

Hydronic Loop Performance: Design vs. Installed

**Why design and modeling data don't always
match a building's actual performance**

David Kandel



**Rocky Mountain ASHRAE
November 6, 2013**

Agenda

Hydronic Loop Performance: Design vs. Installed

- **Design and Modeling Assumptions & Coil Behavior**
 - **Performance Problems**
 - Valve Sizing
 - Valve Authority
 - Coil Performance
 - **Potential Solutions**
-

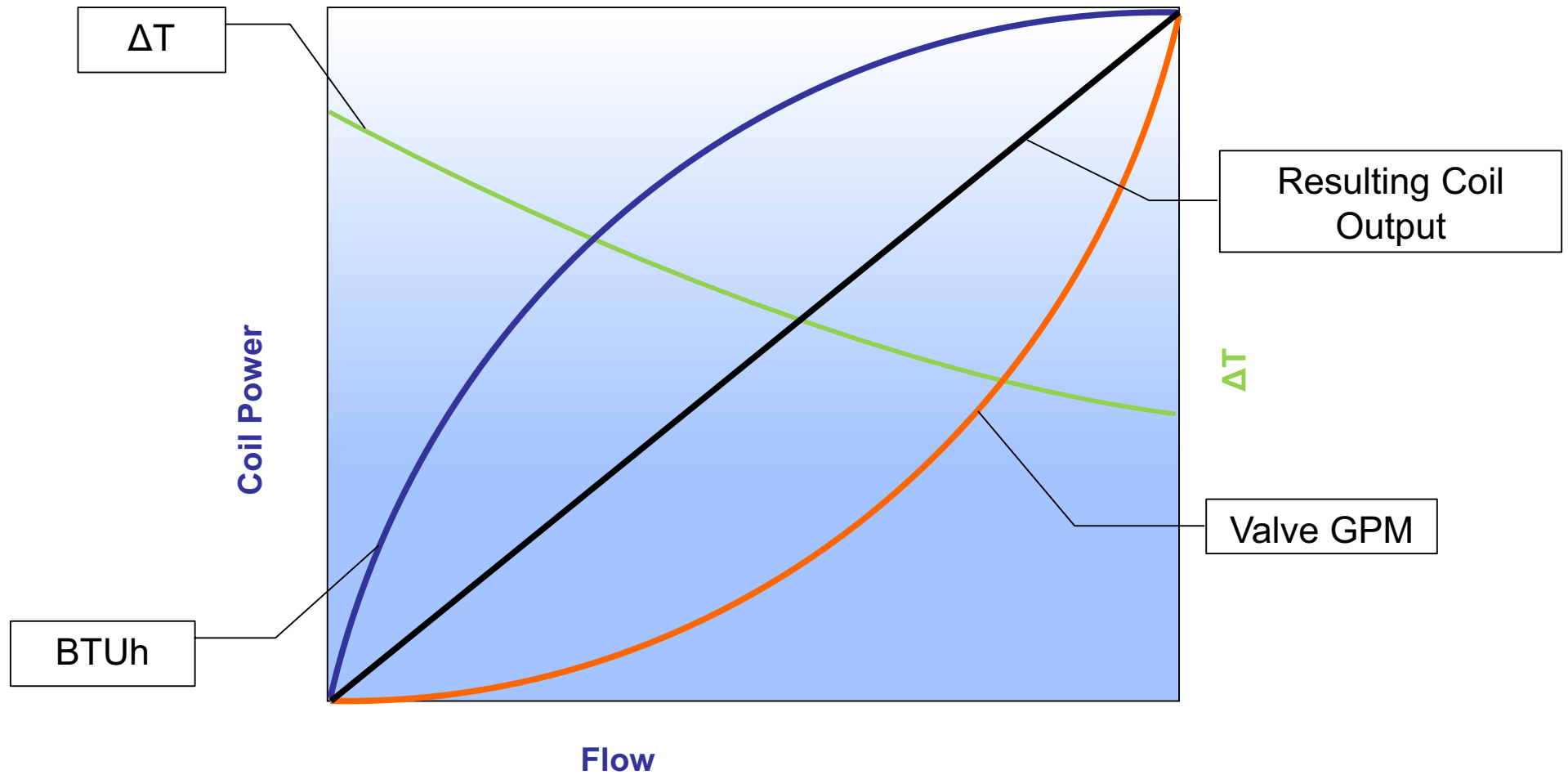
Valve Specs

- **Design / Modeling Assumptions**
 - Proper Valve Sizing
 - Stable System Pressures
 - Perfect Valve Authority



Valve / Coil Performance

Coil Performance



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Hydronic Valve Sizing

$$C_v = \frac{\text{gpm}}{\sqrt{\Delta P}} = \frac{250}{\sqrt{4}} = \frac{250}{2} = 125$$

Example:

- **Coil Requires 250 GPM**
 - **Design ΔP for valve, 4 psi**
 - **ΔP of Valve not to exceed 5 psi**
-

Hydronic Valve Sizing

C_v	Inches	2-way Flanged
65	2½	G665
90	3	G680
170	4	G6100
263	5	G6125C
344	6	G6150C

$$C_v = \frac{250}{\sqrt{4}} = \frac{250}{2} = 125$$

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Hydronic Valve Sizing

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

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Hydronic Valve Sizing

Checking ΔP

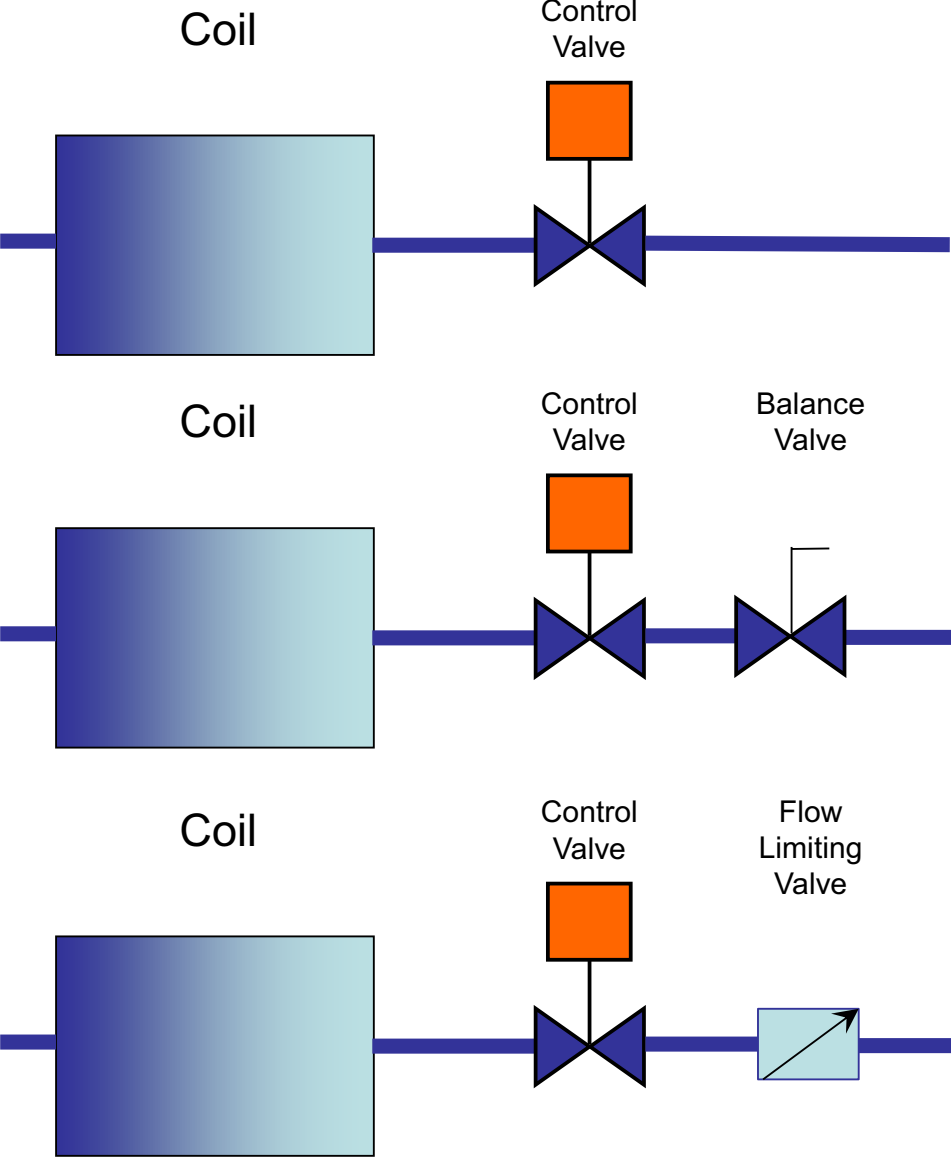
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$$\Delta P = \left(\frac{\text{GPM}}{C_v} \right)^2$$

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

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

Piping Options



No Balancing Device

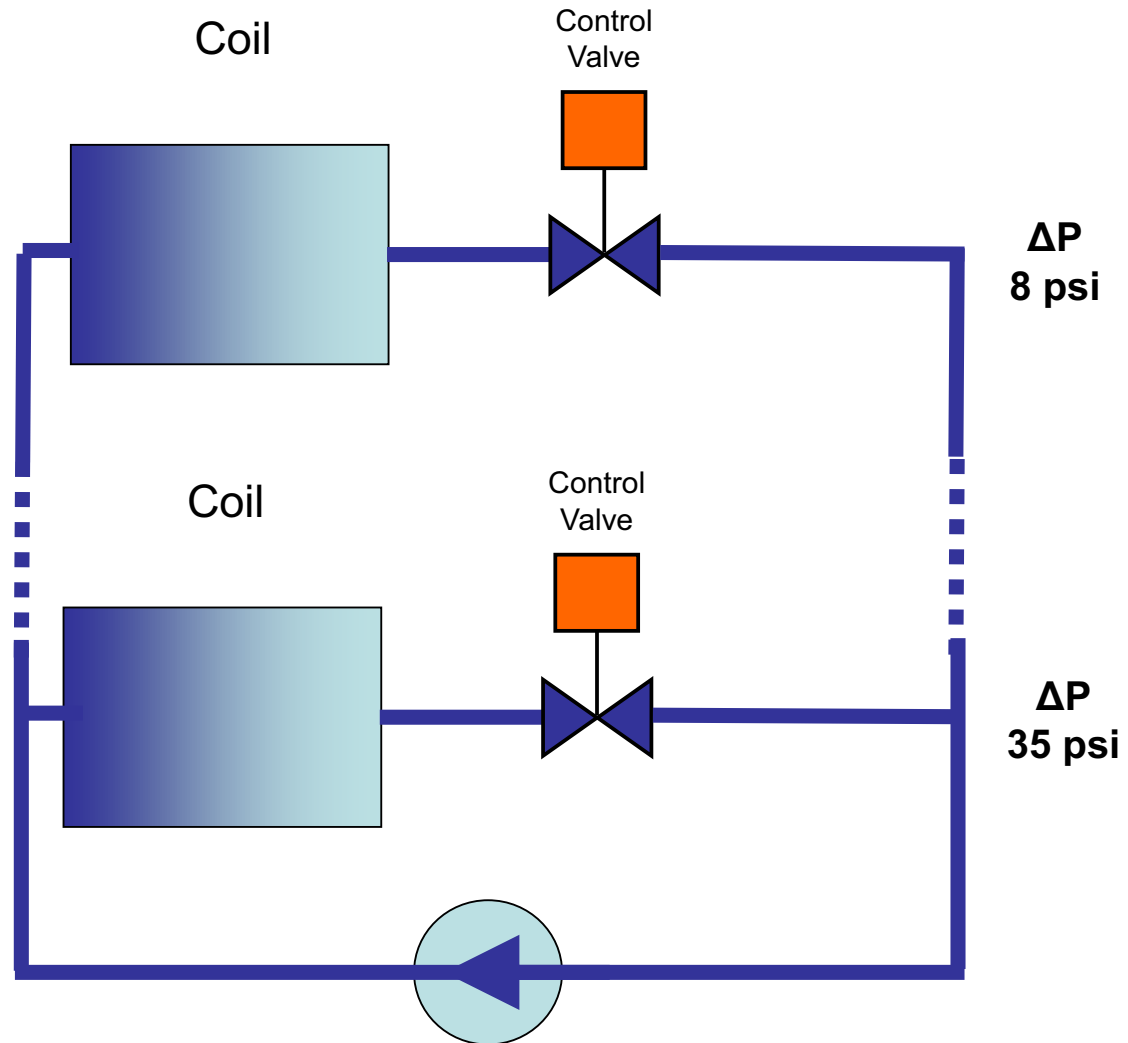
Oversized Control Valves

Far From Pump:

- Oversized Valve cause overflow
- No Protection from pressure changes

Near Pump:

- High ΔP causes massive overflow



Traditional Balancing Valve

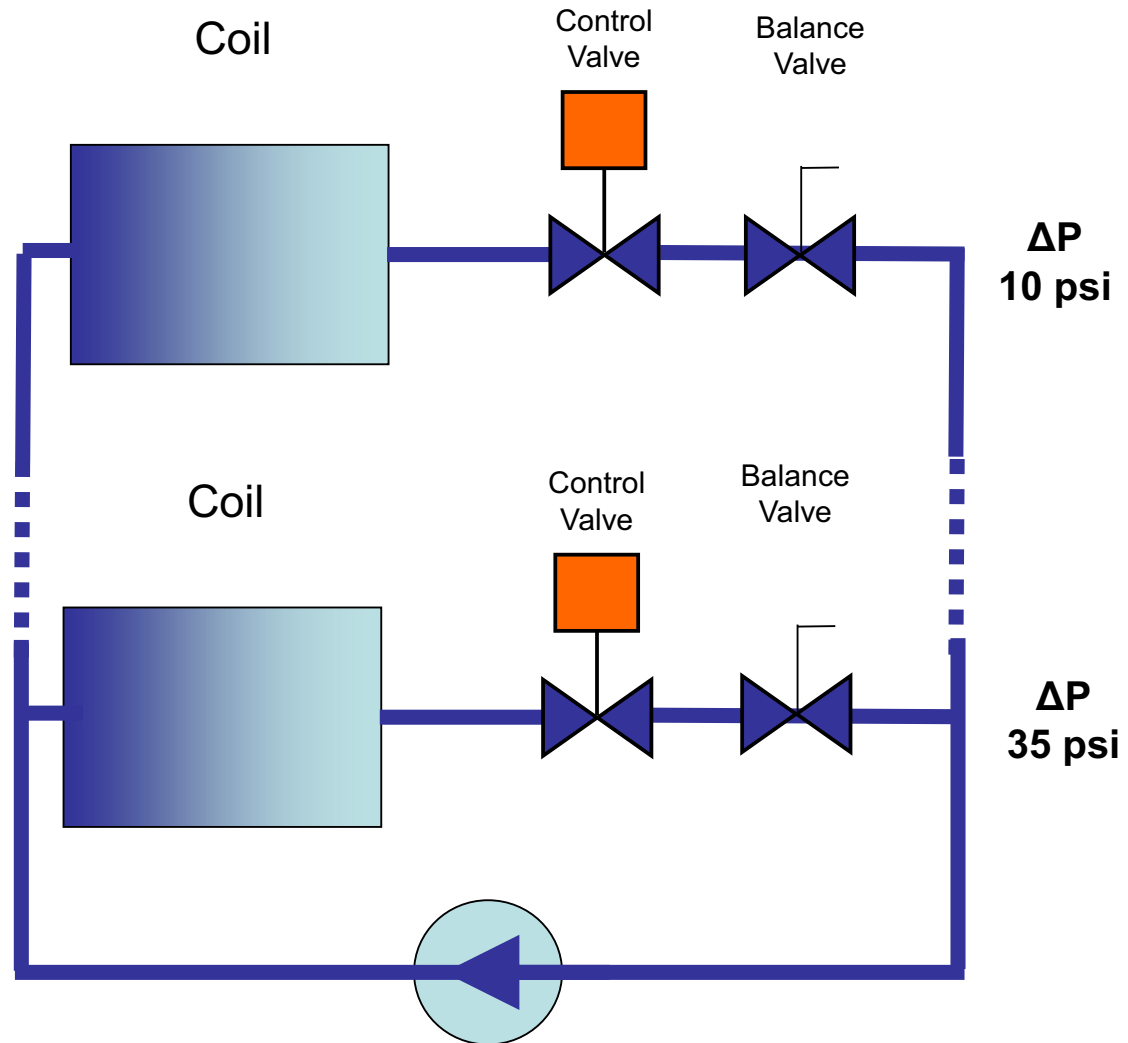
Oversized Control Valves

Far From Pump:

- Minor Valve Authority issues
- No Protection from pressure changes

Near Pump:

- Major Valve Authority issues
- No Protection from pressure changes



Flow Limiting Valve

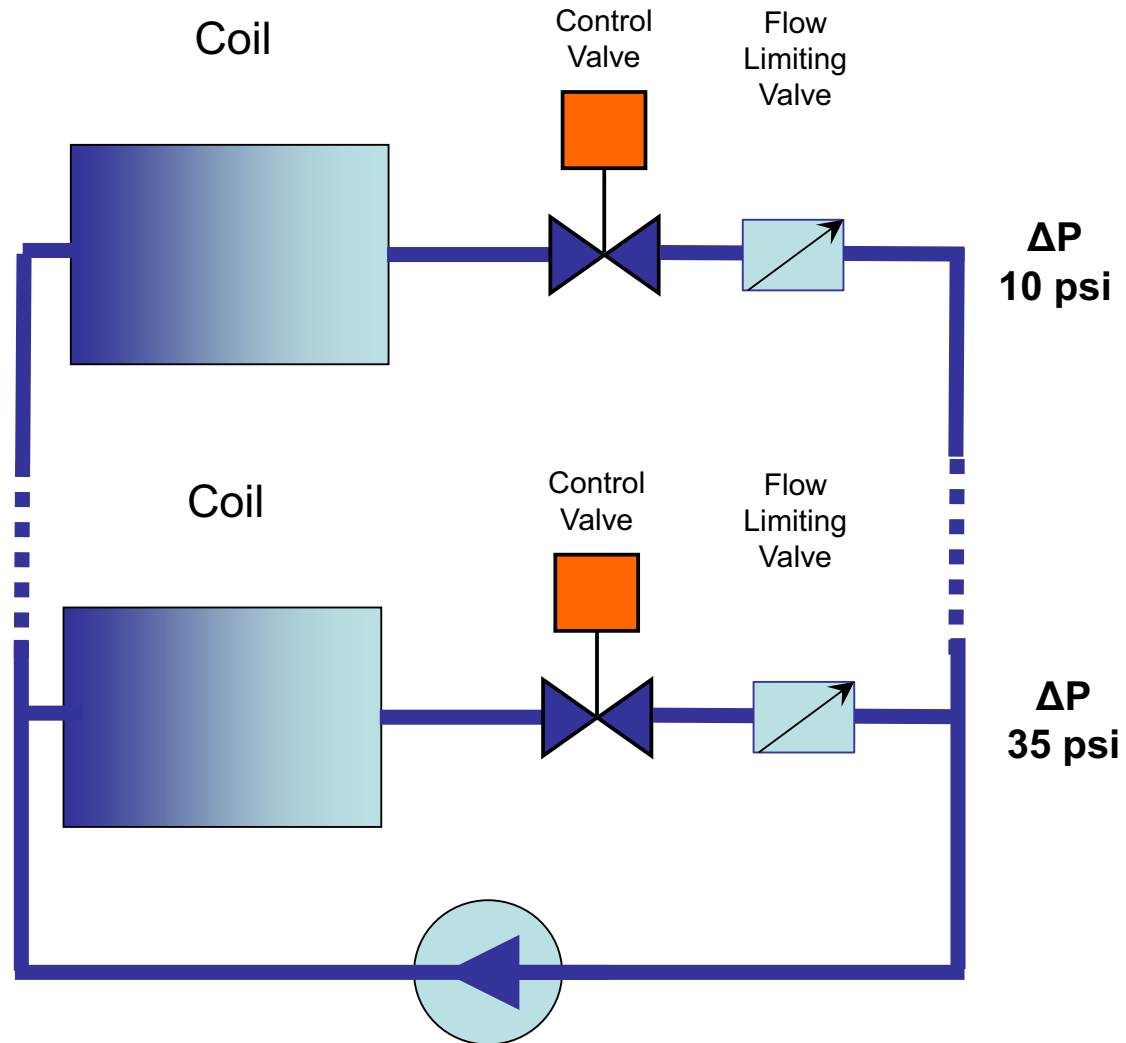
Oversized Control Valves

Far From Pump:

- Minor Valve Authority issues
- No Protection from pressure changes below full flow

Near Pump:

- Major Valve Authority issues
- No Protection from pressure changes below full flow



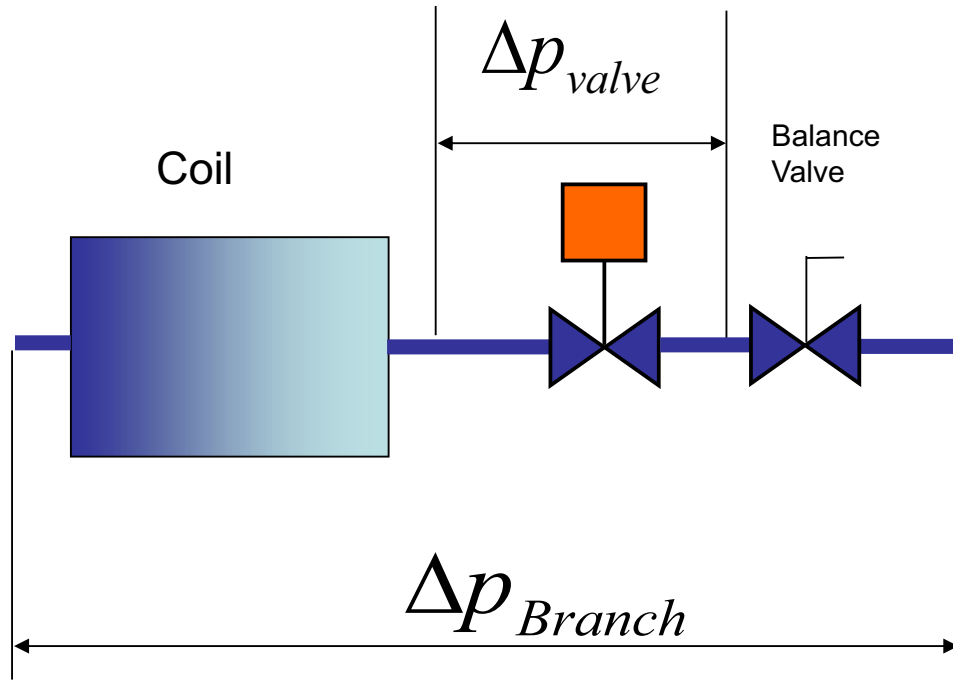
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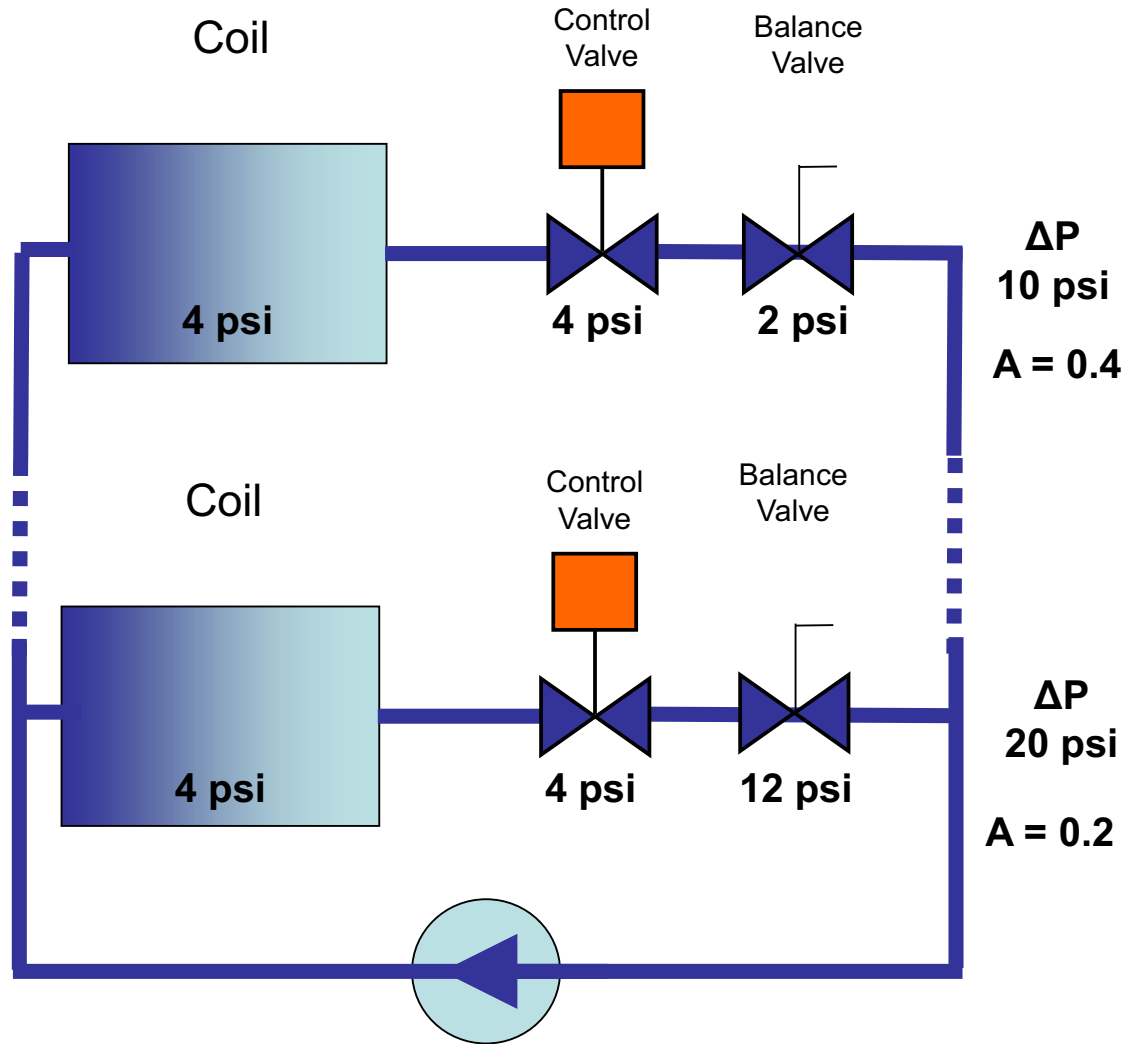
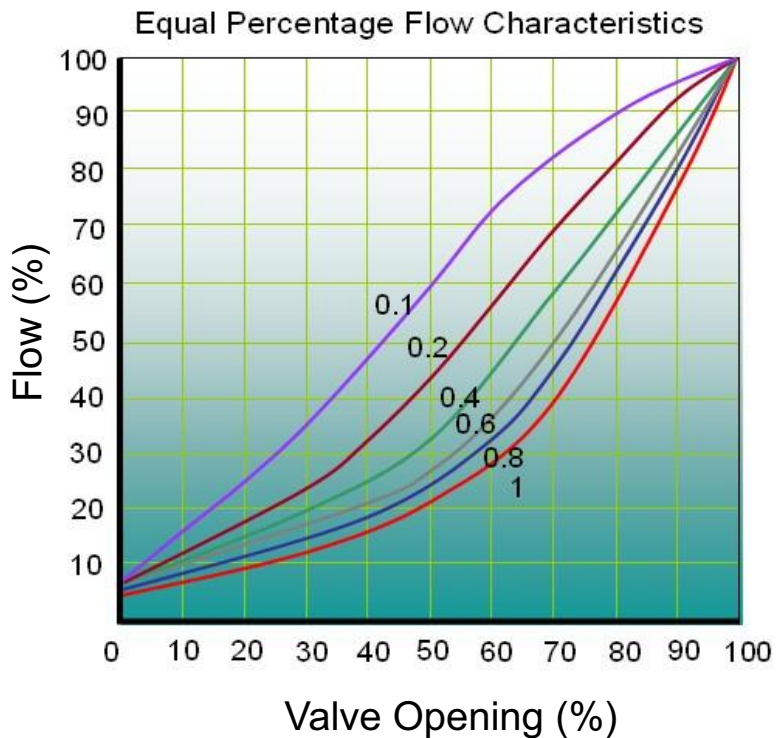
Valve Authority

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



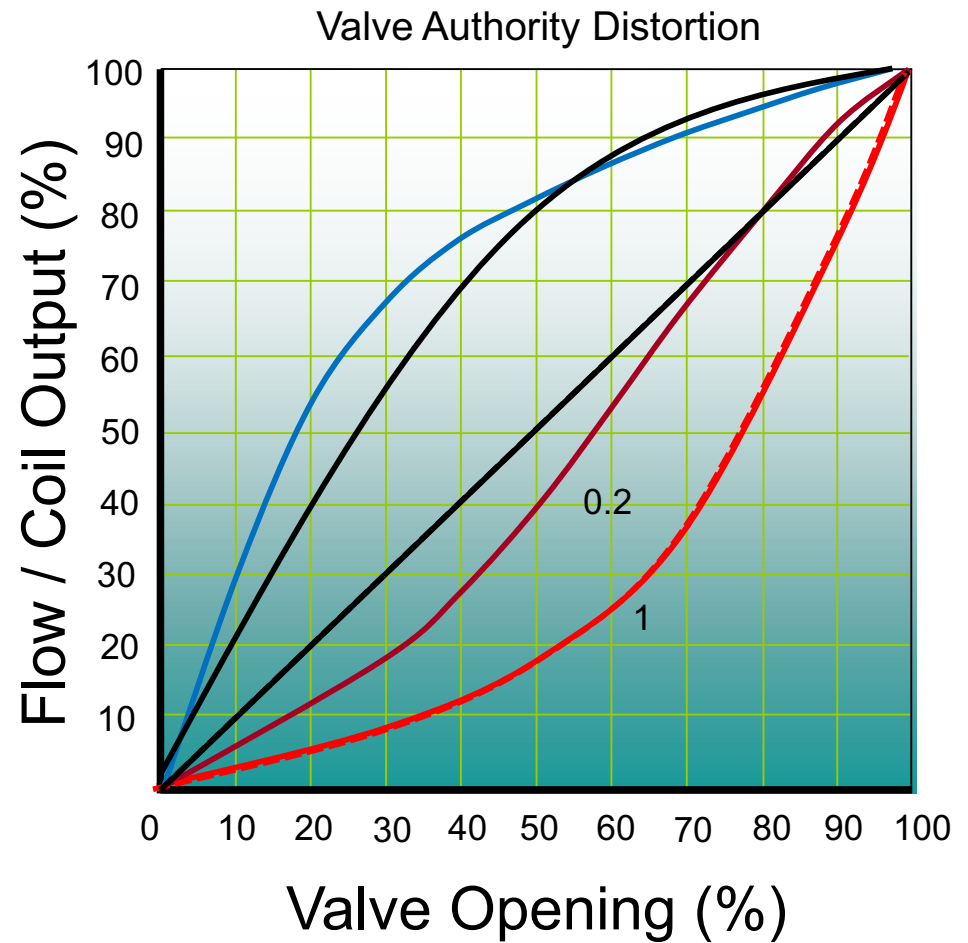
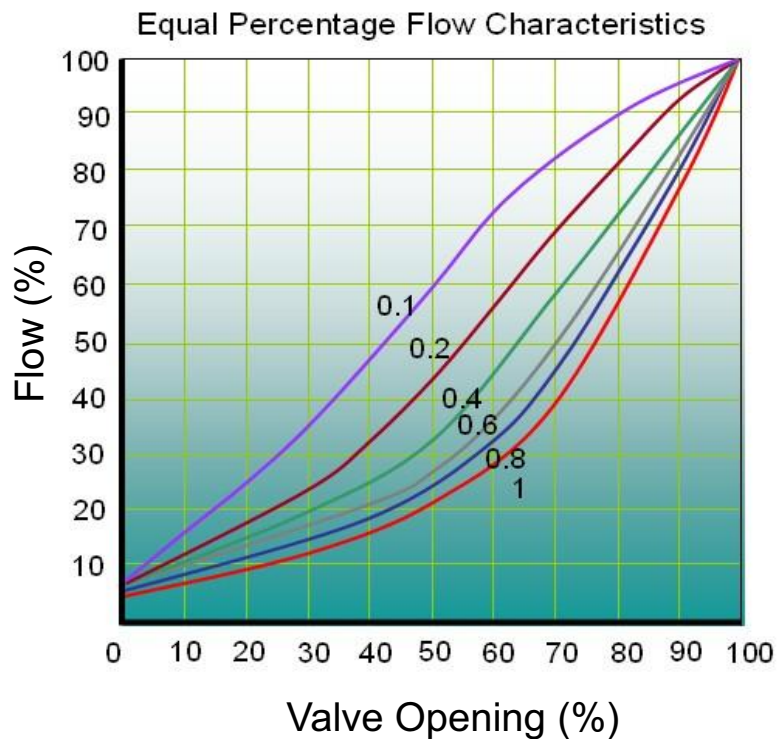
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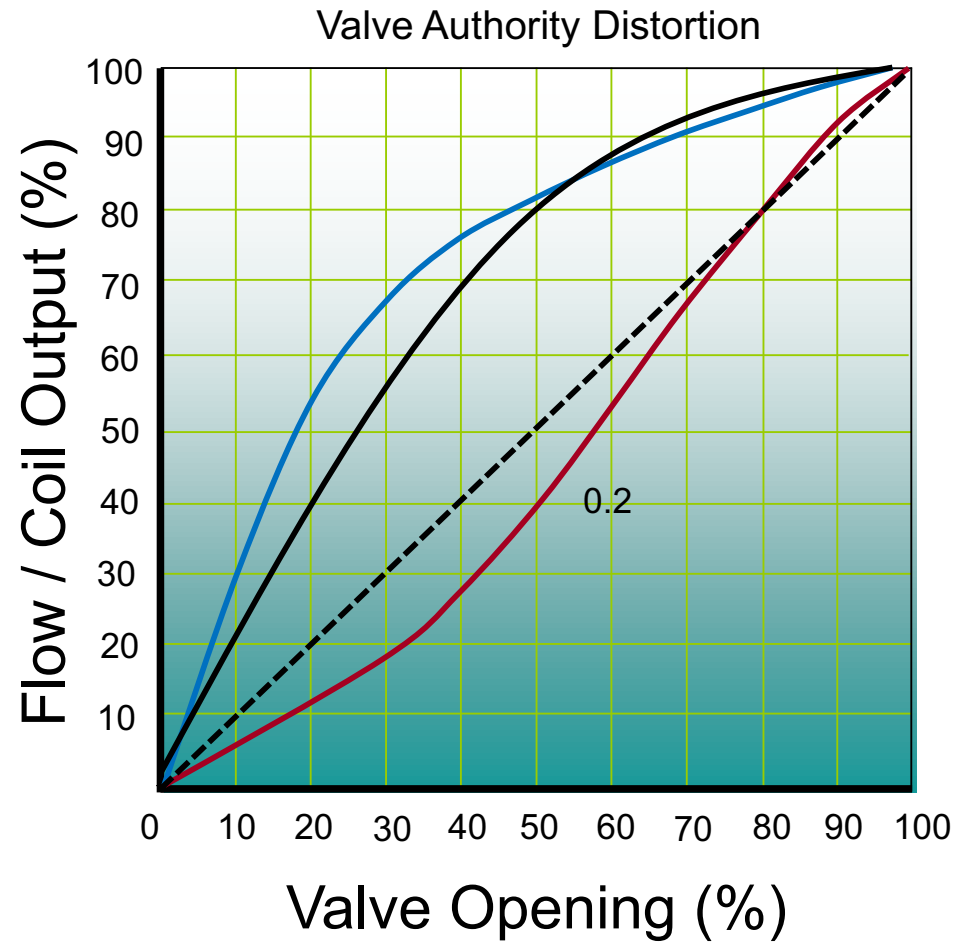
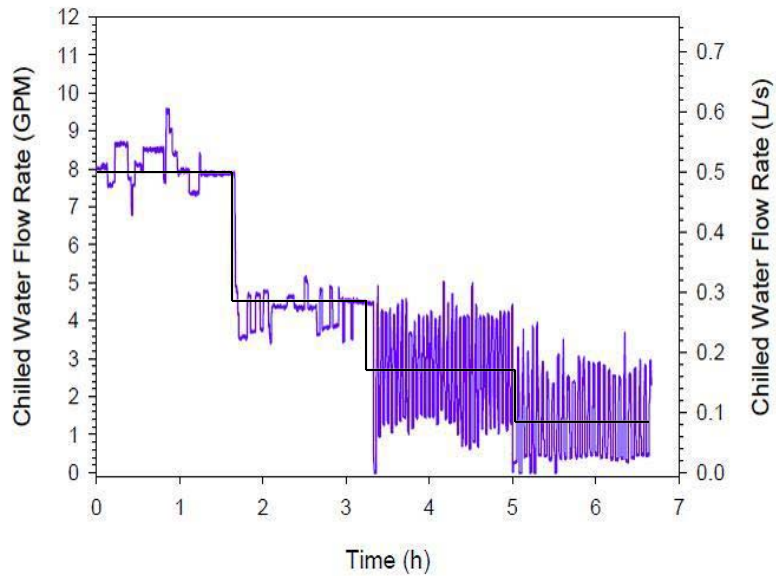


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Valve Authority

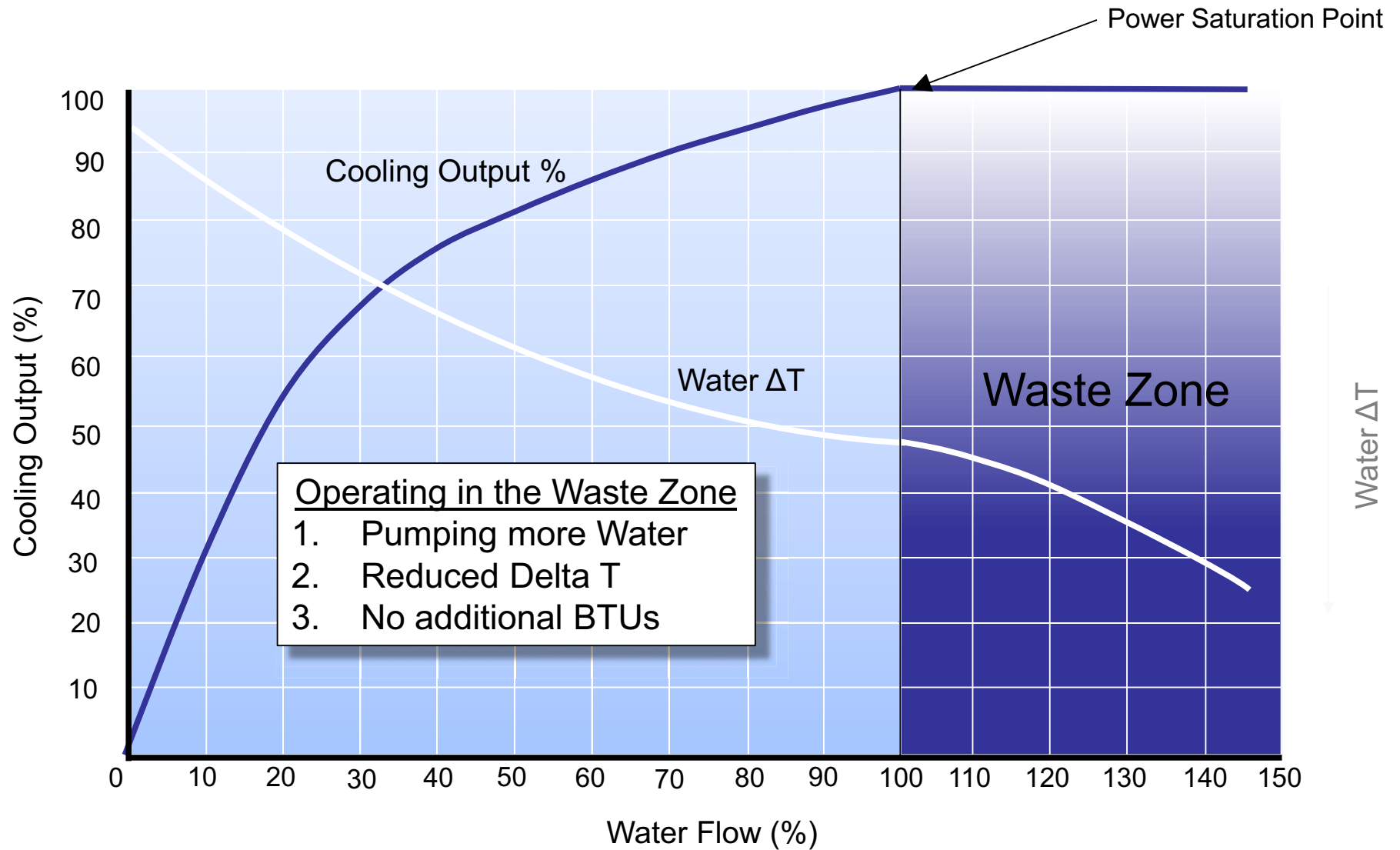


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Understanding Coil Behavior



Coils

Heat Transfer Coefficients

- **Air film coefficient** of sensible heat transfer between air and the external surface of the coil
- **Water film coefficient** of heat transfer between the internal coil surface and the coolant fluid within the coil
- **Unit conductance** of the coil material

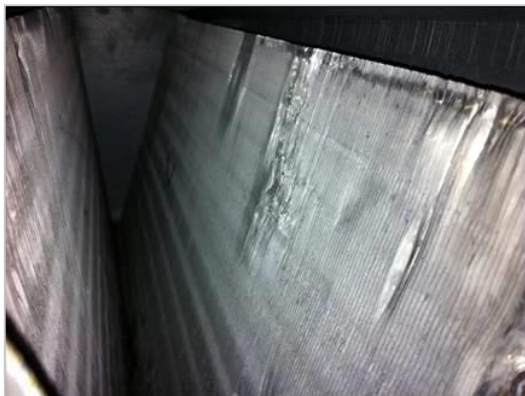
Based on a coil design with a *clean, non-fouled surface*



Coil Degradation

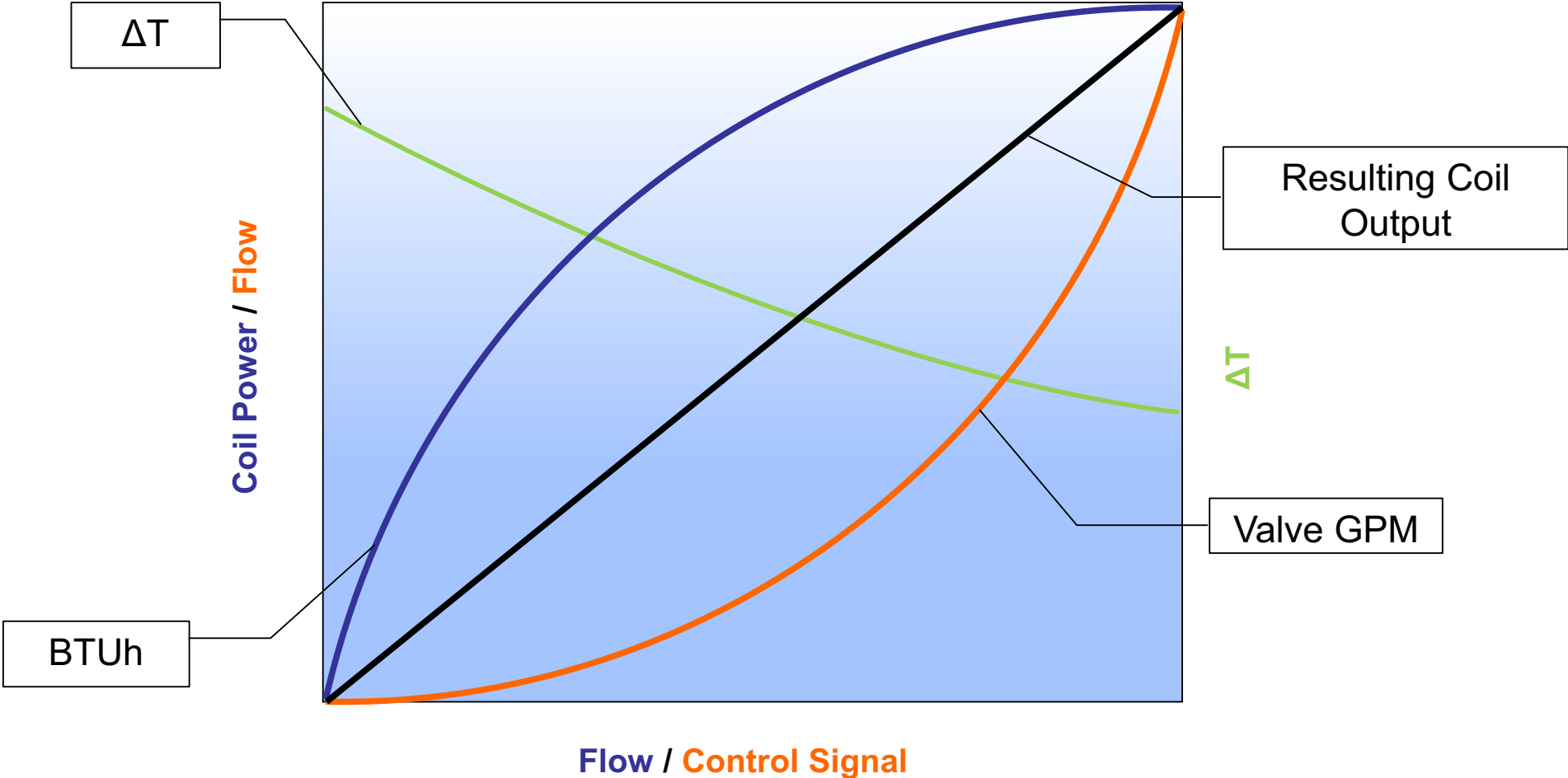
Heat Transfer of Coil Degrades Over Time

- Damage to coil or fins
- Air-side fouling
- Water-side fouling



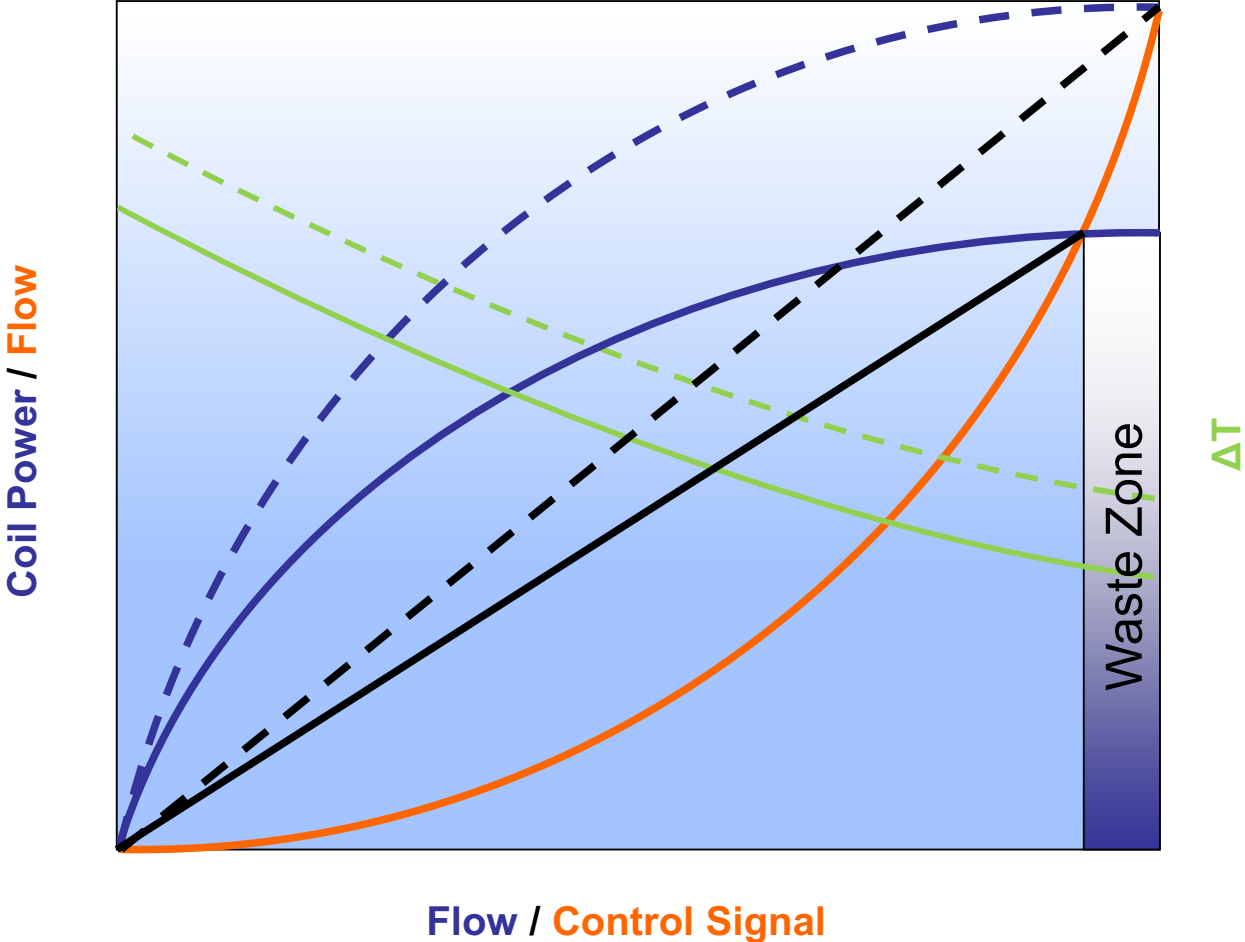
Coil Degradation

Coil Performance



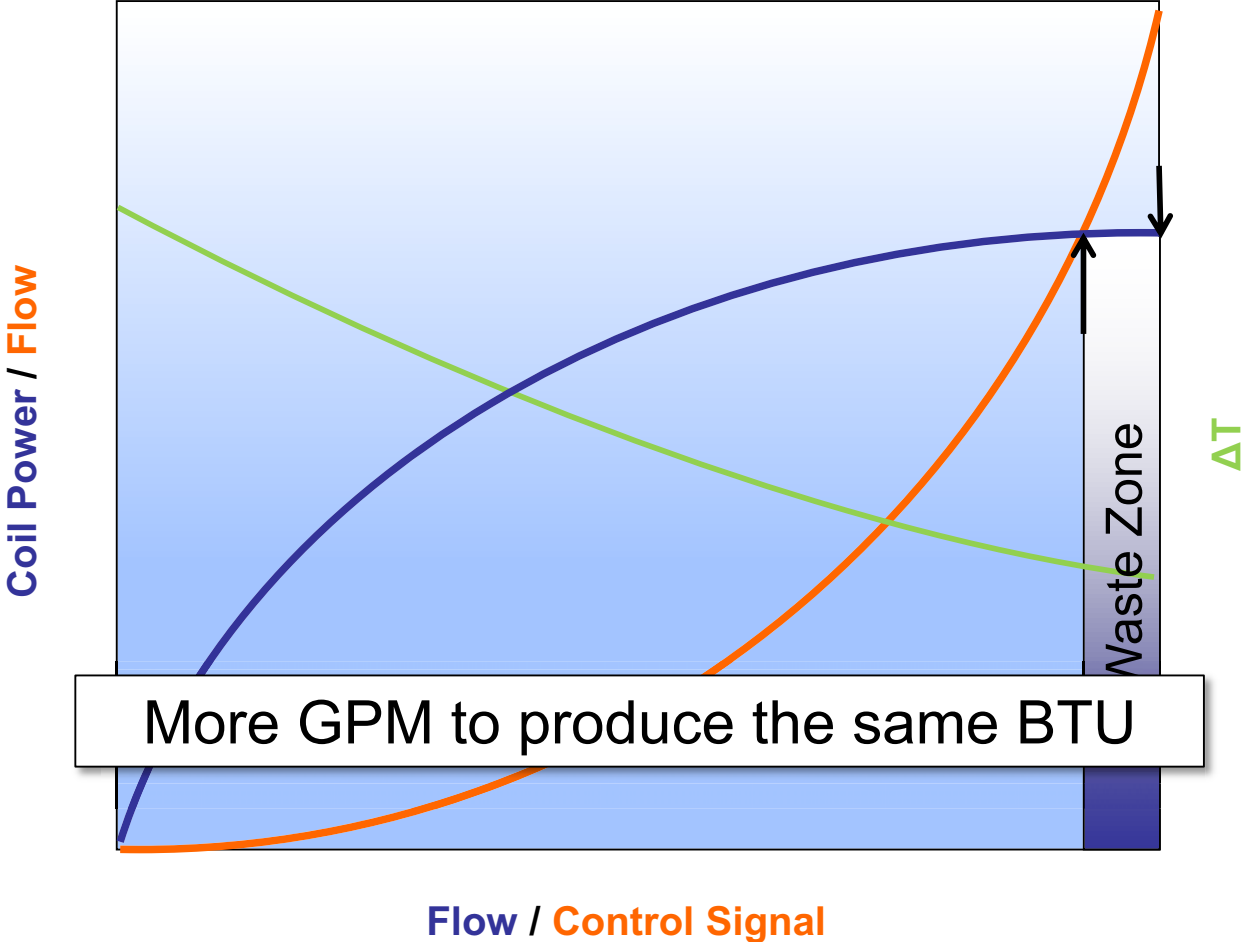
Coil Degradation

Coil Performance



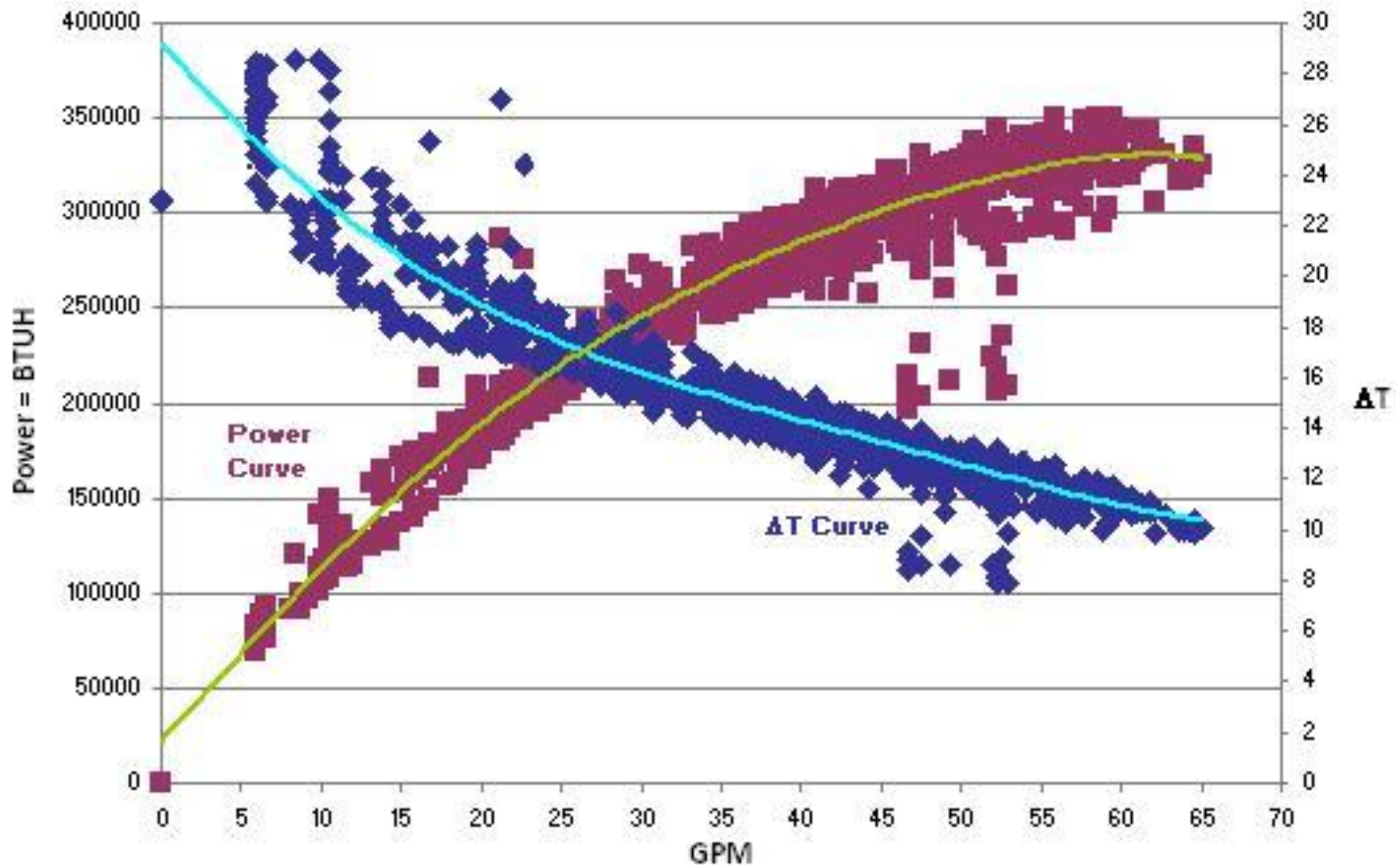
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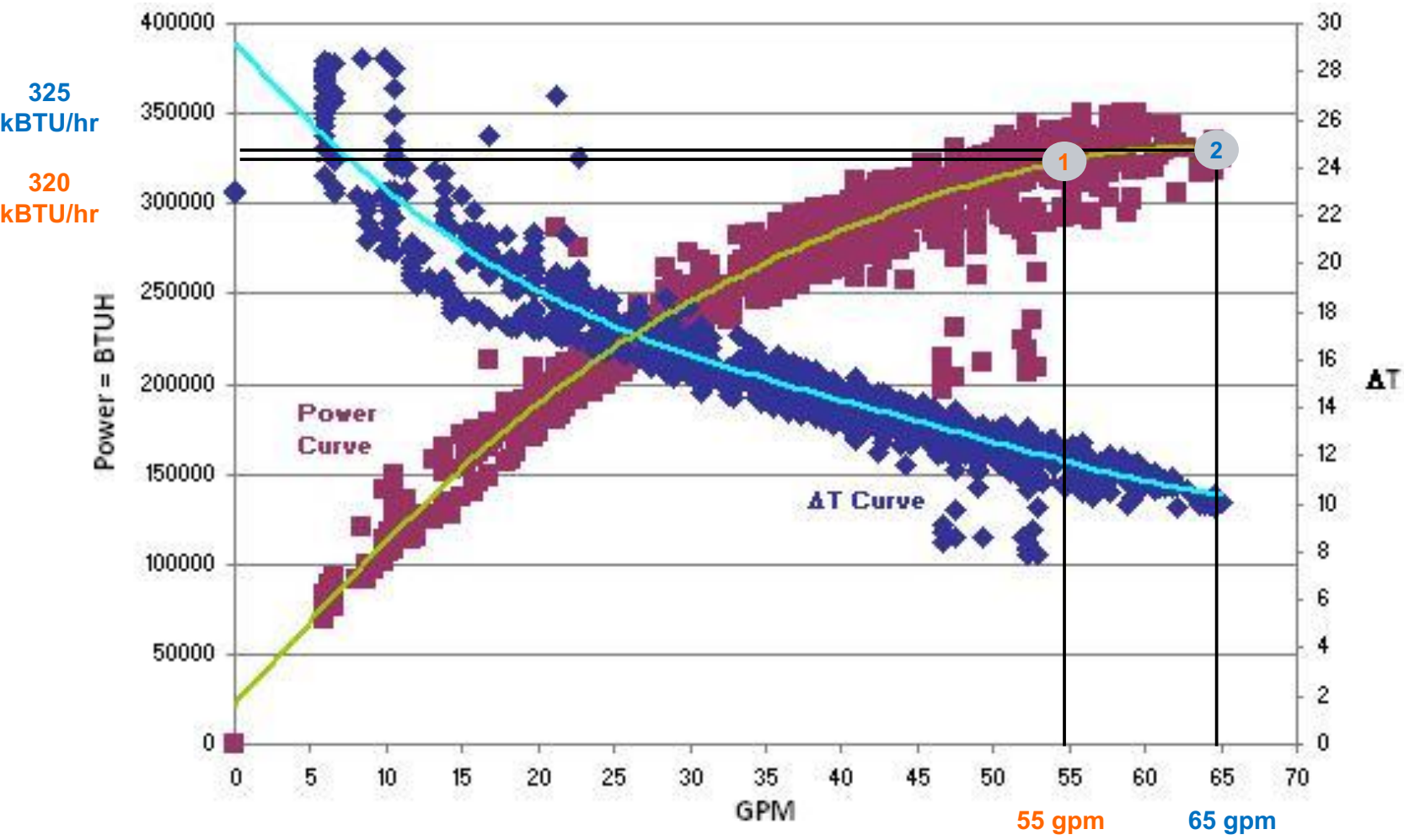
Coil Degradation

Cost of Operating in the Waste Zone



Coil Degradation

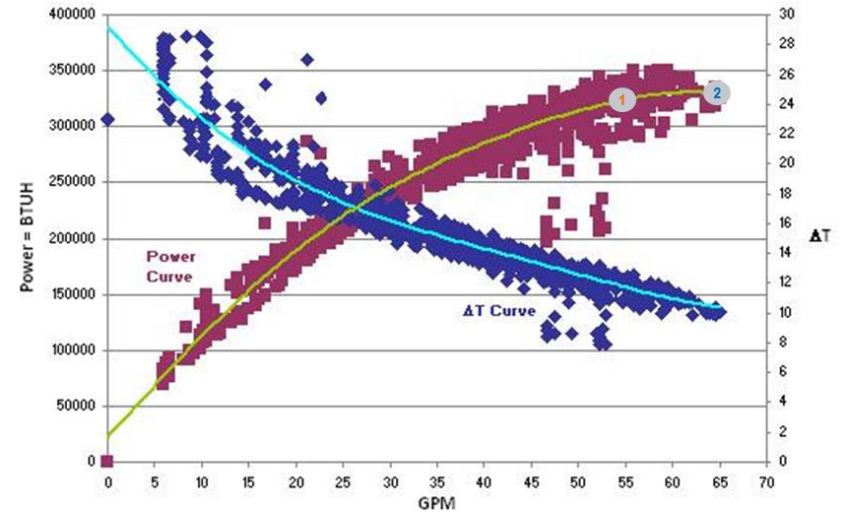
Cost of Operating in the Waste Zone



Coil Degradation

Cost of Operating in the Waste Zone

	1	2	Δ
BTUh	320,000	325,000	1.6%
GPM	55 GPM	65 GPM	18%
Pump hp	Hp increase = $(65/55)^3$		65%



$$\frac{HP_2}{HP_1} = \frac{GPM_2}{GPM_1}$$

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 - Pressure Independent Valves
 - Delta T Limiting
 - Direct BTU Control
-

Pressure Independent Valves

Better Performance

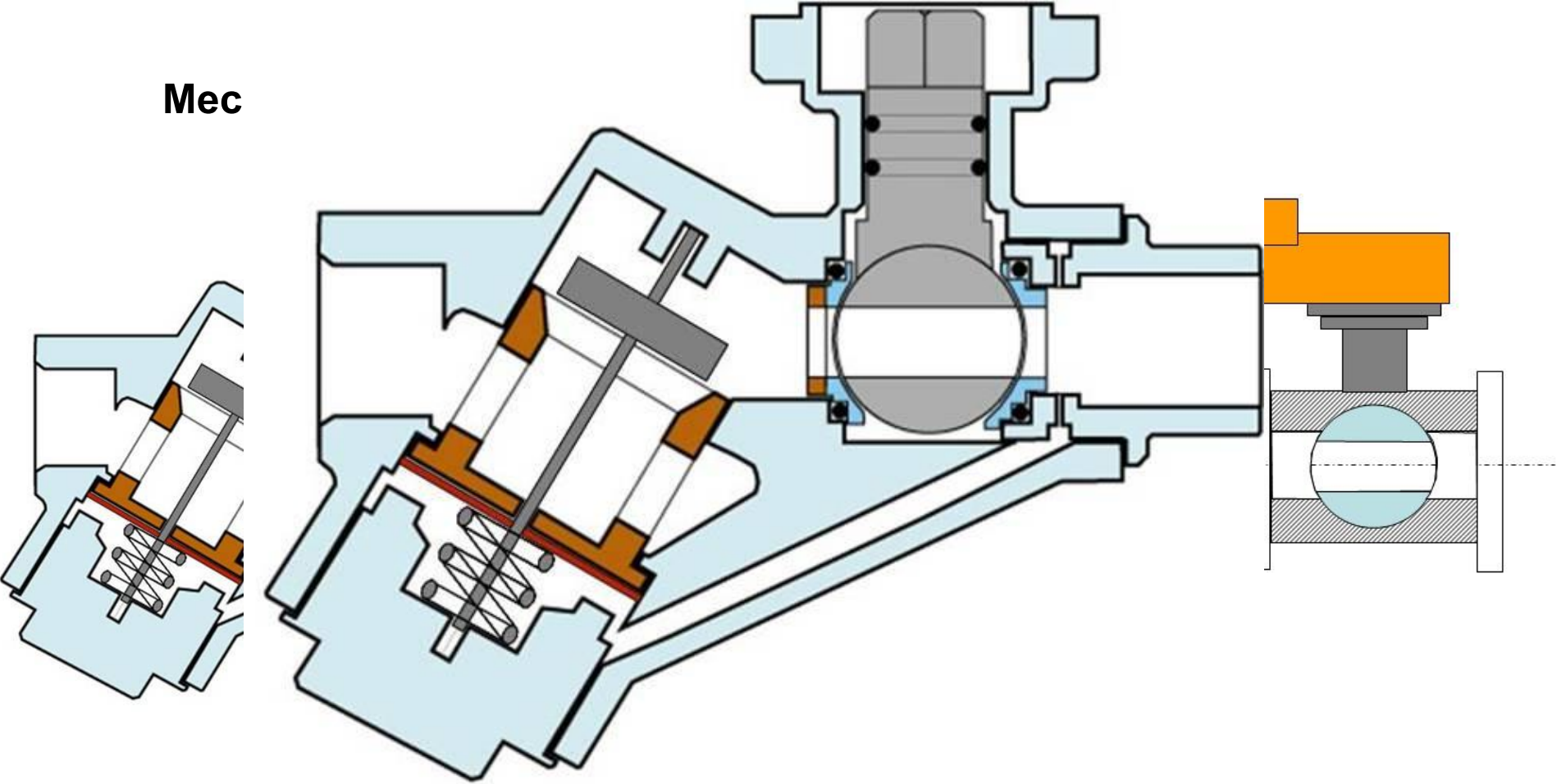
- No Issues with oversizing
- Perfect Valve Authority
- Stable control, part load and full load



Pressure Independent Valves

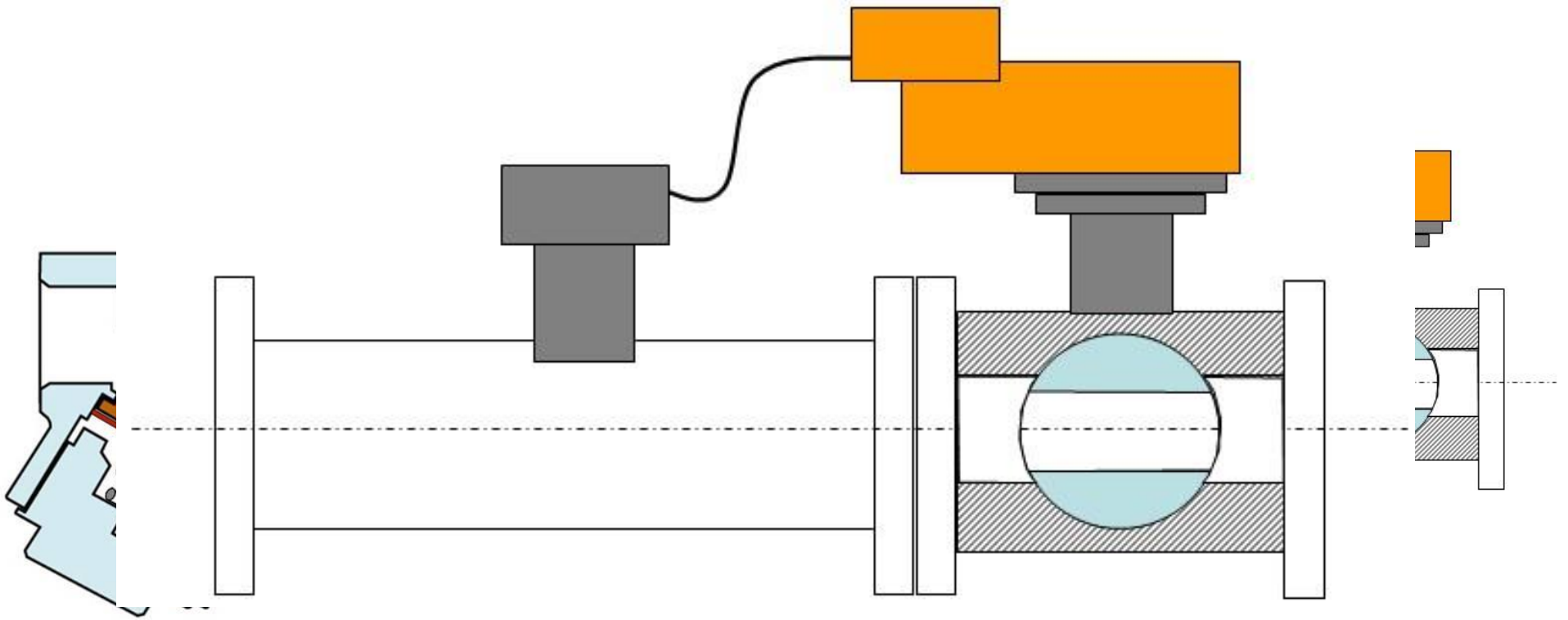
PI Valve Technologies

Mec



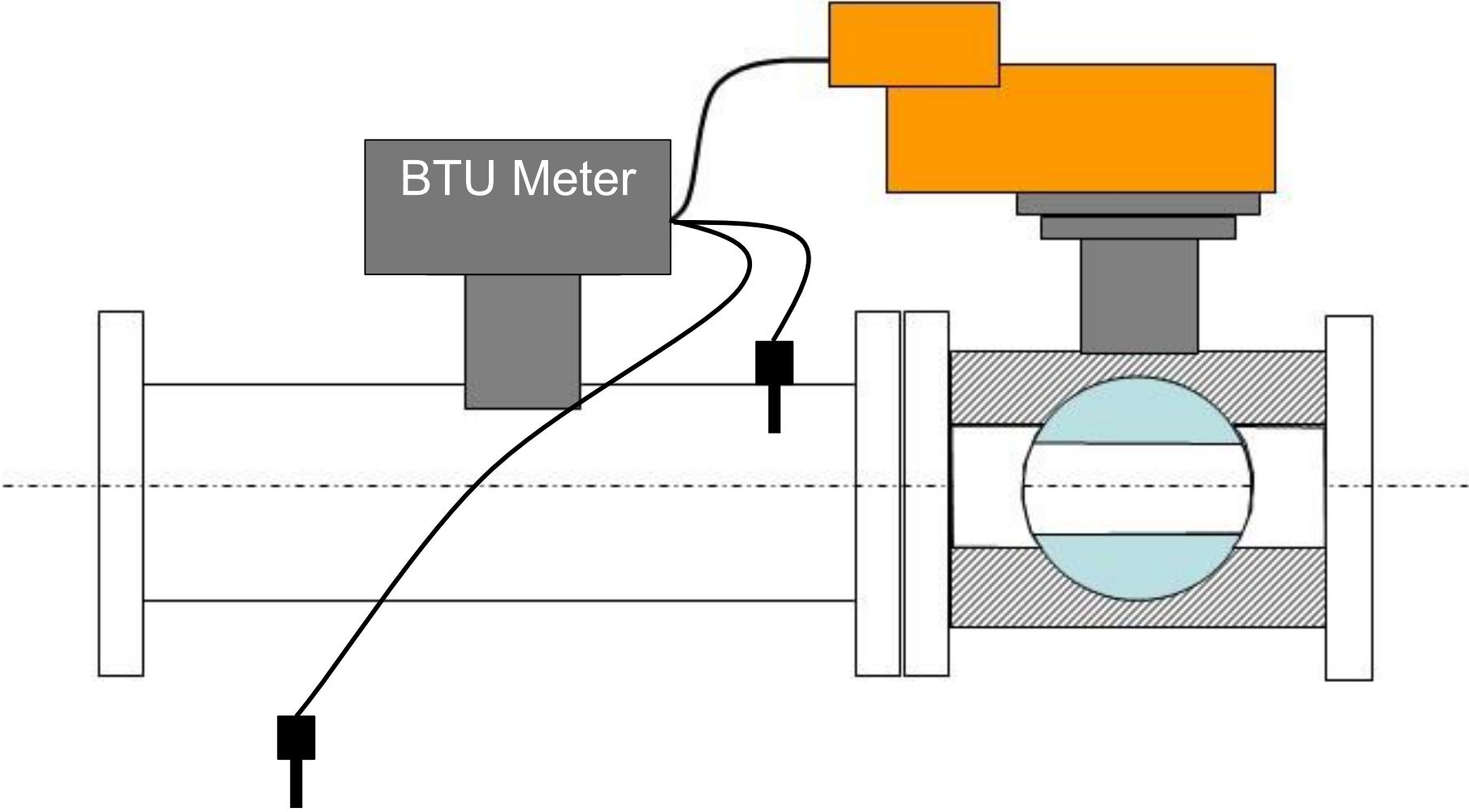
Pressure Independent Valves

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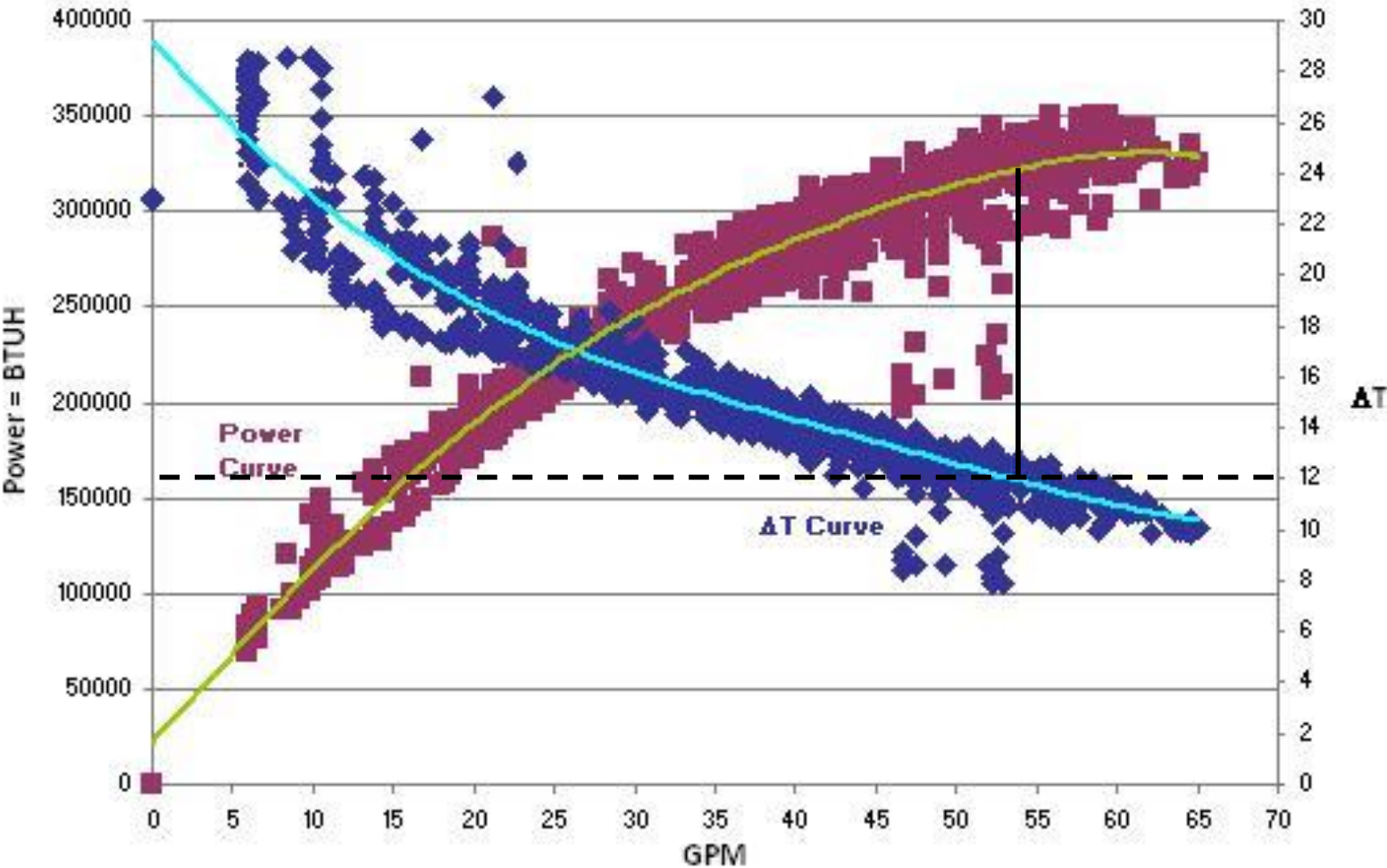
Delta T Limiting

BTU Monitoring



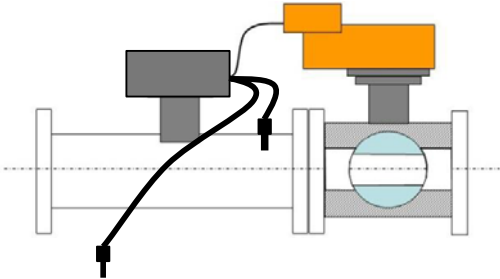
Delta T Limiting

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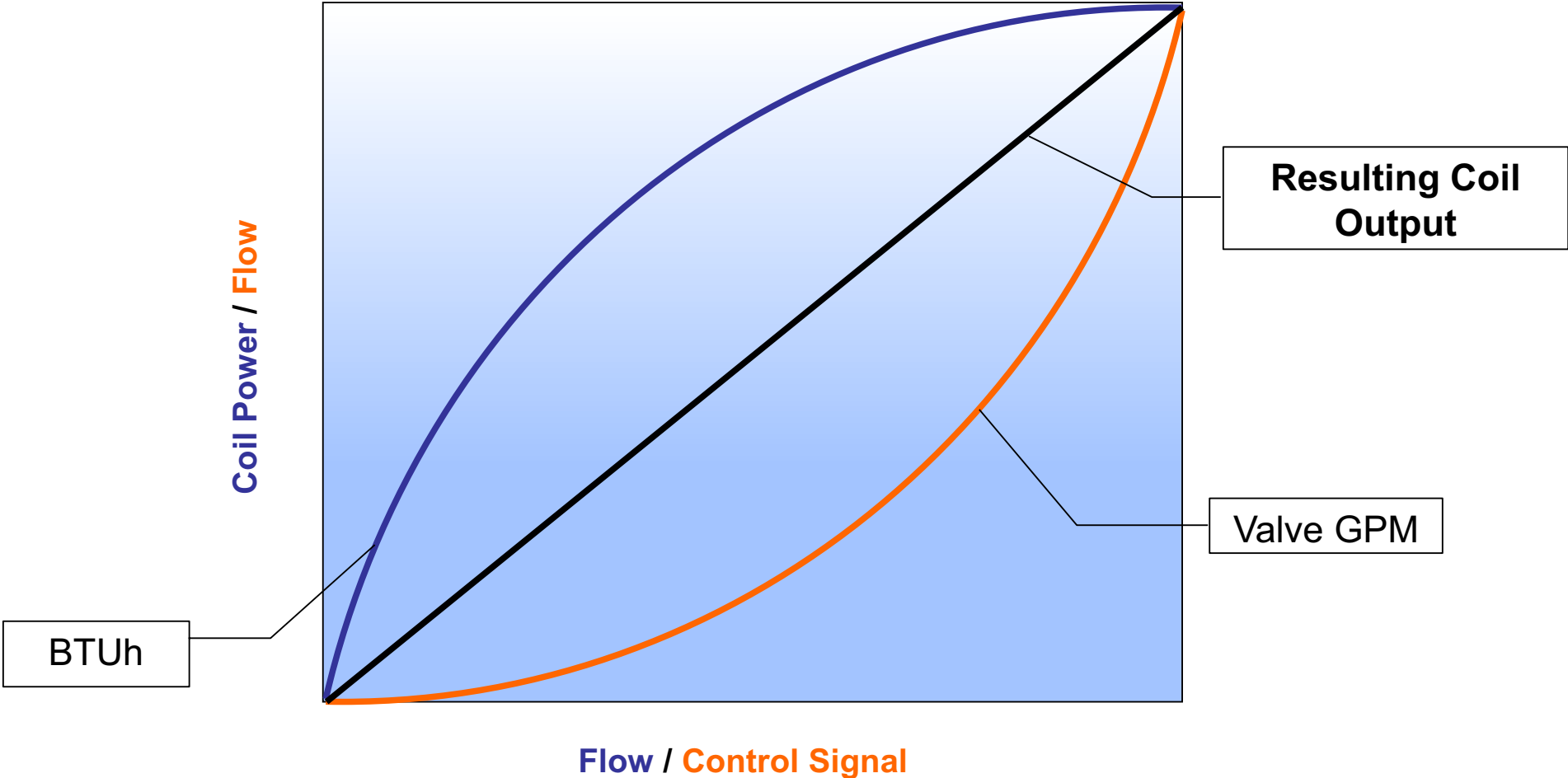


BTU Control

Maximizing Load to Flow Ratio



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Questions?
