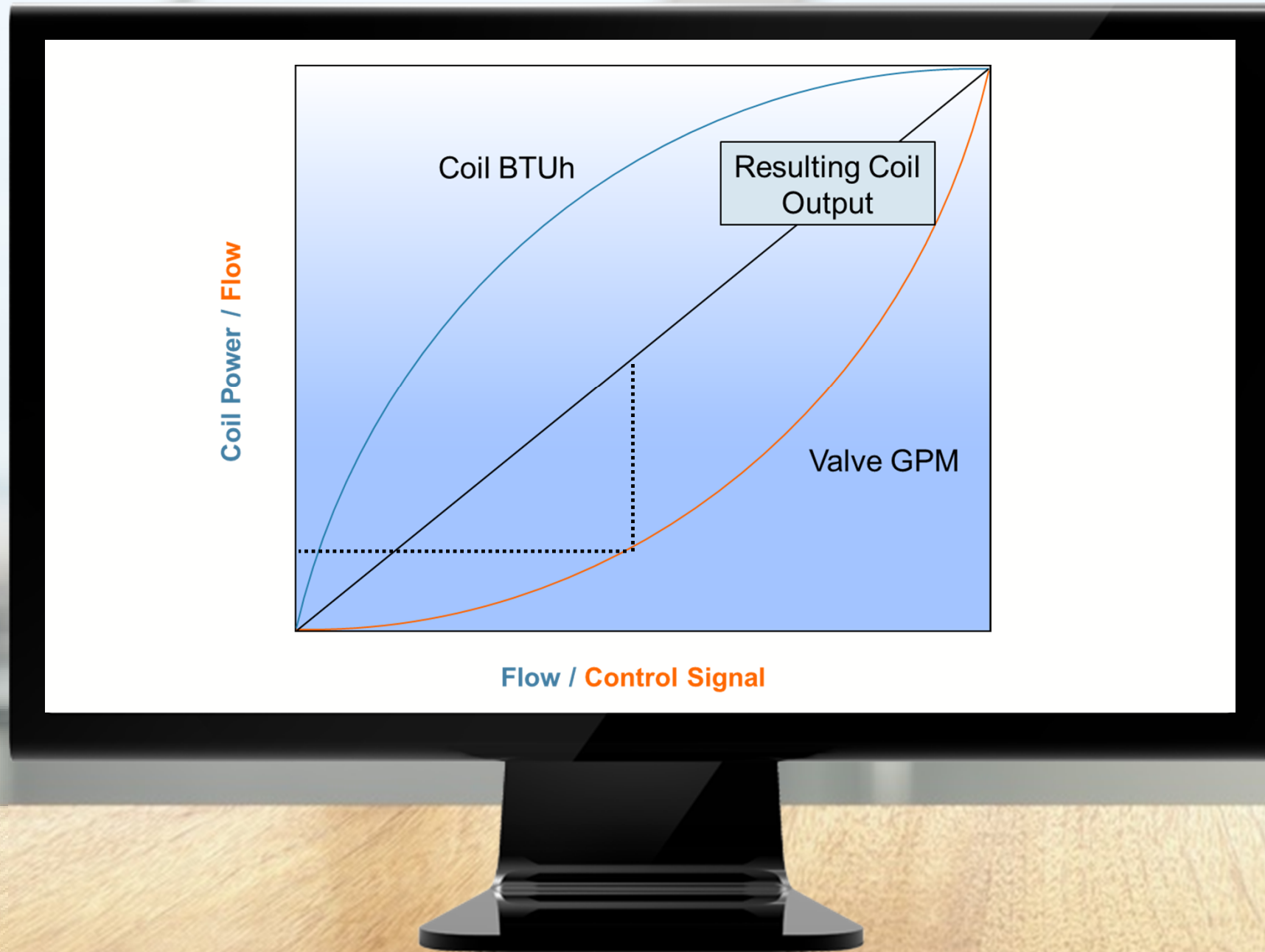
No pressure drop


(Balanced)

100% flow

12 psi pressure drop

What Happens at 20%  
Flow?!?



the Legal Pad 

### Manual Balancing Valves

(Full Open) 100% flow  
No pressure drop

(Balanced) 100% flow  
12 psi pressure drop

What Happens at 20%  
Flow?!?

**Auto Flow Valves**



\* Some flow-limiting valve manufacturers claim that their valve plus a standard pressure-dependent control valve provide the same performance as a pressure-independent control valve. This is definitely not so. The flow-limiting valve essentially does nothing when flow is below design, as this is when the valve is throttling flow. So it does nothing to limit the differential pressure across the control valve. With a pressure-independent valve, the differential pressure across the control valve is always constant.

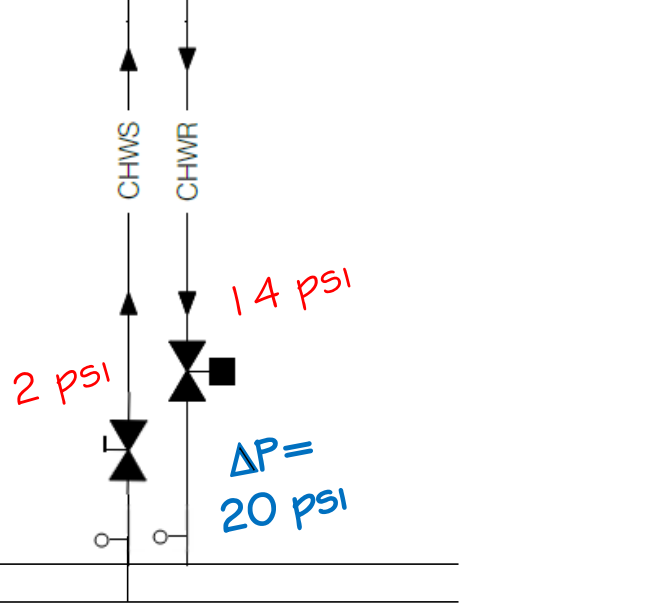
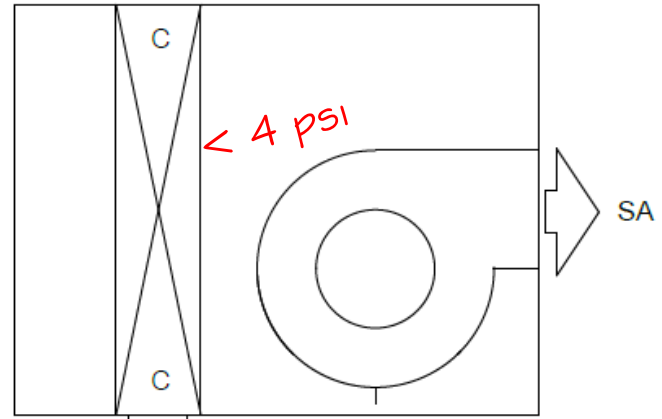
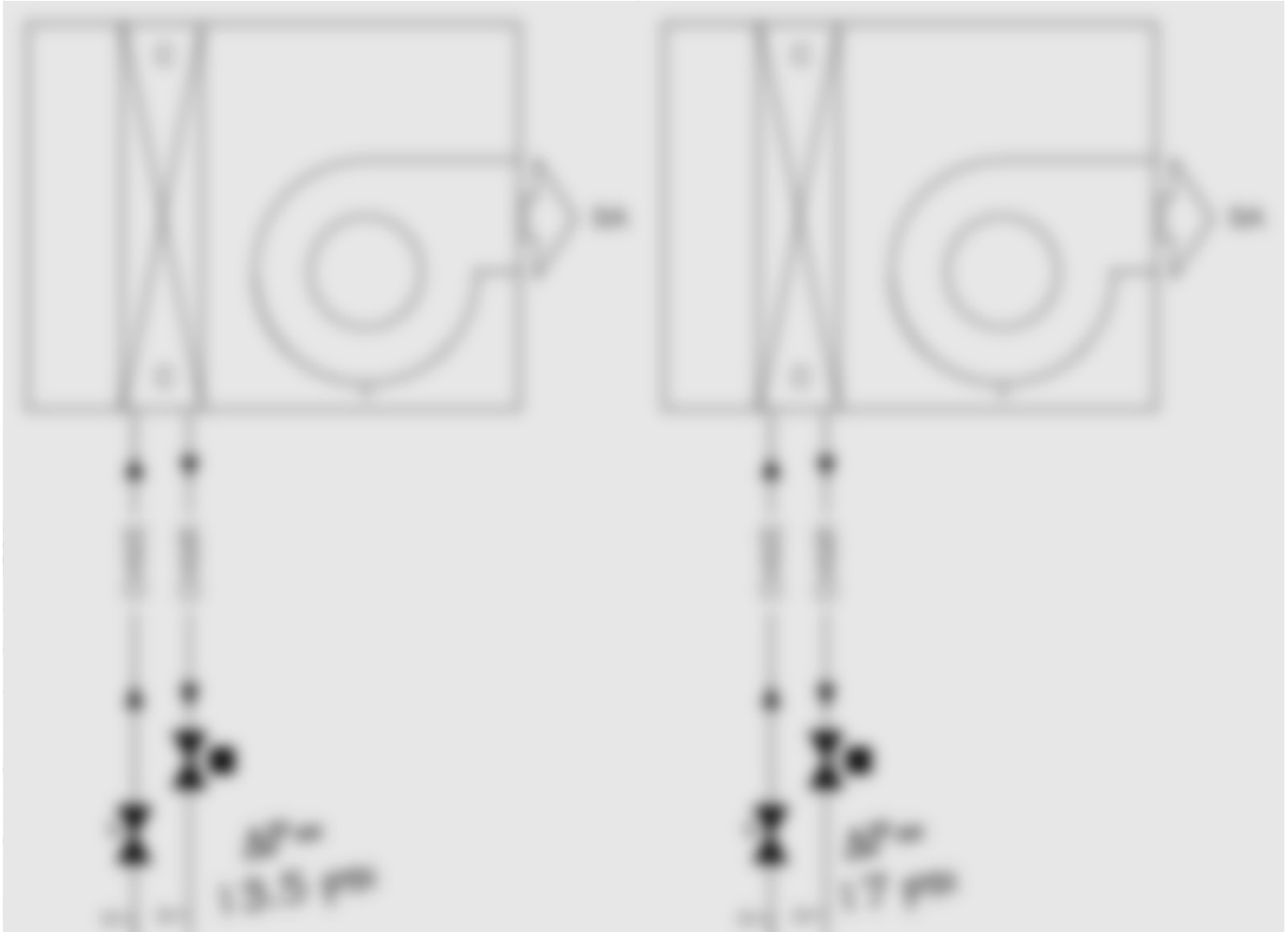
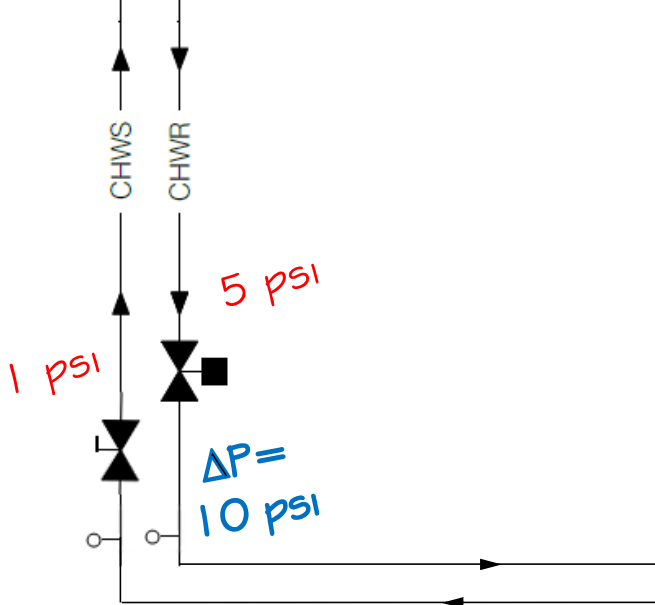
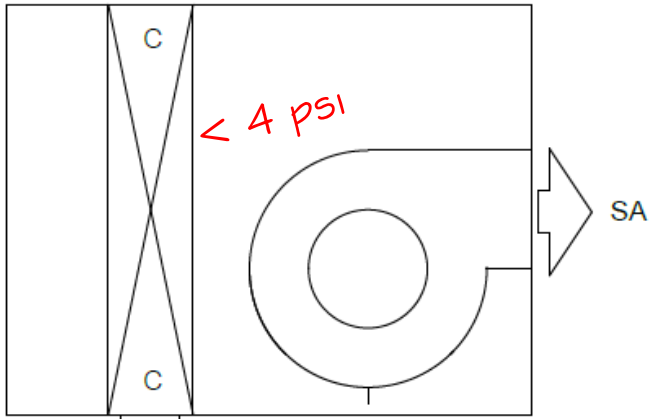
the Legal Pad



## Auto Flow Valves

Limit the Maximum Flow to the coil...

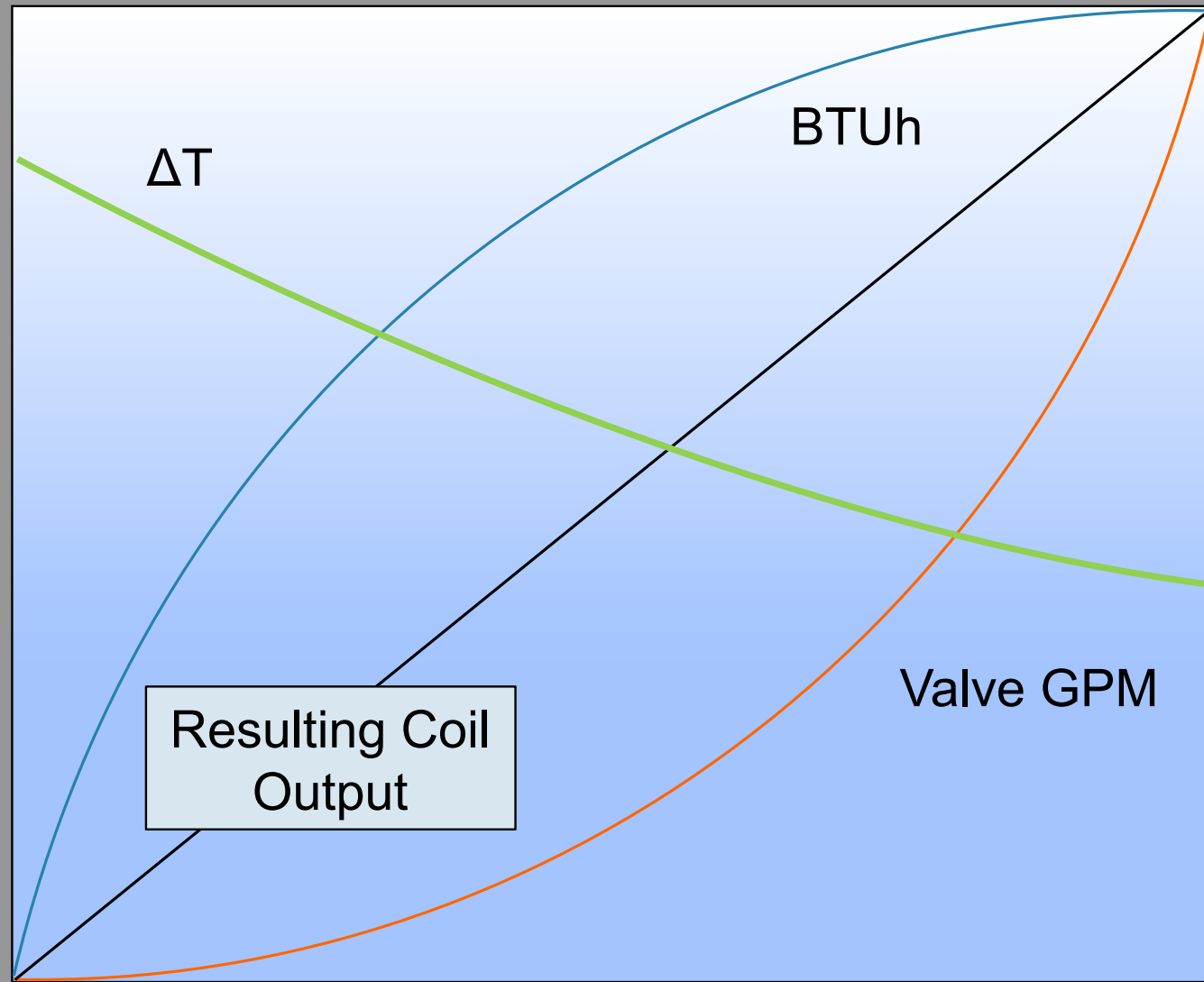
But, what happens below max flow?



# System Performance Problems

Coil Performance

Coil Power / Flow

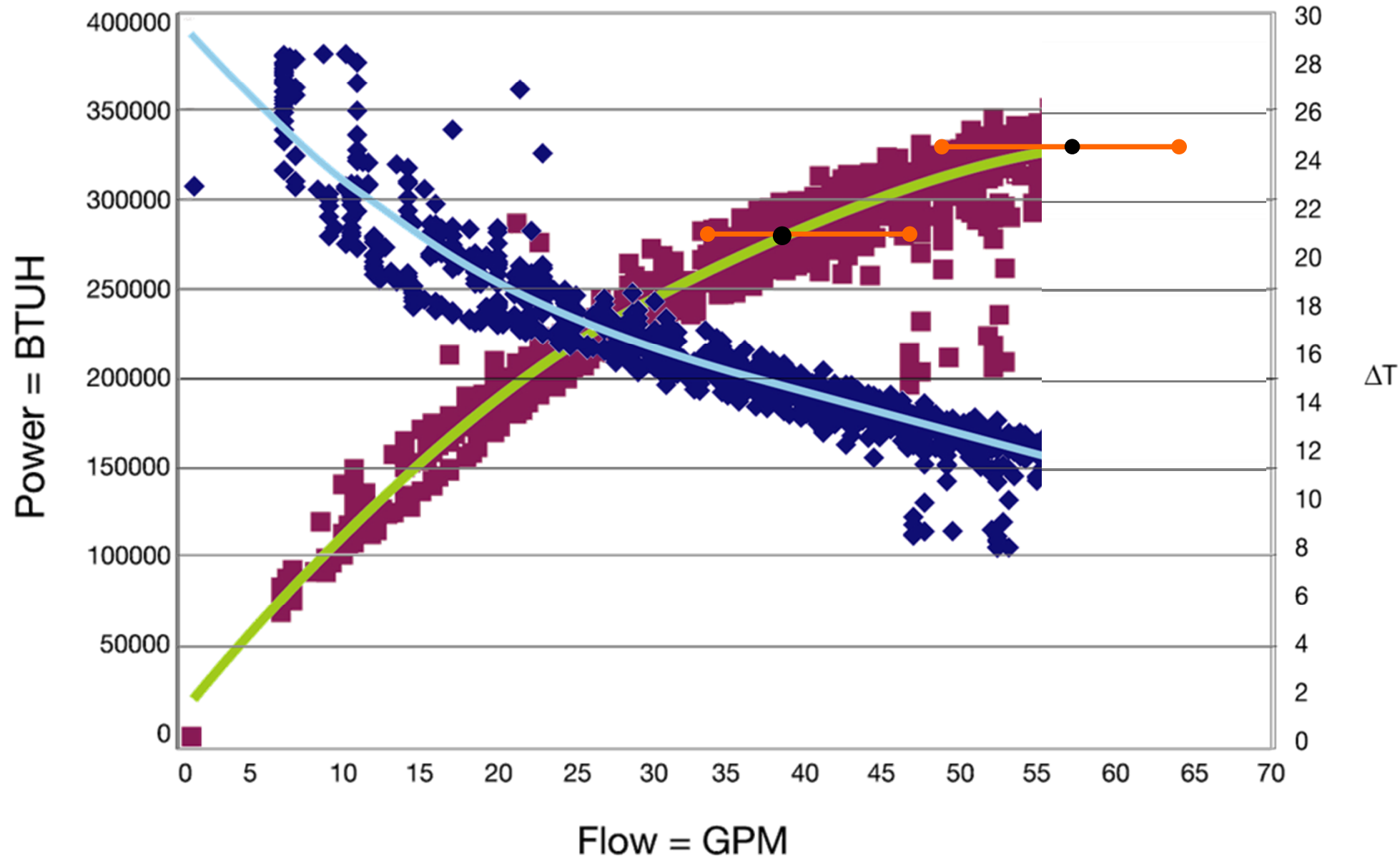


Resulting Coil Output

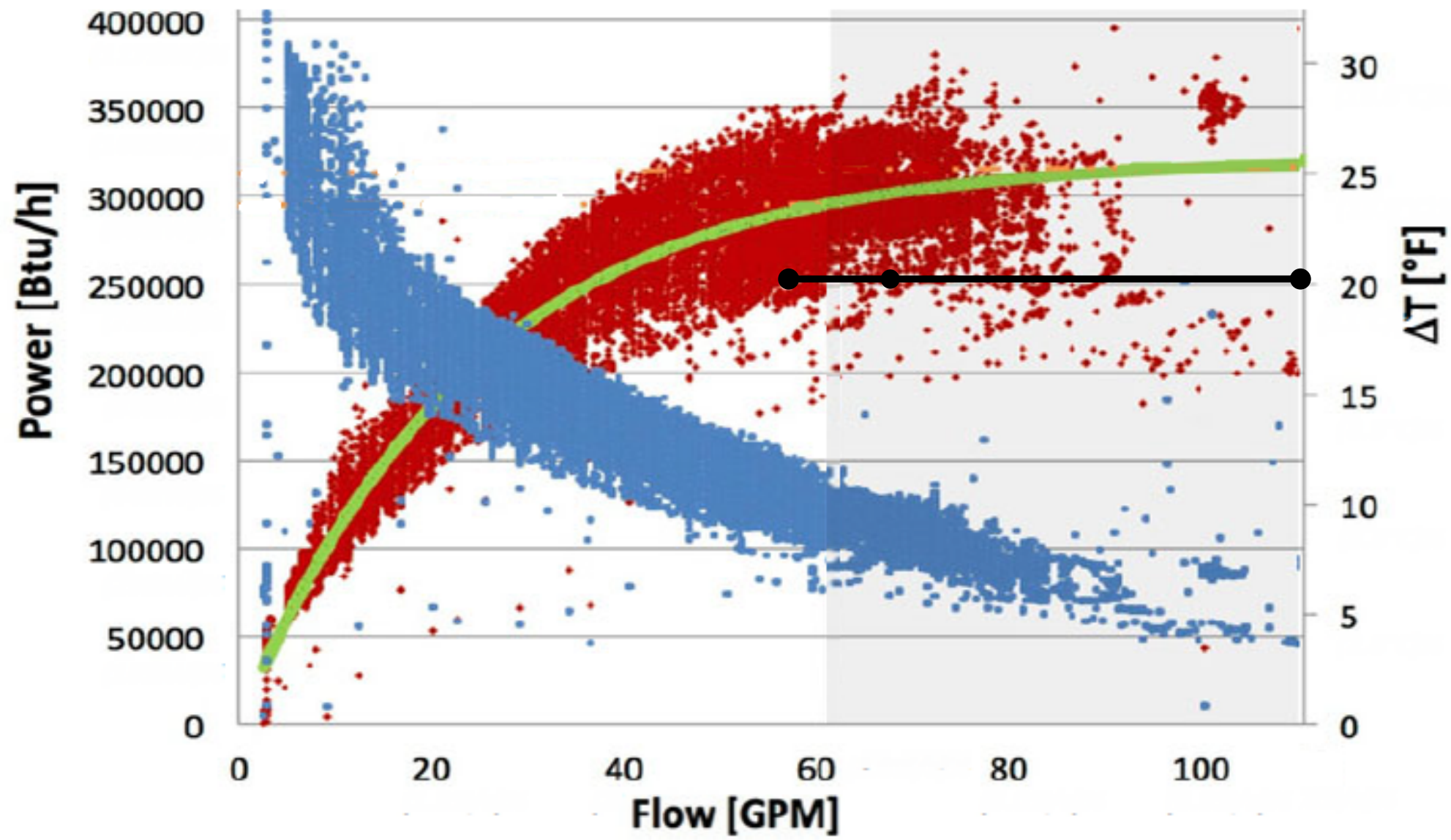
Flow / Control Signal

$\Delta T$

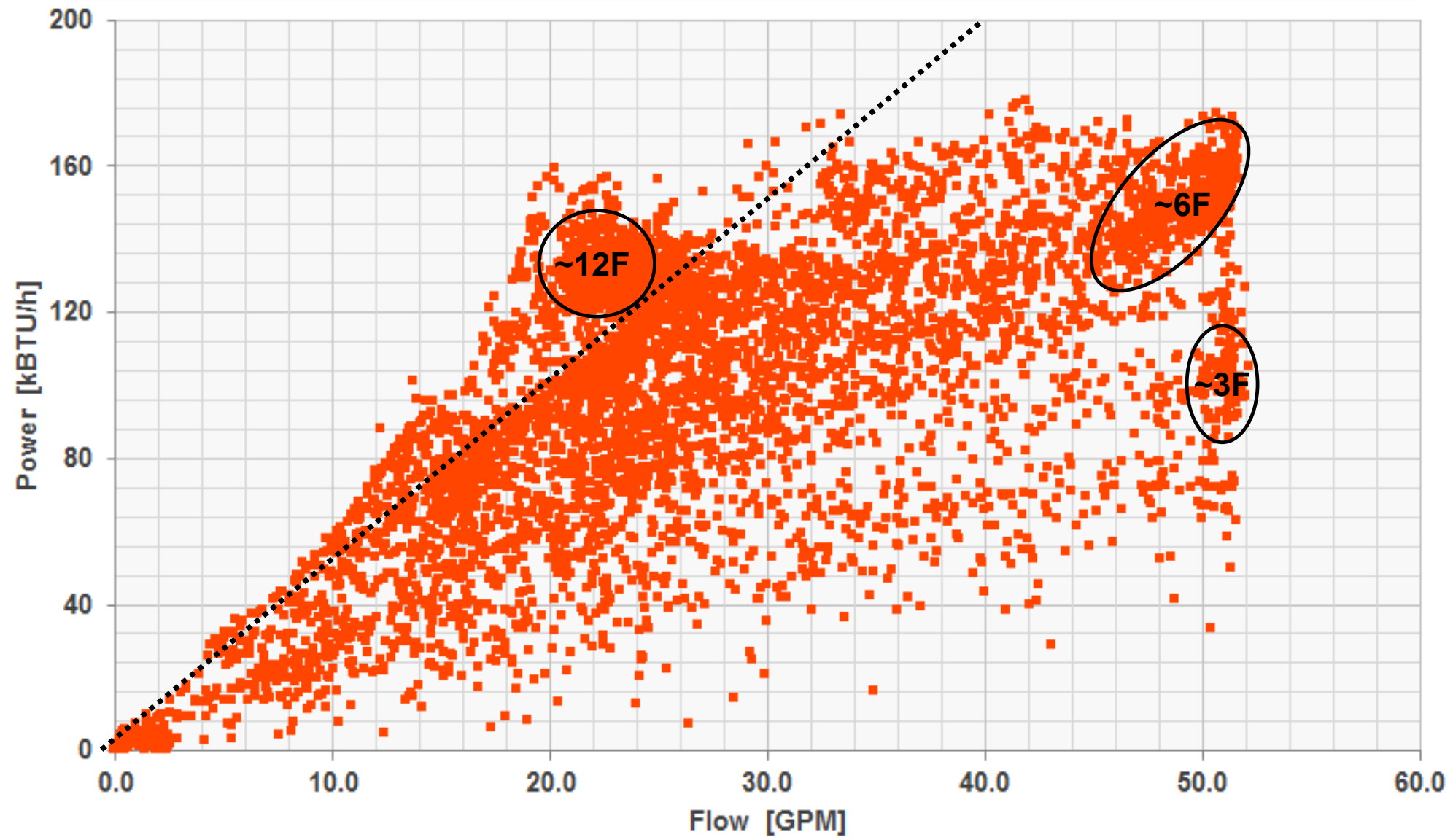


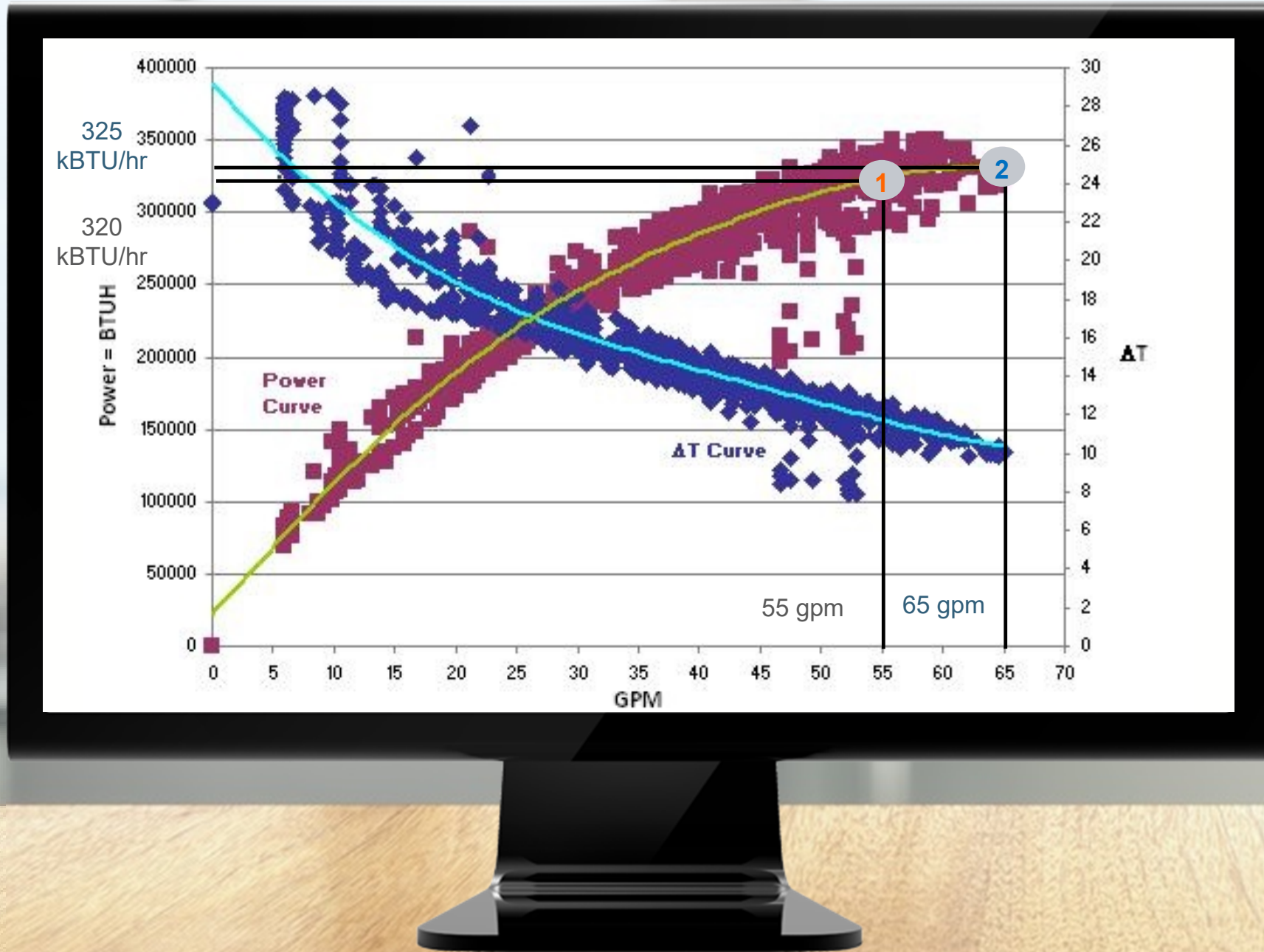


- Power Output:
1. Pump more Water
  2. Reduce Delta T
  3. No additional BTUs
- $$Q(Btu/h) = 500 \times GPM \times \Delta T$$



# POWER AND DT VS FLOW





the Legal Pad Tops.

-> Less than 2% more Btuh  
 -> 18% more water!

$$\frac{HP_2}{HP_1} = \left(\frac{GPM_2}{GPM_1}\right)^3$$

$$\frac{HP_2}{HP_1} = \left(\frac{65}{55}\right)^3 = 1.65$$

65% more Pump hp!



**Perfect Valve Authority**

**Stable System Pressures**

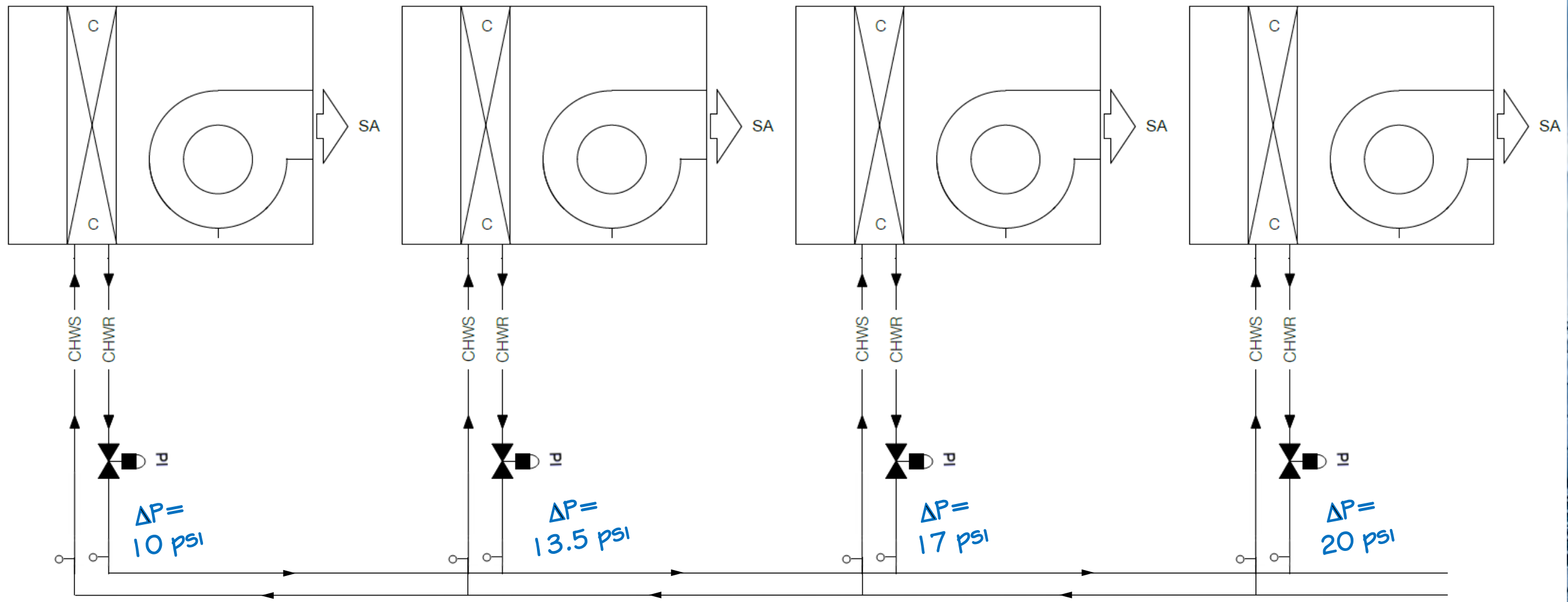
**Proper Valve Sizing**

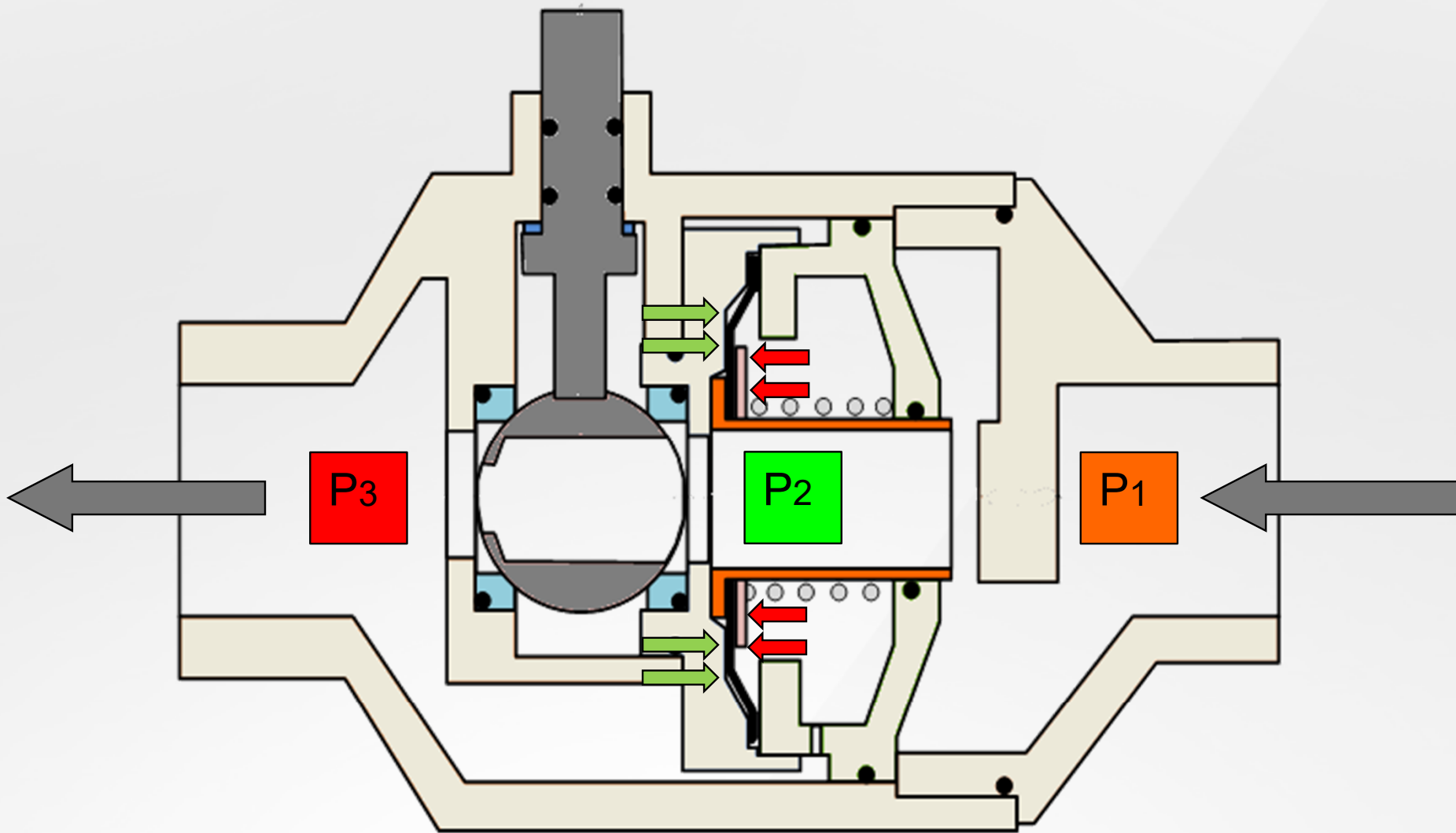
# Potential Solutions

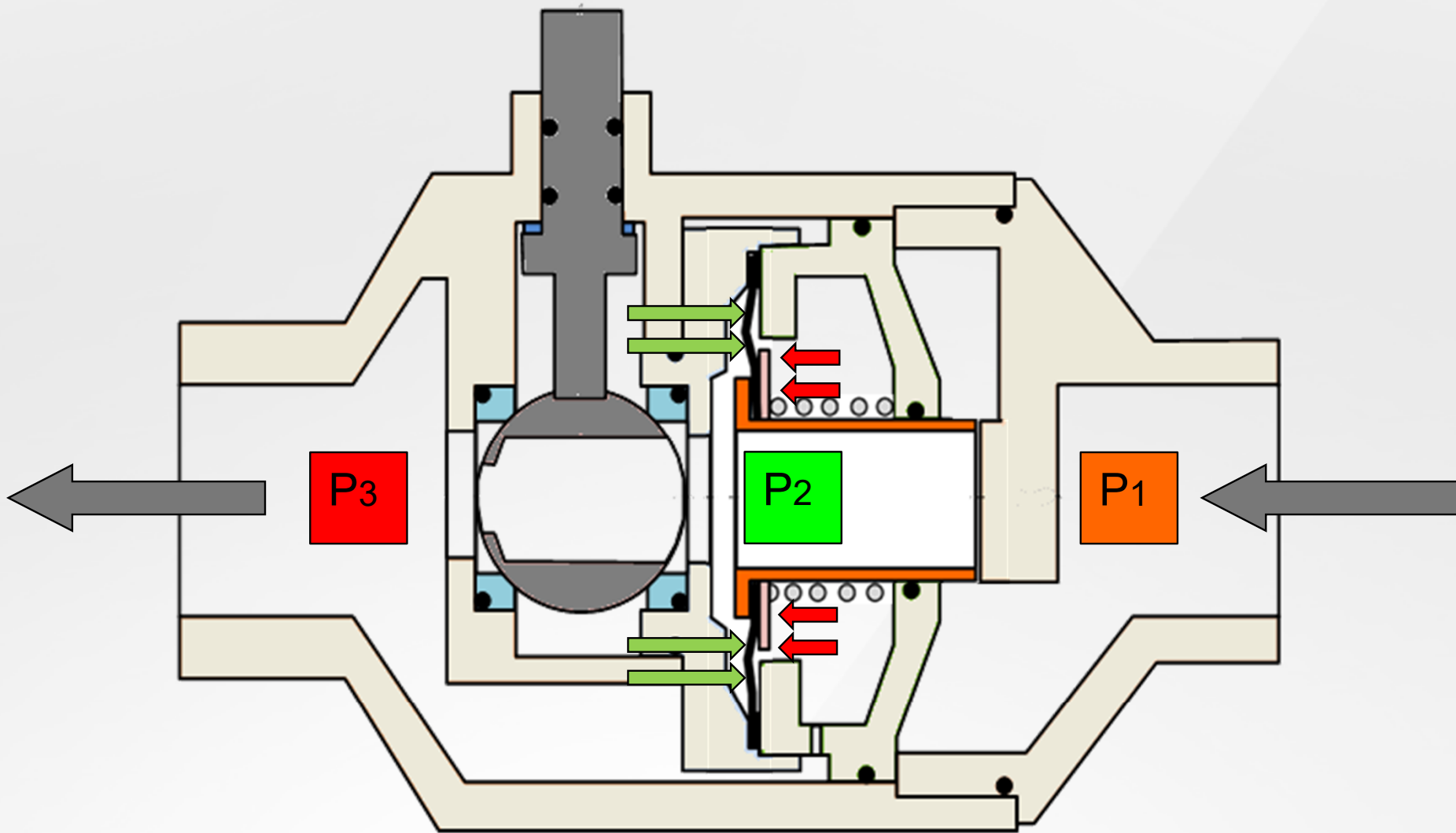
**Pressure Independent Control Valves**



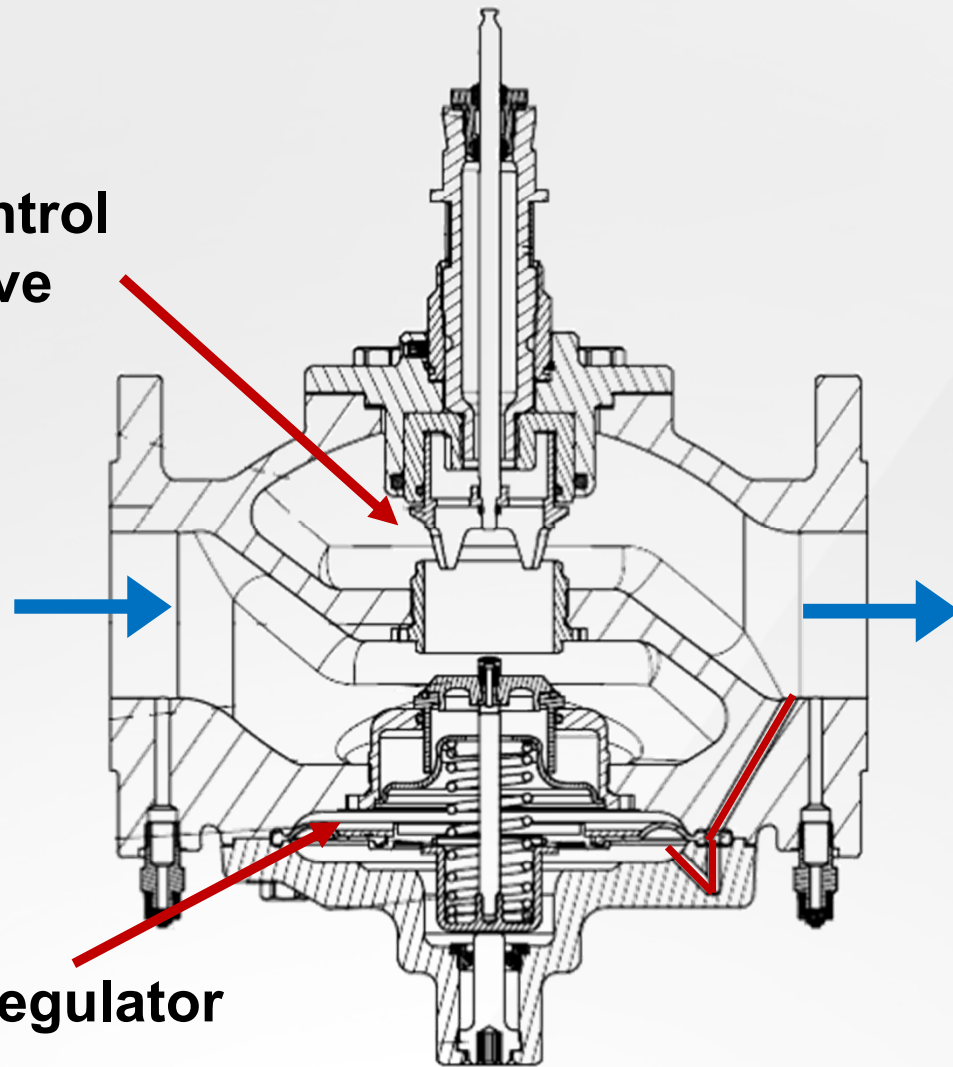
**Dynamic  
Balancing**



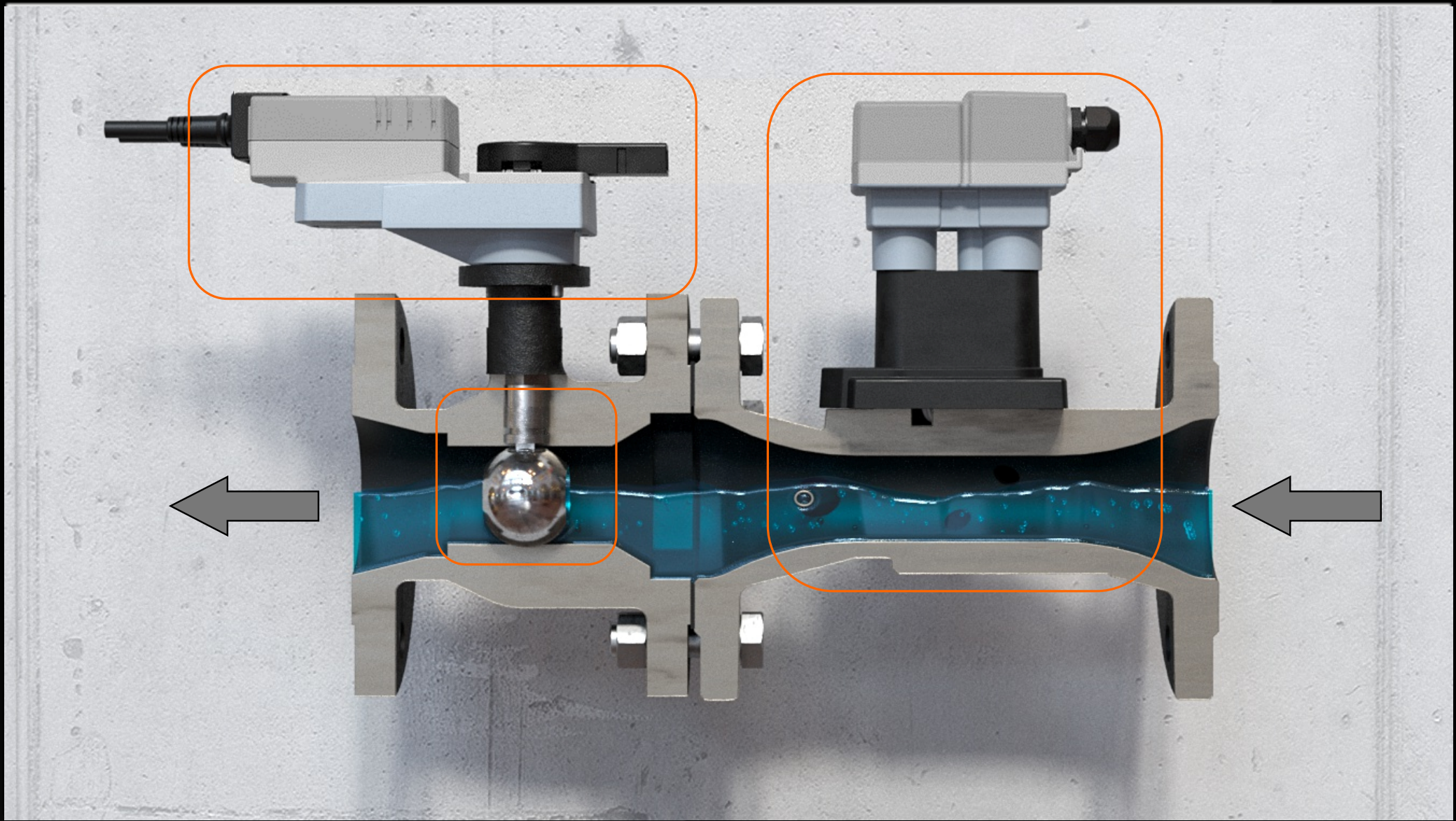


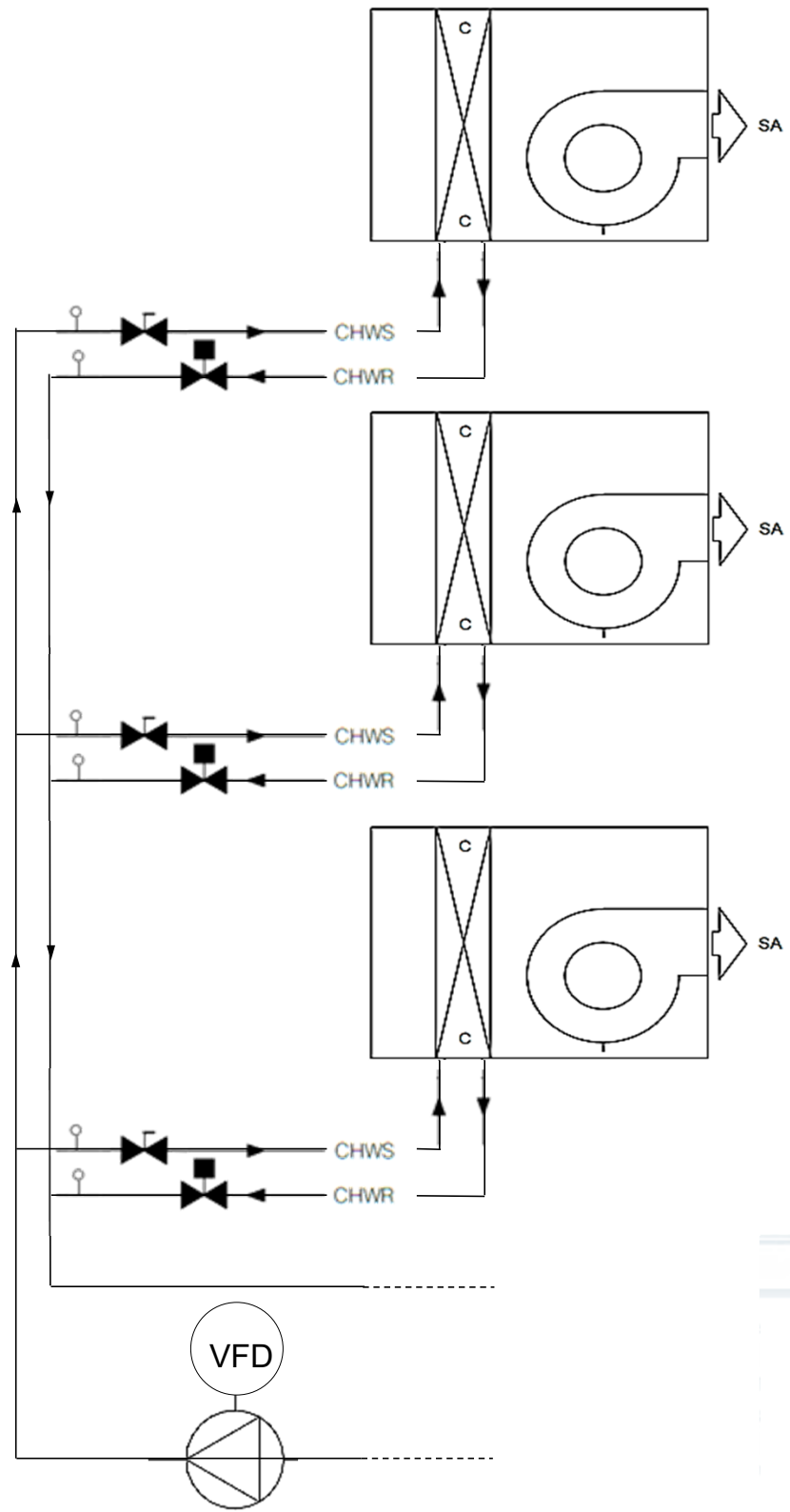


**Control Valve**



**Regulator**





Other Zones Over-Pressurize

$\Delta P =$   
~~10 psi~~ 15 PSI

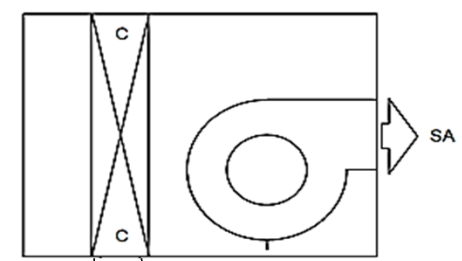
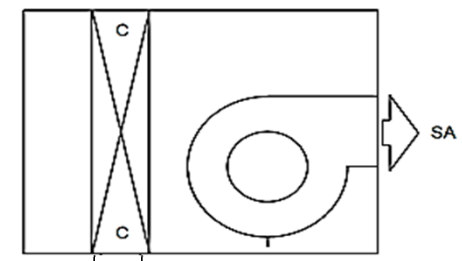
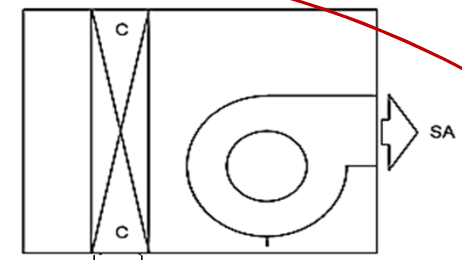
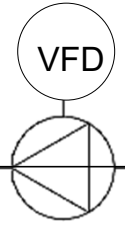
$\Delta P =$   
~~15 psi~~ 20 PSI

$\Delta P$  goes to 0

$\Delta P =$   
~~20 psi~~

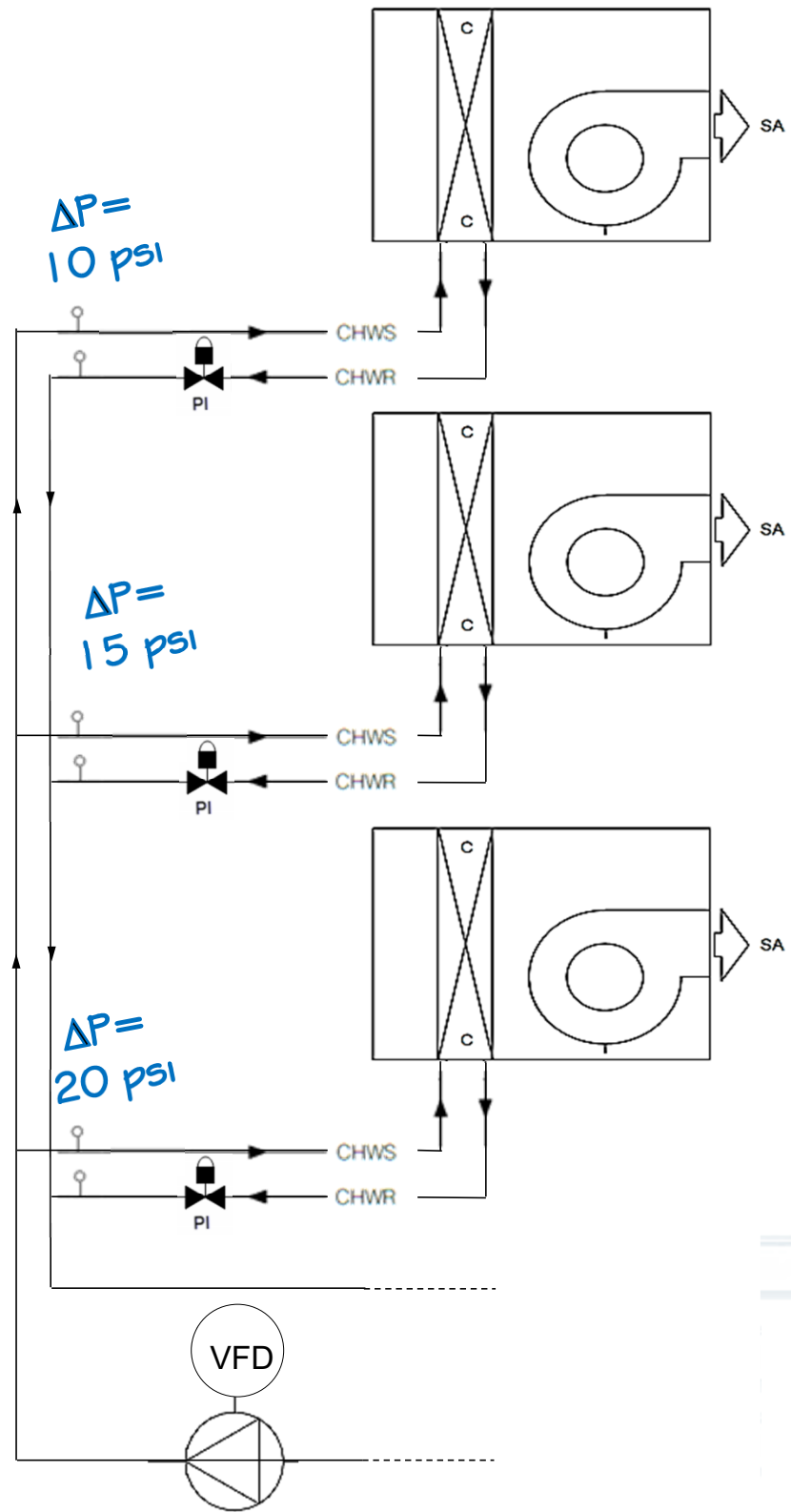
Valve closes

VFD Modulates

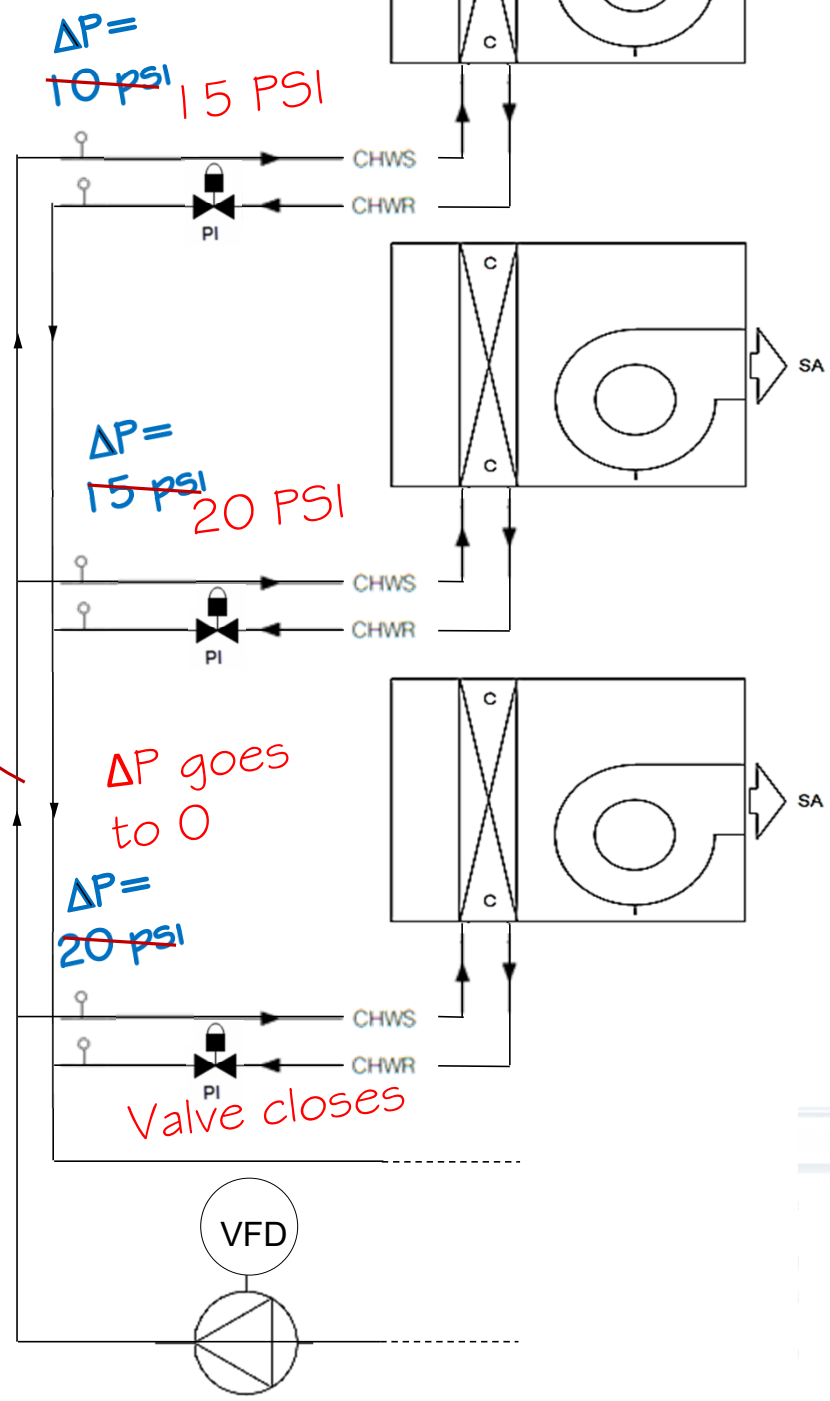


DAT disrupted





Other Zones Over-Pressurize



Coil flow unaffected



# Potential Solutions

**Delta T Management - Smart Valves**



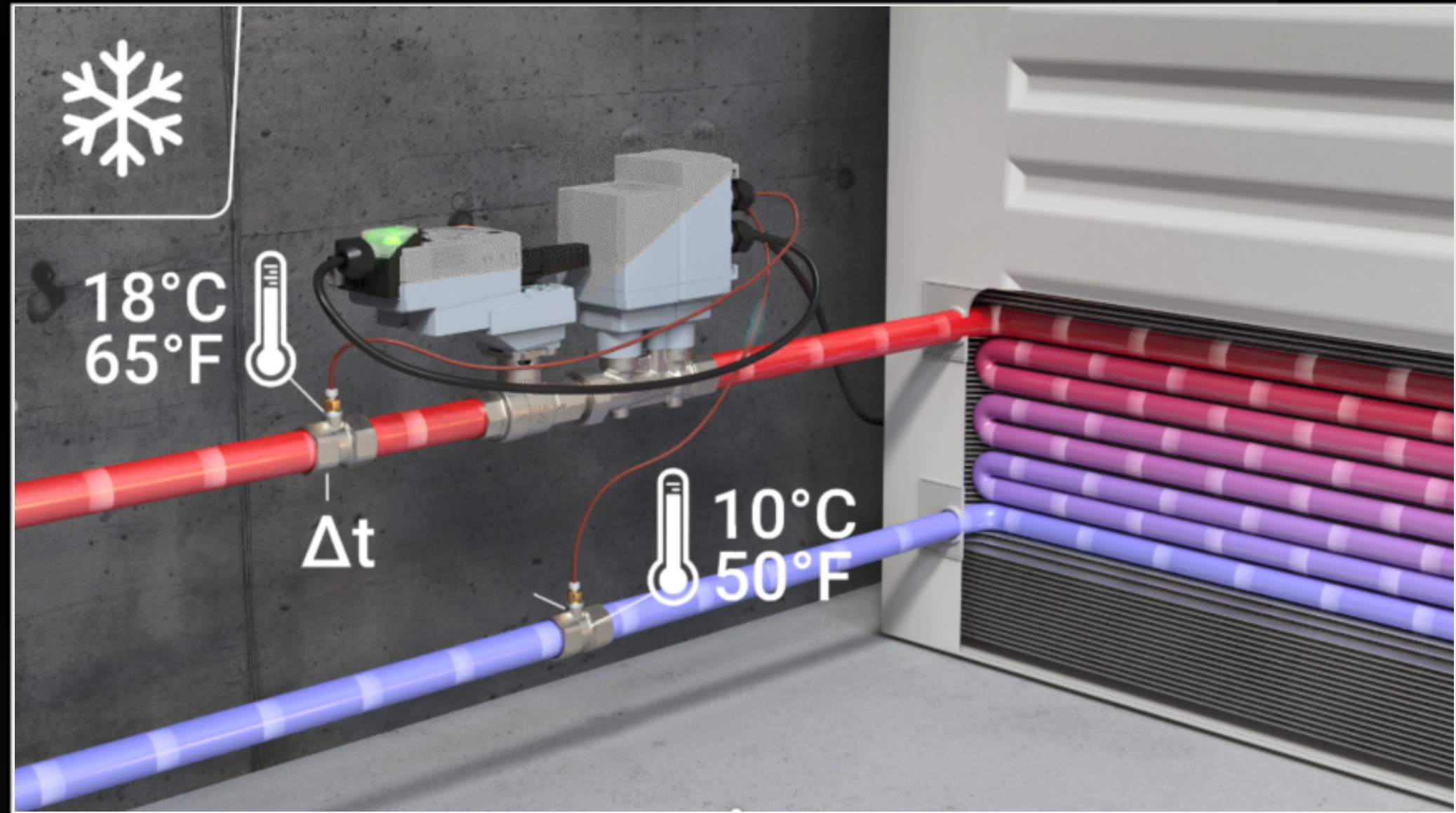
18°C  
65°F

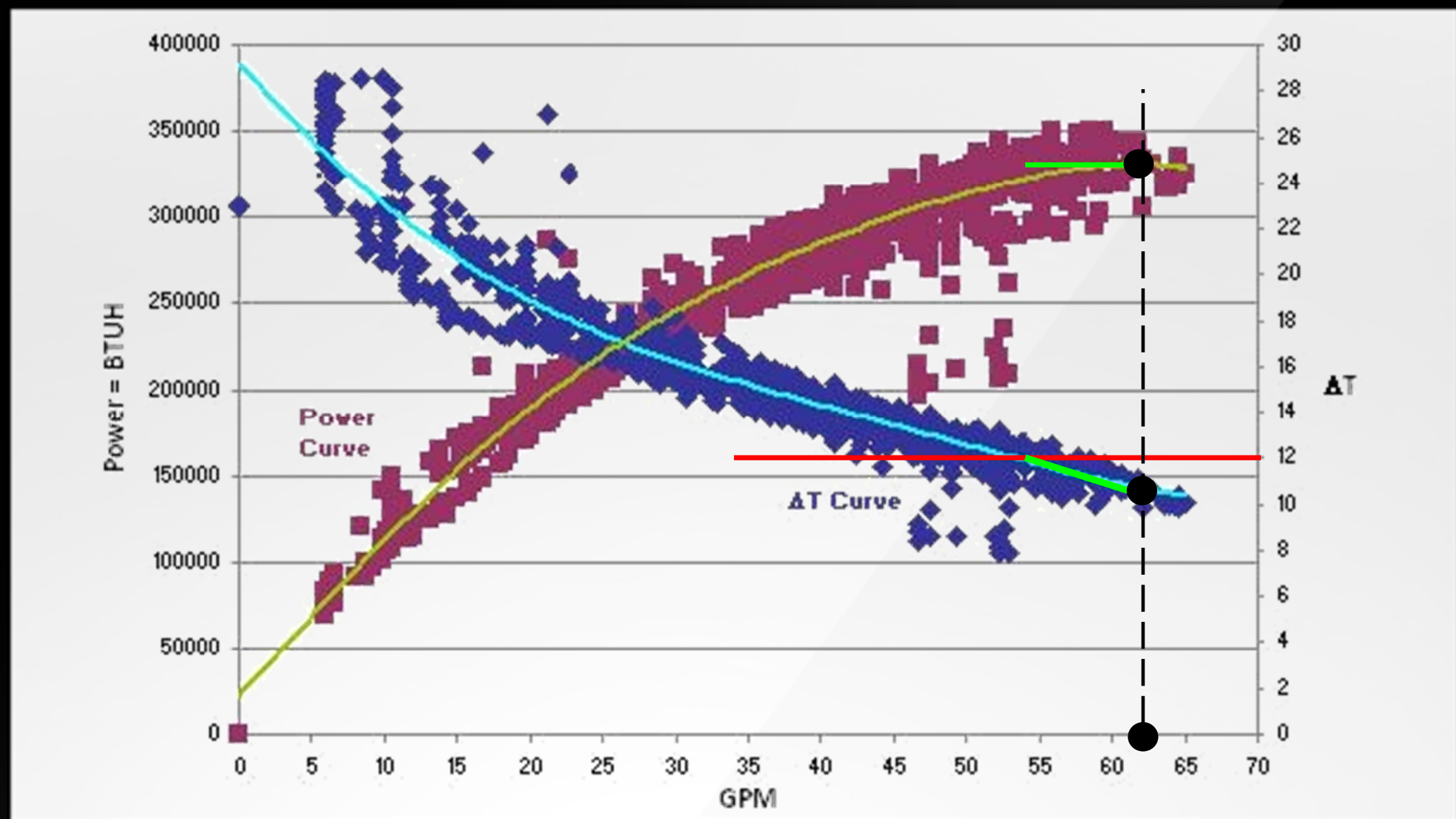


$\Delta t$

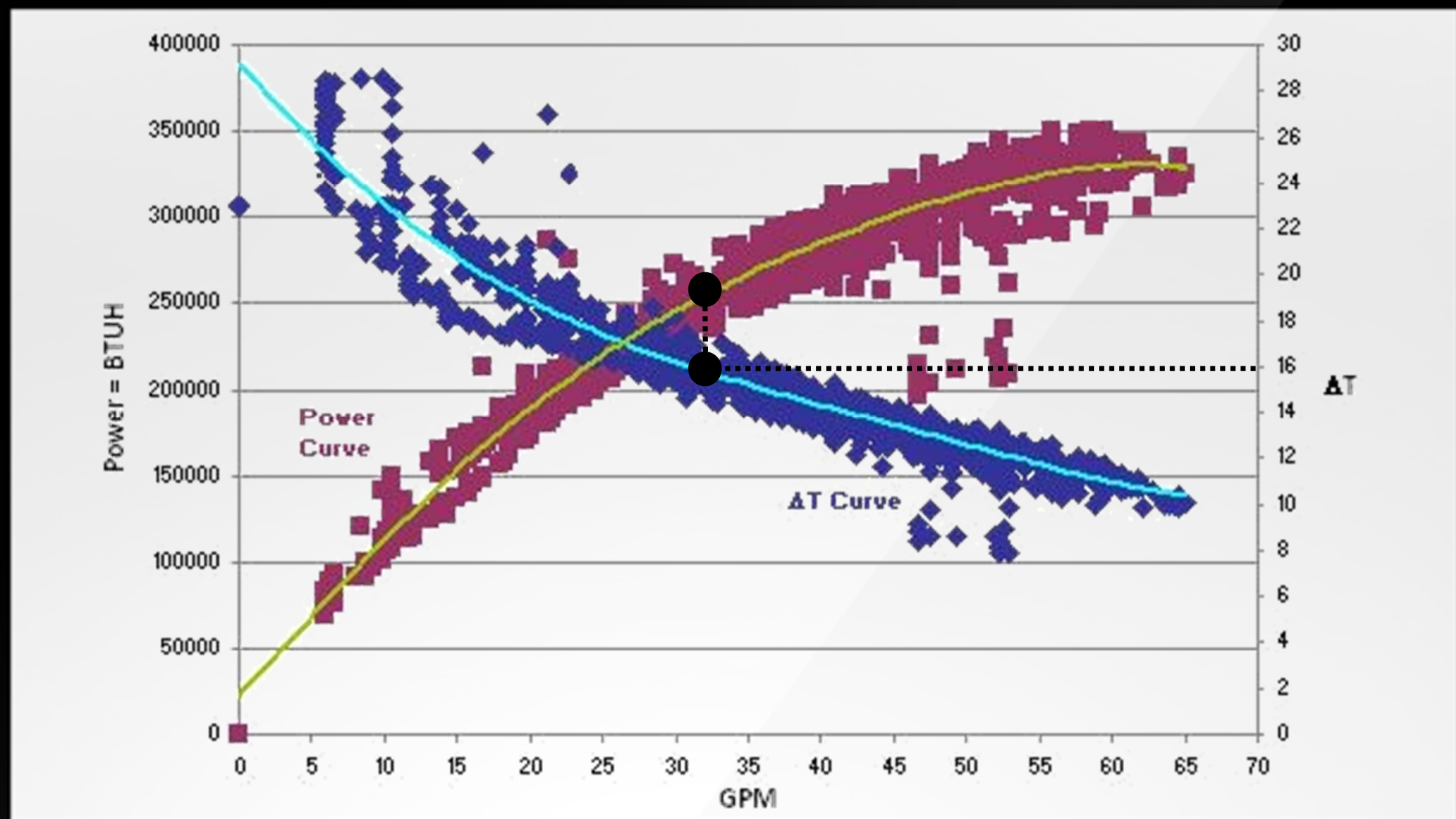


10°C  
50°F



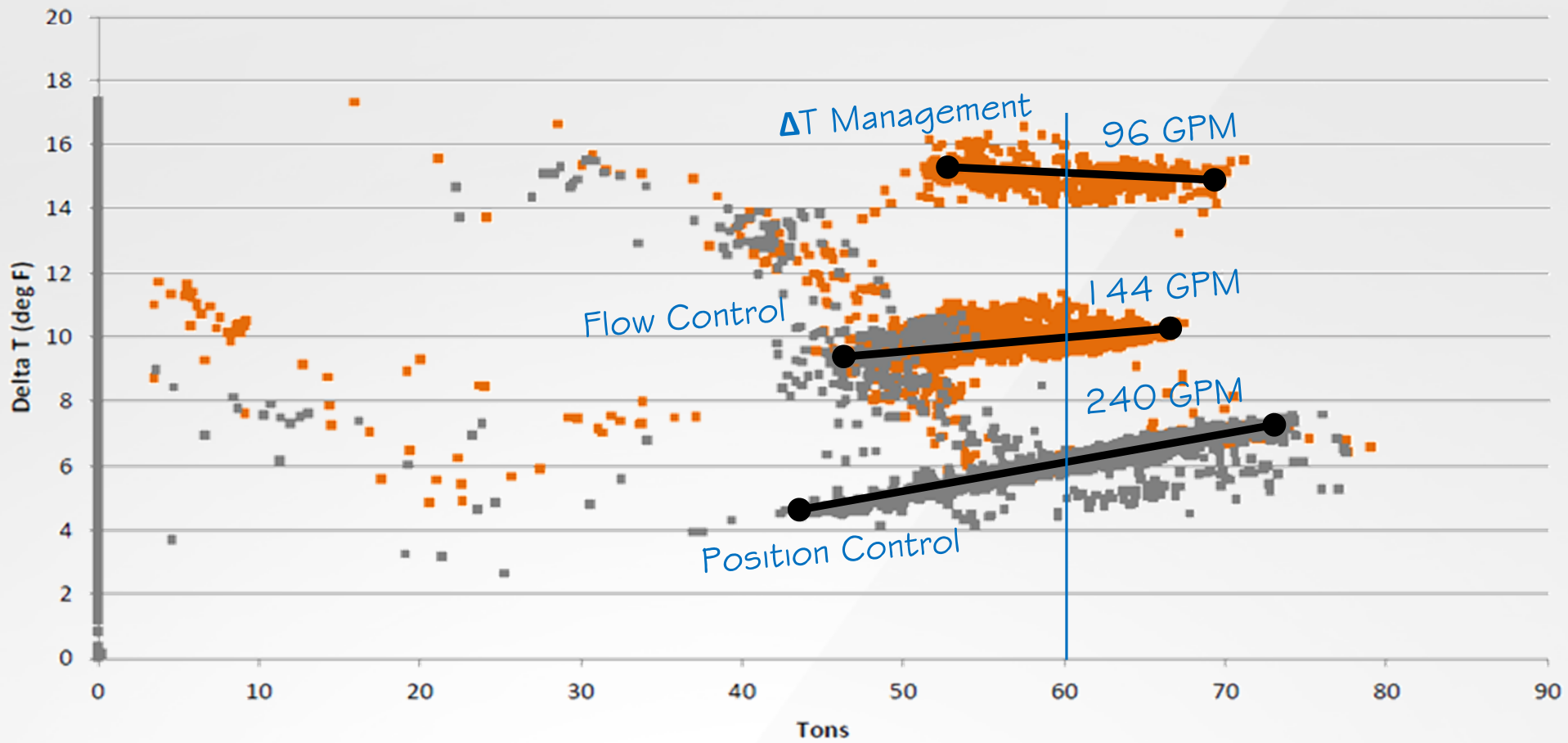


Delta T Management



# Delta T vs. Tons - B500 AHU3

■ Smarts On ■ Smarts Off



## Key Takeaways:

1. **Even the best designed buildings are oversized most of the year**
2. **Balancing Valves and Automatic Circuit Setters are static devices only offering value at “design” conditions.**
3. **PI Valves create Dynamically Balanced Systems and Hydronically Isolated Loops**
4. **Delta T Management can optimize water usage during heat exchange**

