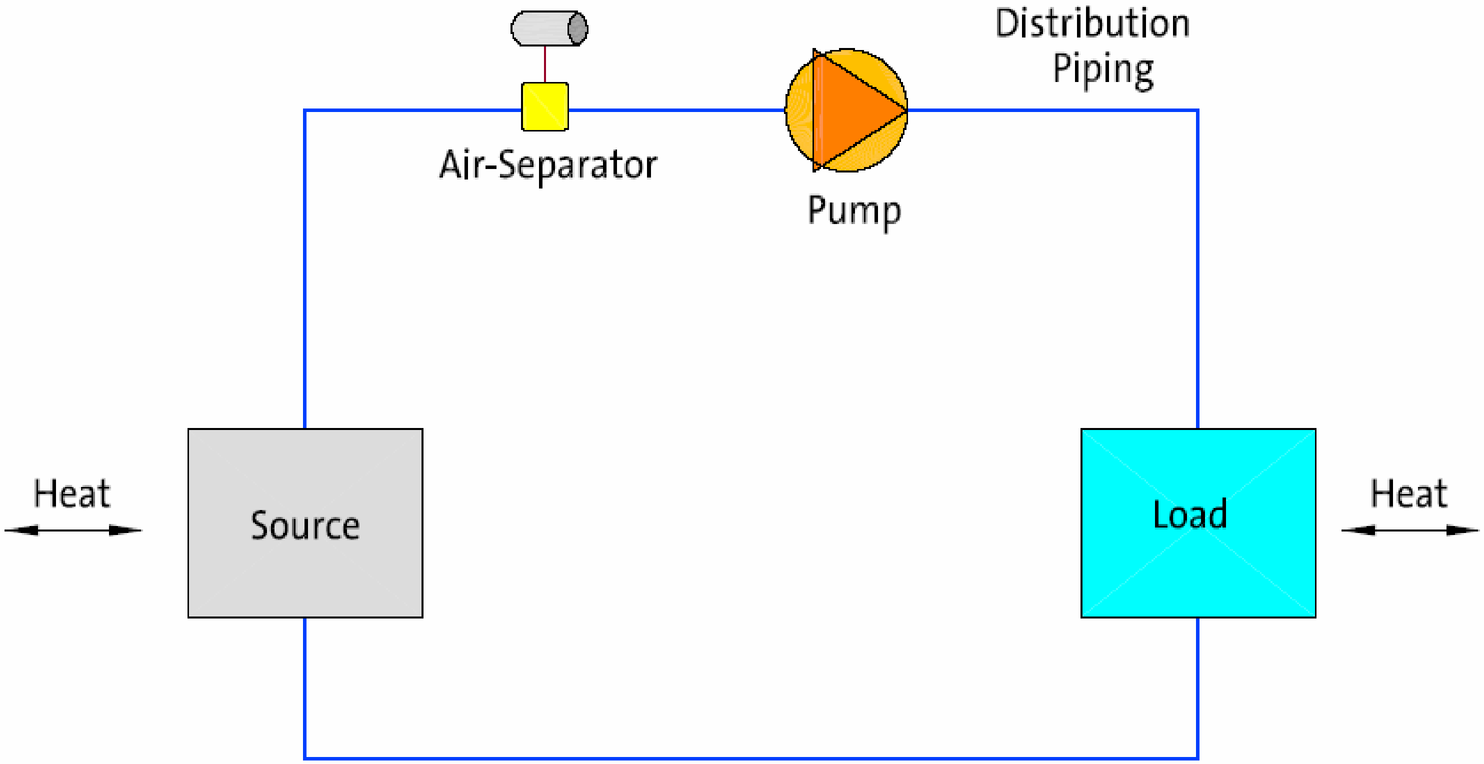
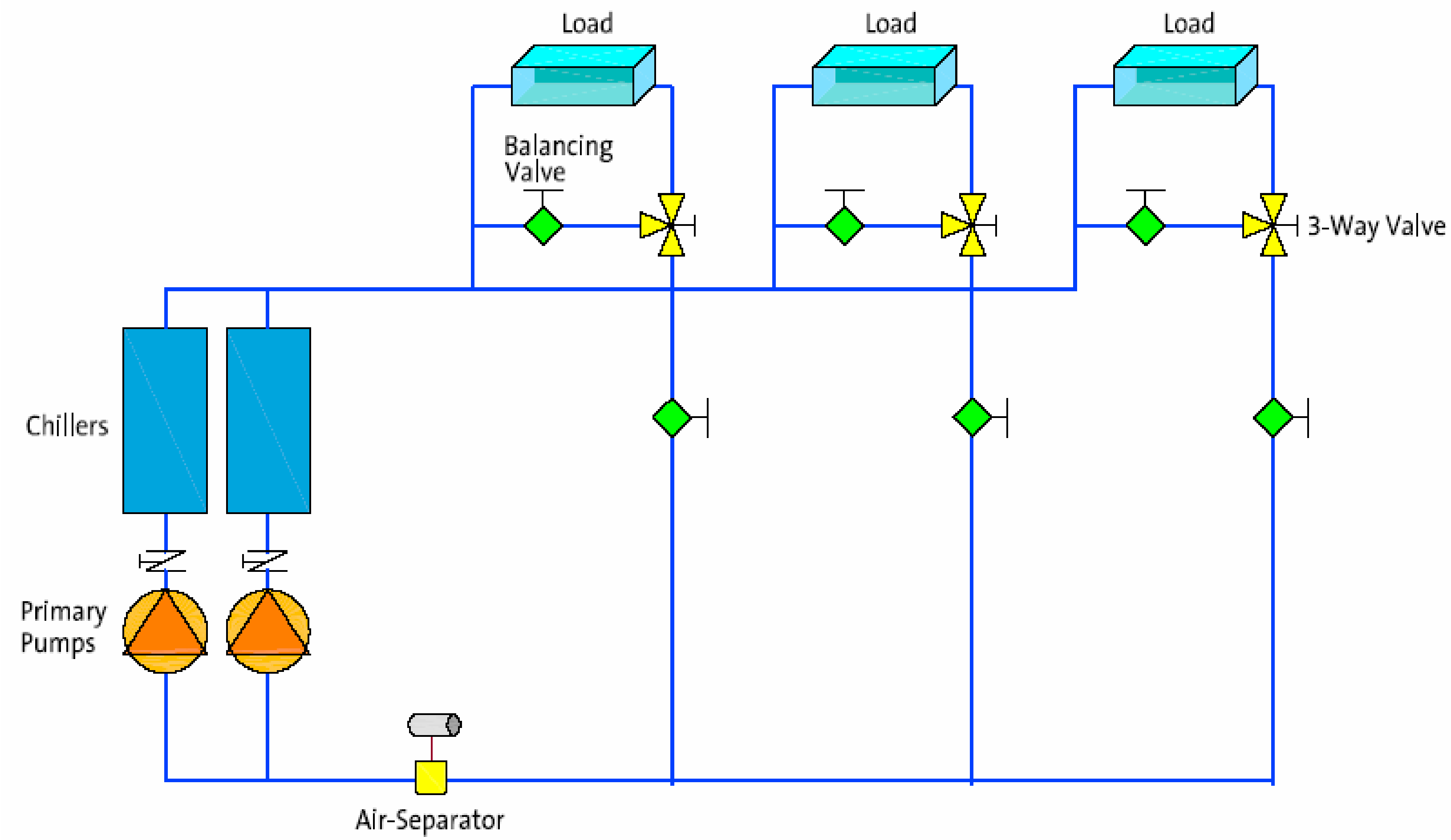
Chilled Water System Presentation

Constant Volume Distribution

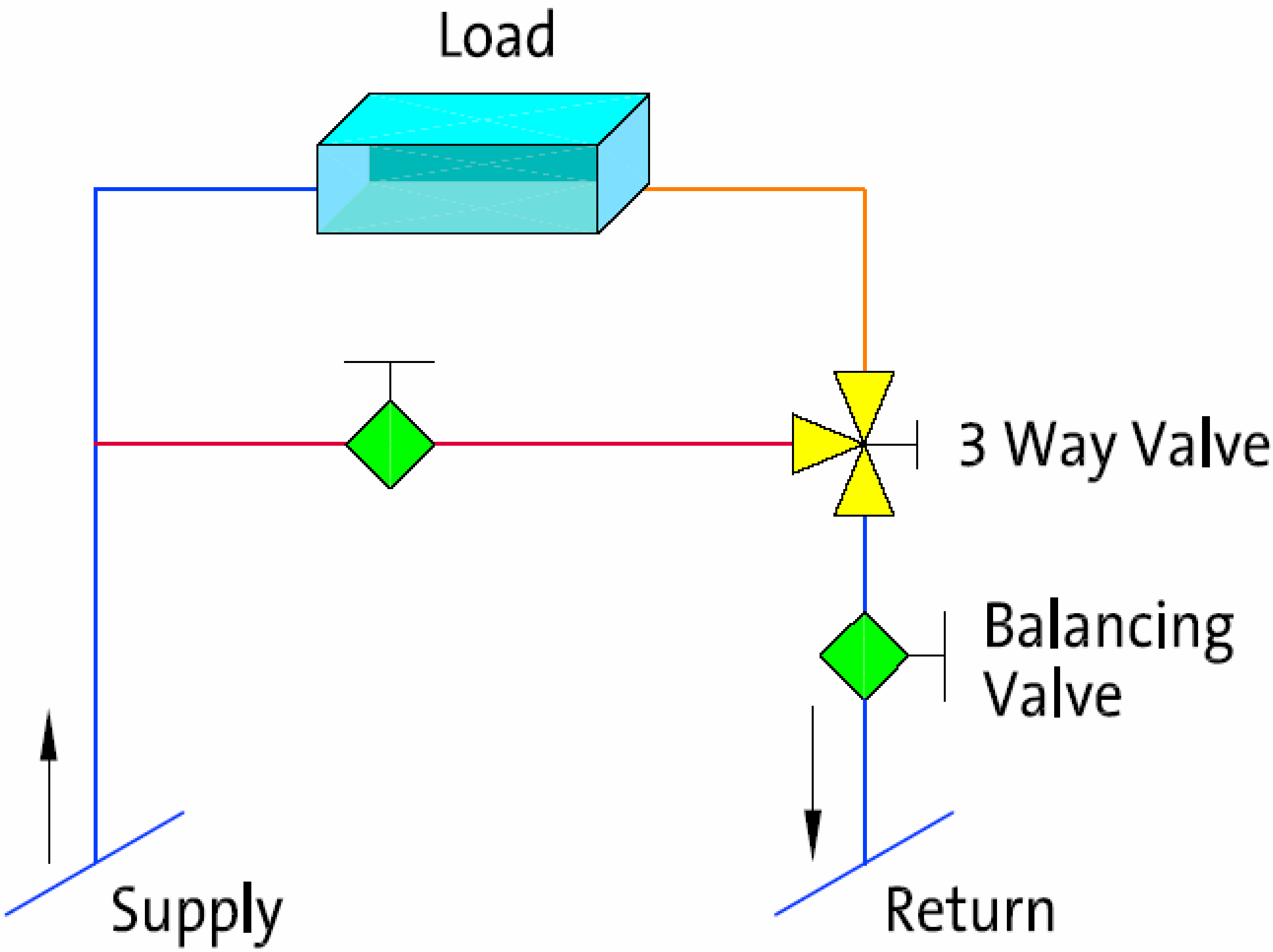
Air-conditioning System Components



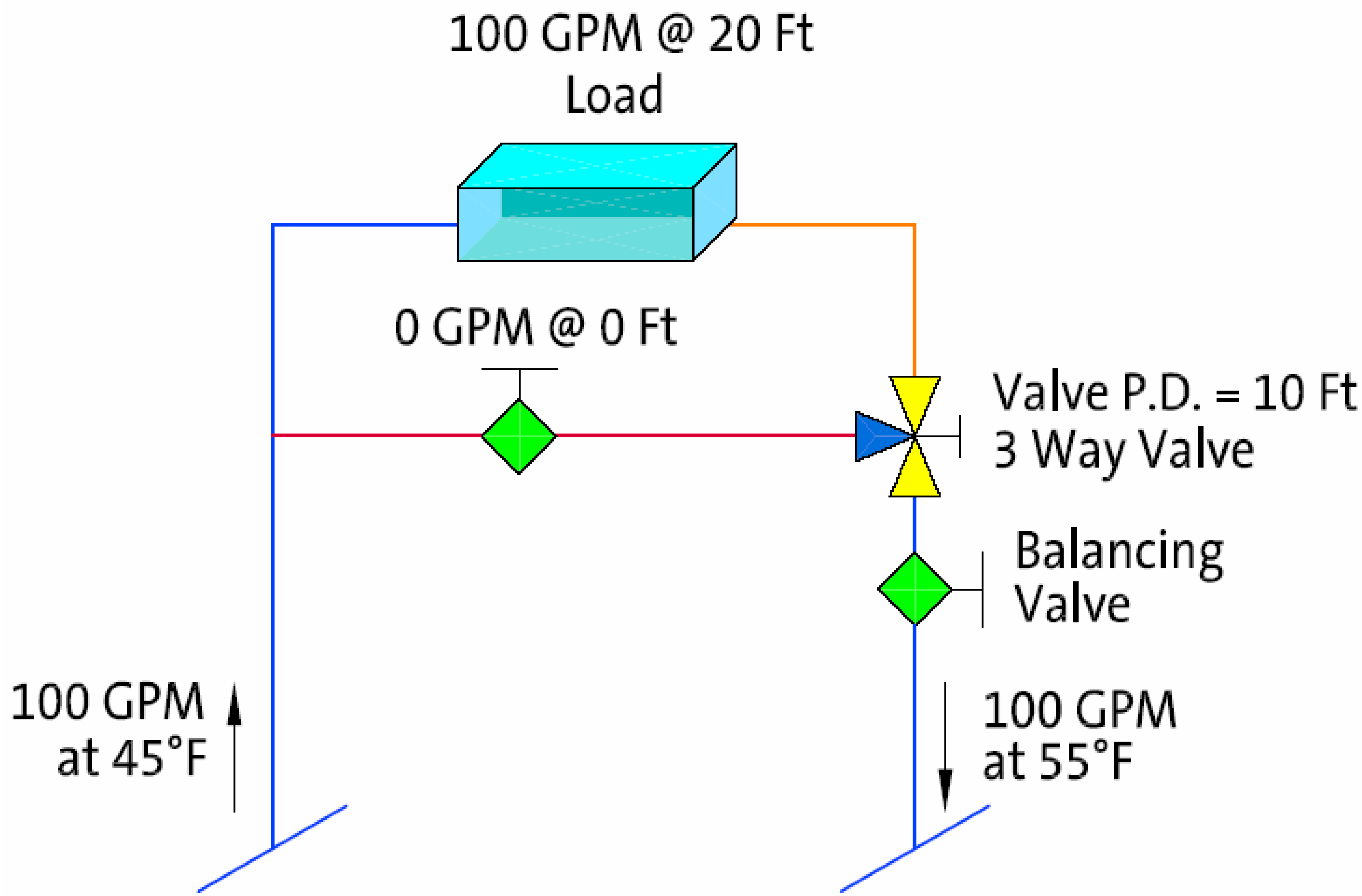
Constant Volume System Components



Typical 3-way Valve Zone



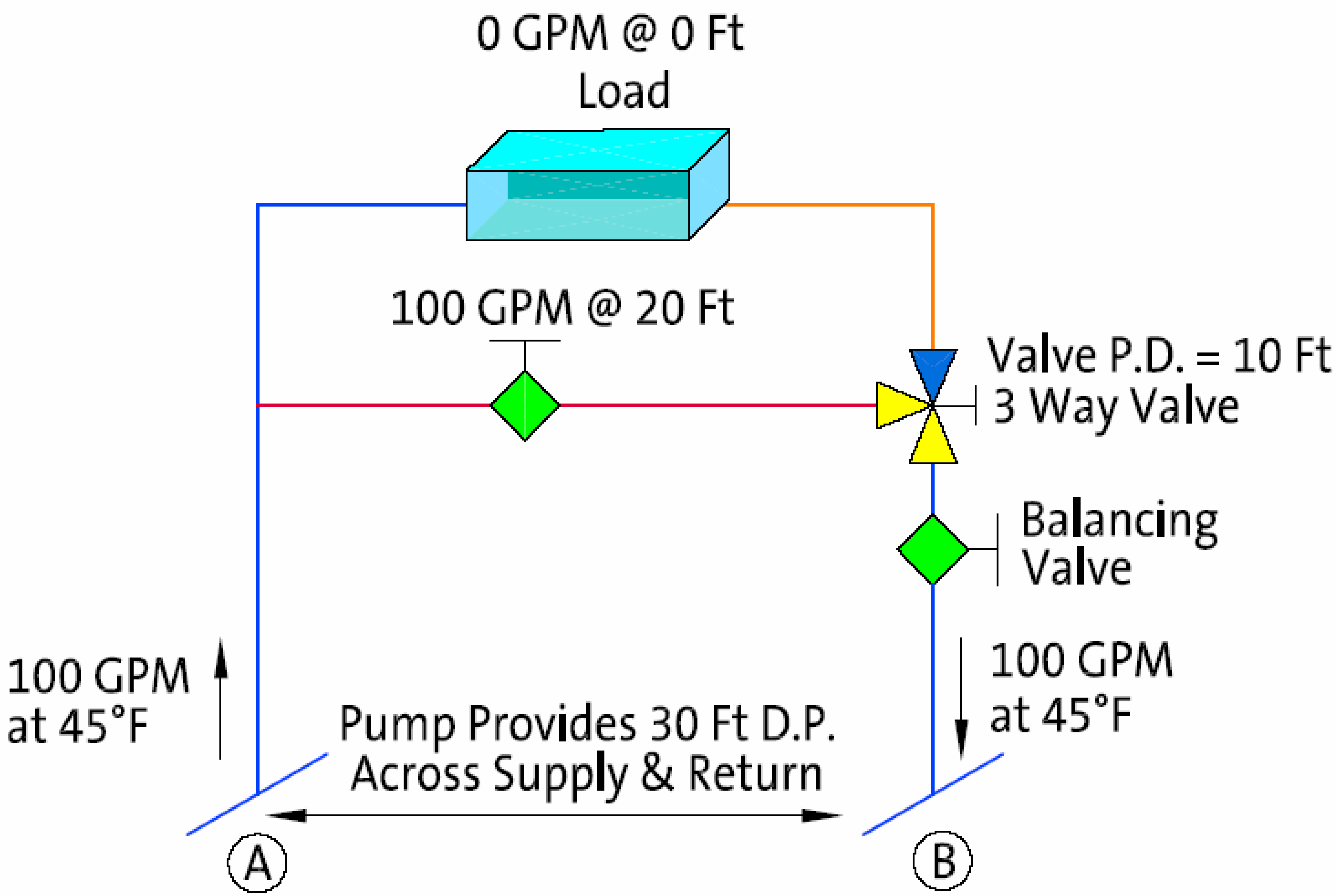
Full Load Condition



Fully Loaded Coil

• Supply water temperature	45°F
• Design return water temp.	55°F
• Coil design flow	100 GPM
• Coil design pressure drop	20 FT
• Load (flow x 10°F$_{\Delta}$ x 500)	500,000 Btuh
• Coil ΔP @ design flow	20 FT
• Bypass flow	0 GPM
• Bypass ΔP	3-way valve closed
• 3-way valve pressure drop	10 FT
• Pump flow and head	100 GPM @ 30 FT
• Actual return water temp	55 °F

Unloaded Condition



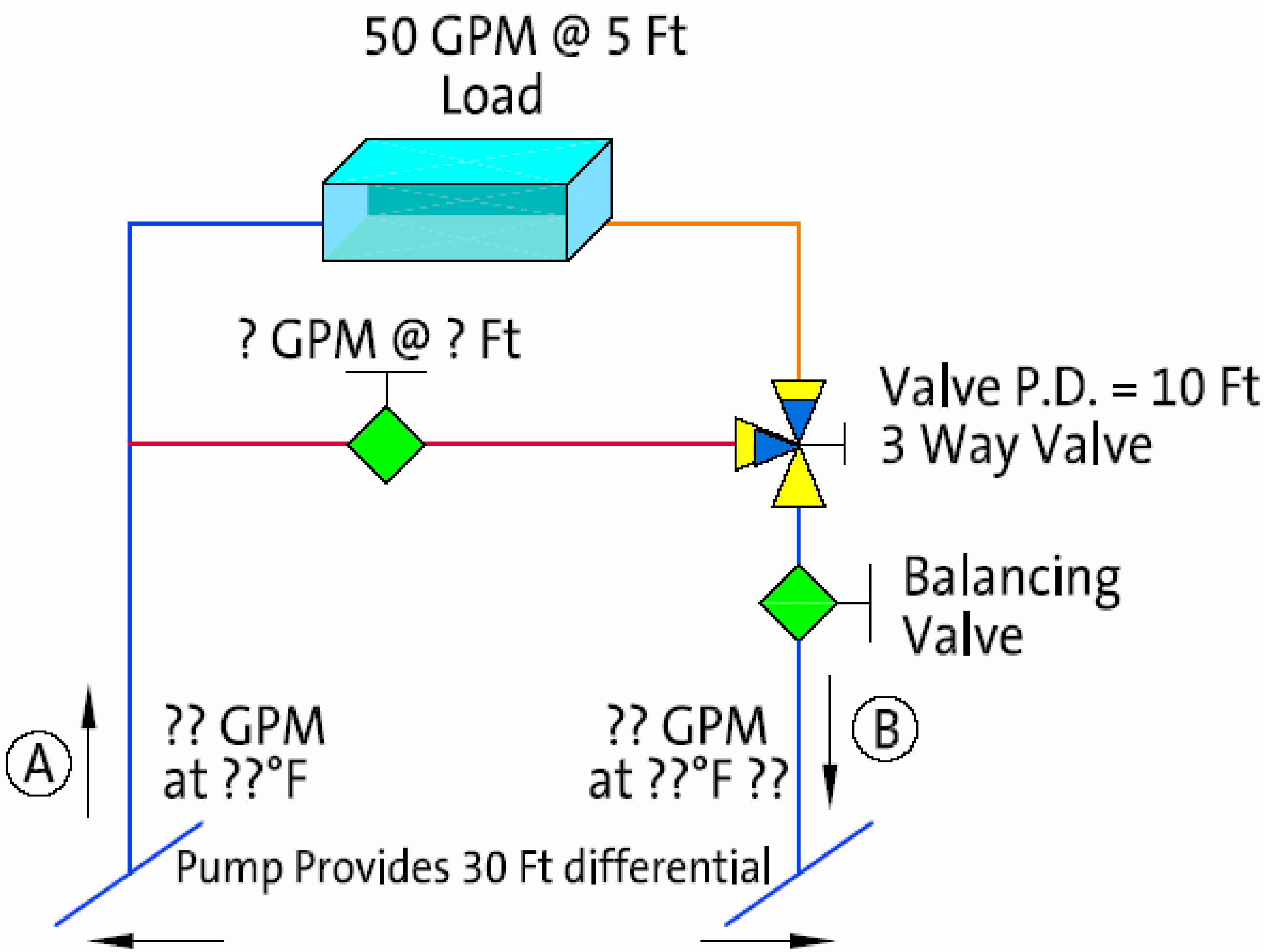
Unloaded Coil

• Supply water temperature	45°F
• Design return water temp.	55°F
• Coil design flow	0 GPM
• Coil design pressure drop	3-way valve closed
• Load (flow x $10^\circ F_{\Delta}$ x 500)	0.0 Btuh
• Coil ΔP @ design flow	0 FT
• Bypass flow	100 GPM
• Bypass ΔP	20 FT
• 3-way valve pressure drop	10 FT
• Pump flow and head	100 GPM @ 30 FT
• Actual return water temp	45 °F

So What?

- When the load on the coil is zero, the valve is returning “unused” chilled water at essentially supply temperature.
- Cold return water “unloads” the chillers, causing them to operate inefficiently.

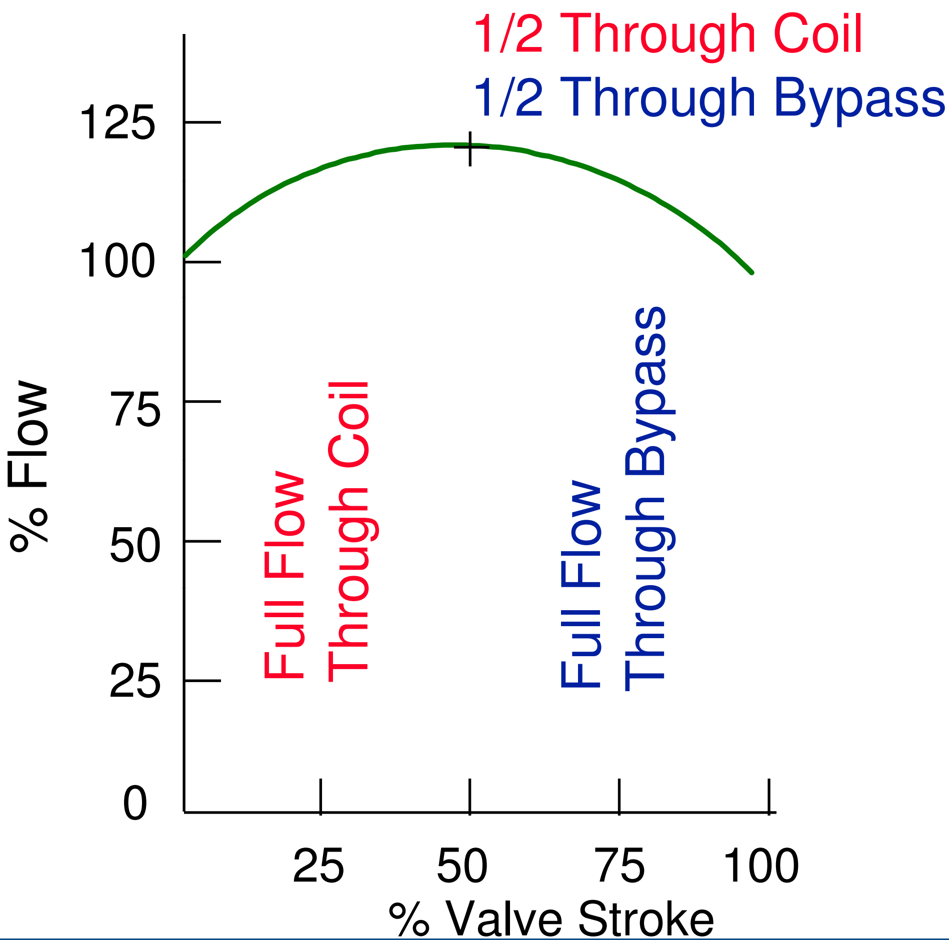
Part Load Condition



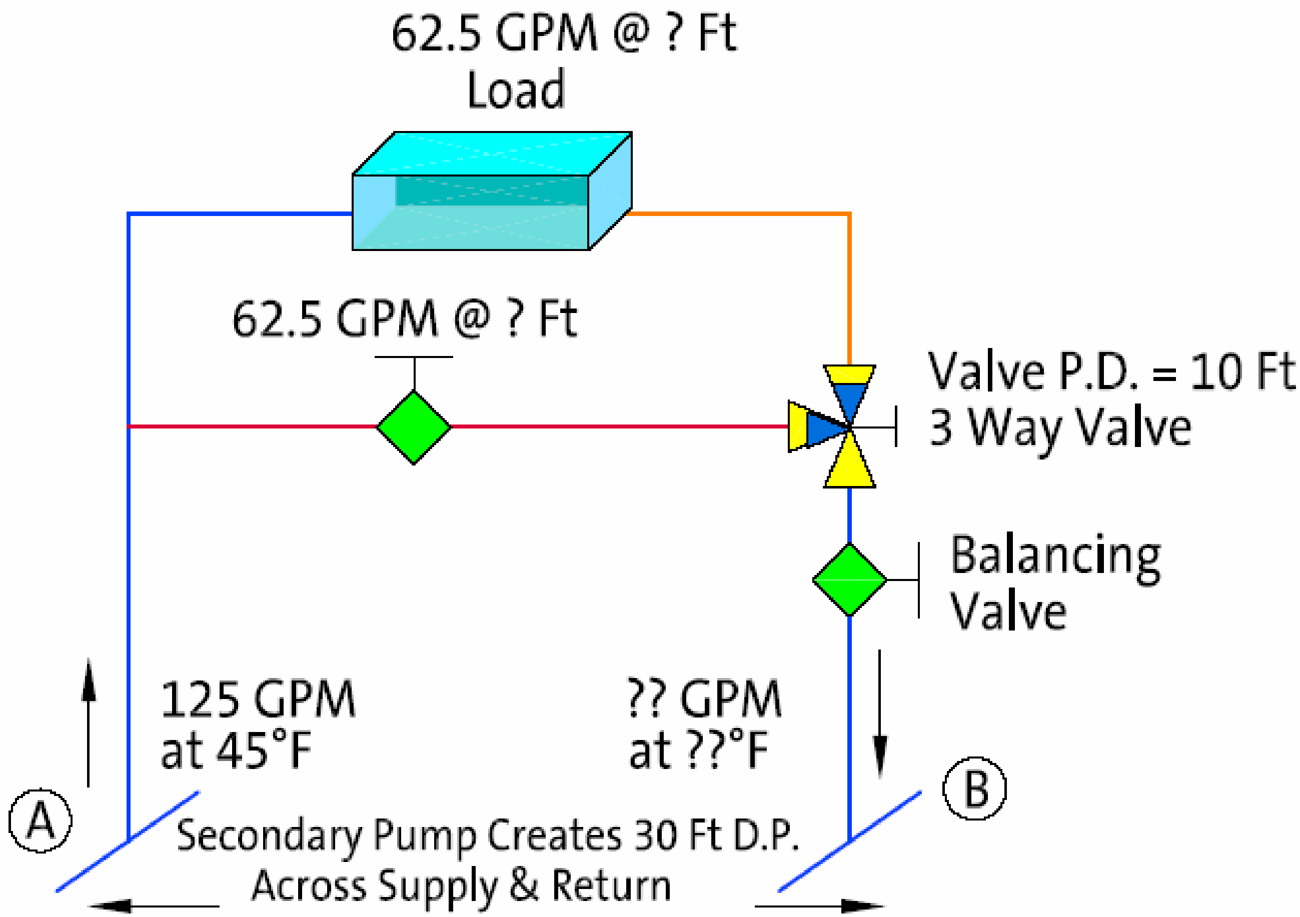
Partially Loaded Coil

• Supply water temperature	45°F
• Design return water temp.	55°F
• Coil design flow	50 GPM
• Coil design pressure drop	20 FT
• Load (flow x 10°F$_{\Delta}$ x 500)	250,000 Btuh
• Coil $_{\Delta}$P @ design flow	5 FT
• Bypass flow	??? GPM
• Bypass $_{\Delta}$P	3-way partially closed
• 3-way valve pressure drop	10 FT
• Pump flow and head	??? GPM @ 30 FT
• Actual return water temp	?? °F

3-way Valve Characteristic



What's Really Happening?



Coil with 3-way Valve at Mid-position

• Supply water temperature	45 °F
• Design return water temp.	55 °F
• Load (flow x 10°F$_{\Delta}$ x 500)	250,000 Btuh
• Coil design pressure drop	20 FT
• Coil flow	62.5 GPM
• Coil $_{\Delta}$P @ 62.5% flow	7.8 FT
• Coil leaving water temp	53 °F
• Bypass flow	62.5 GPM
• Bypass $_{\Delta}$P	7.8 FT
• 3-way valve pressure drop	10 FT
• Pump flow and head	125 GPM @ 30 FT
• Actual return water temp	49 °F (62.5 GPM @ 53 °F+ 62.5 GPM @ 45 °F)

$$Head_2 = Head_1(Flow_2/ Flow_1)^2$$

$$Head_2 = 20(.625/1)^2$$

$$Head_2 = 20(.3906)$$

$$Head_2 = 7.8$$

$$\Delta T = Load/ Flow \times 500$$

$$\Delta T = 250{,}000/62.5 \times 500$$

$$\Delta T = 8$$

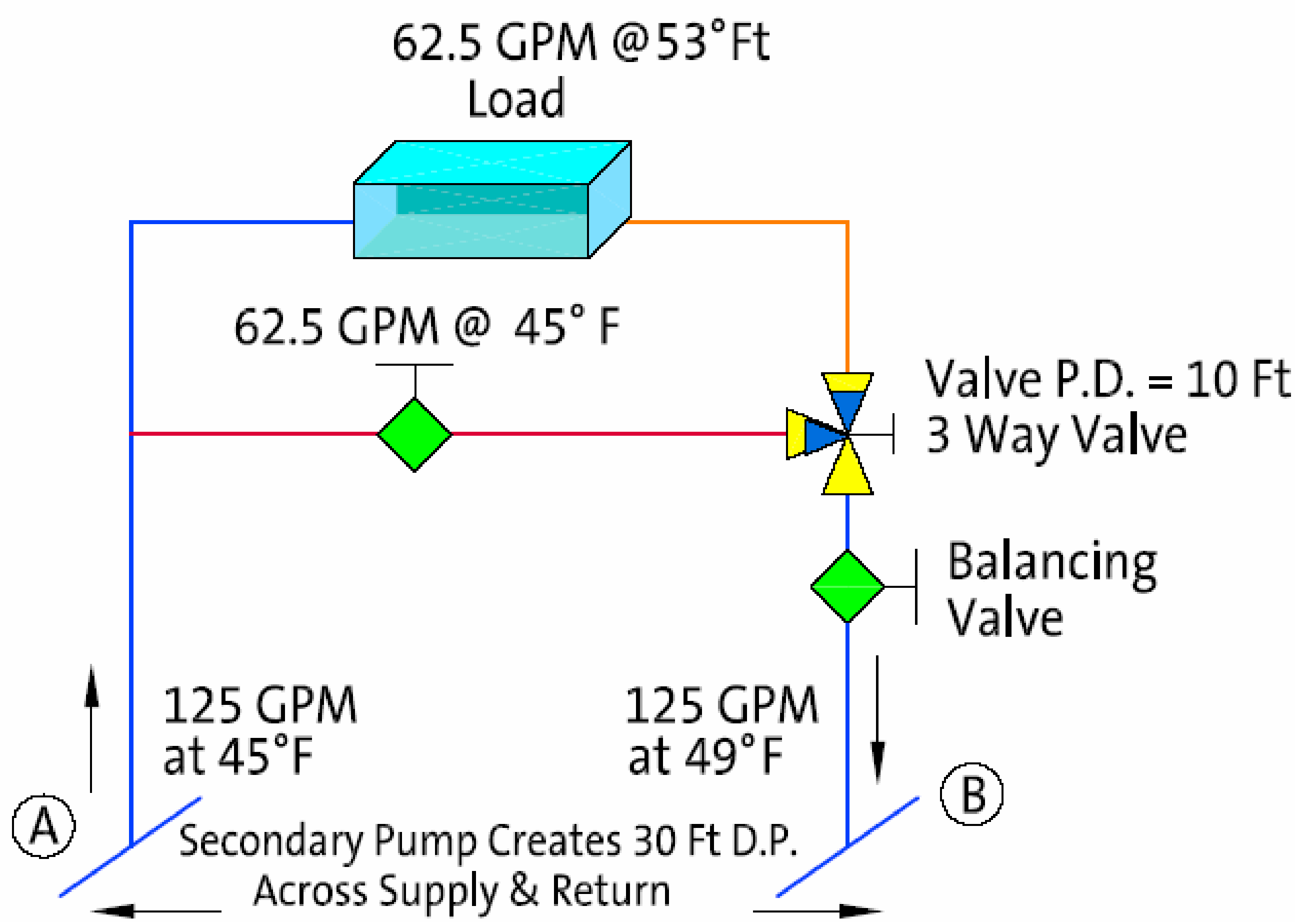
Therefore, $LWT_{coil} = 45 + 8 = 53$

$$RWT = (Flow_1 \ X \ EWT + Flow_2 \ X \ LWT)/\ Flow_{1+2}$$

$$RWT = (62.5 \ X \ 45 + 62.5 \ X \ 53)/125$$

$$RWT = 49$$

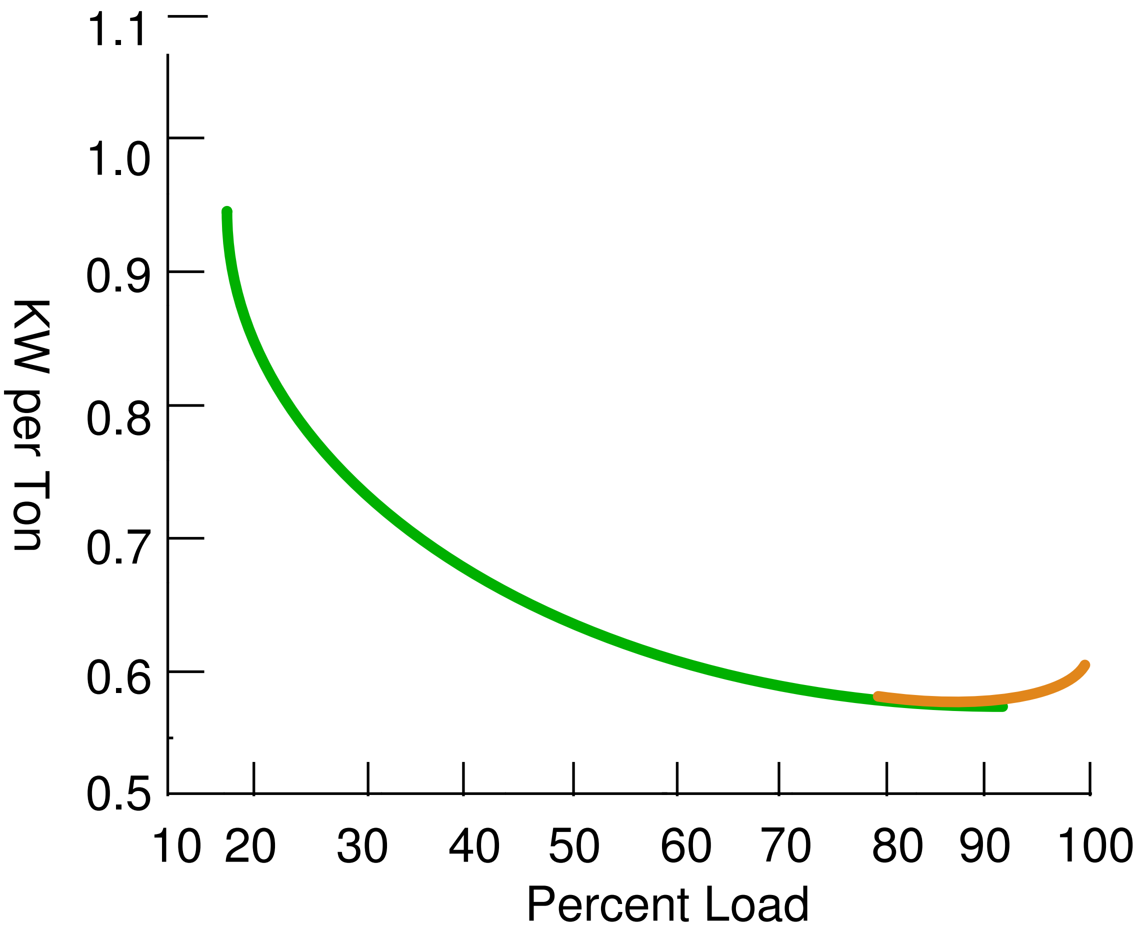
3-way Valve in Mid Position



3-way Valve System Deficiencies

1. Low return water temperatures.
2. Robs chilled water from other coils at part load conditions.
3. Increases flow in primary piping.
4. Adds additional chillers on line.
5. Chiller performance is reduced.

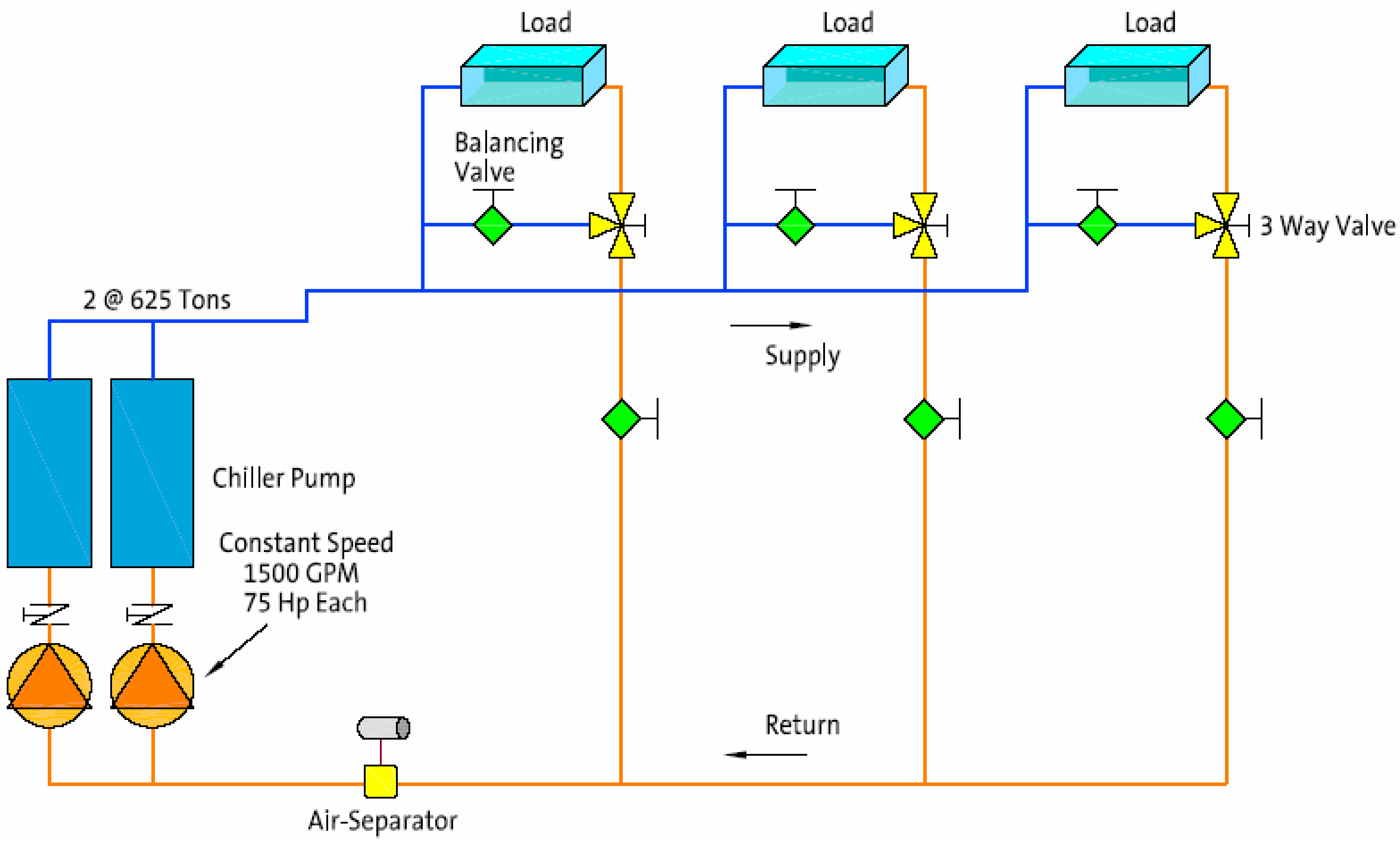
Chiller Performance Curve



Pump Sizing

- Select for full chiller flow
- Head must be adequate for:
  - Chiller evaporator
  - Longest circuit
  - Coil
  - Three way valve
  - Air separator

System Configuration



Any Questions?

Variable Volume Constant Speed

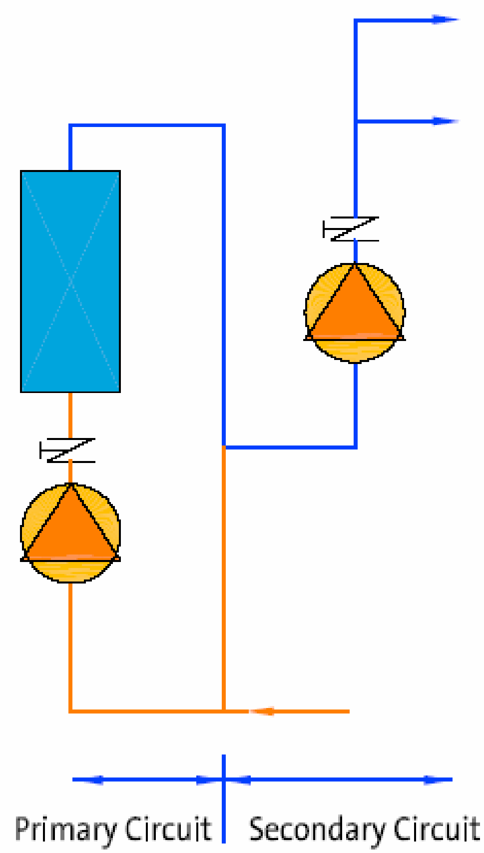
Variable Volume Constant Speed

Primary – Secondary System

Primary – Circuit Includes Chillers & Primary Pump. Constant water flow through the chiller is maintained and chilled water is produced

Secondary – Circuit Chilled water is circulated to the demand area (load) by using Secondary pumps.

PRIMARY - SECONDARY

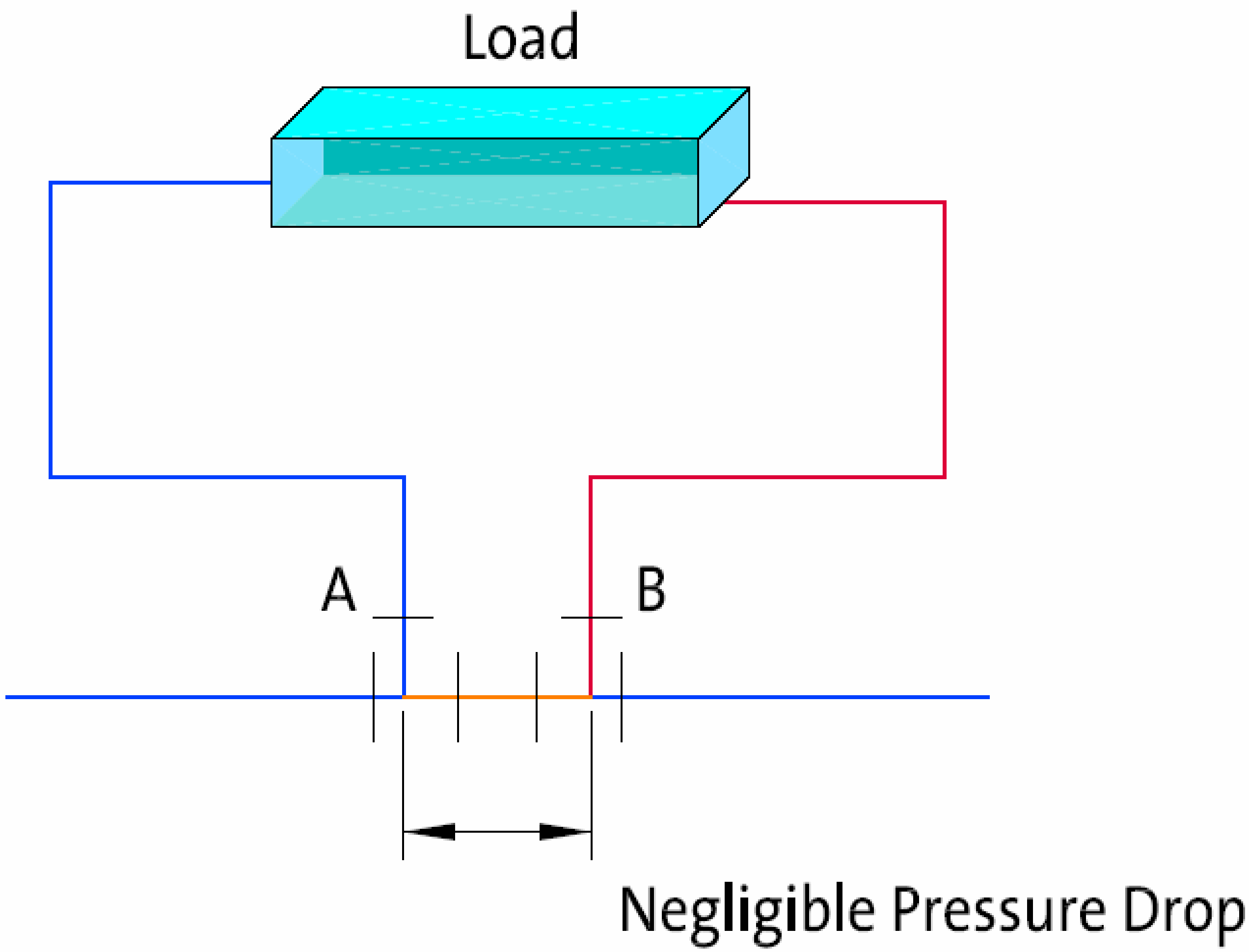


Other Famous Names of Primary-Secondary

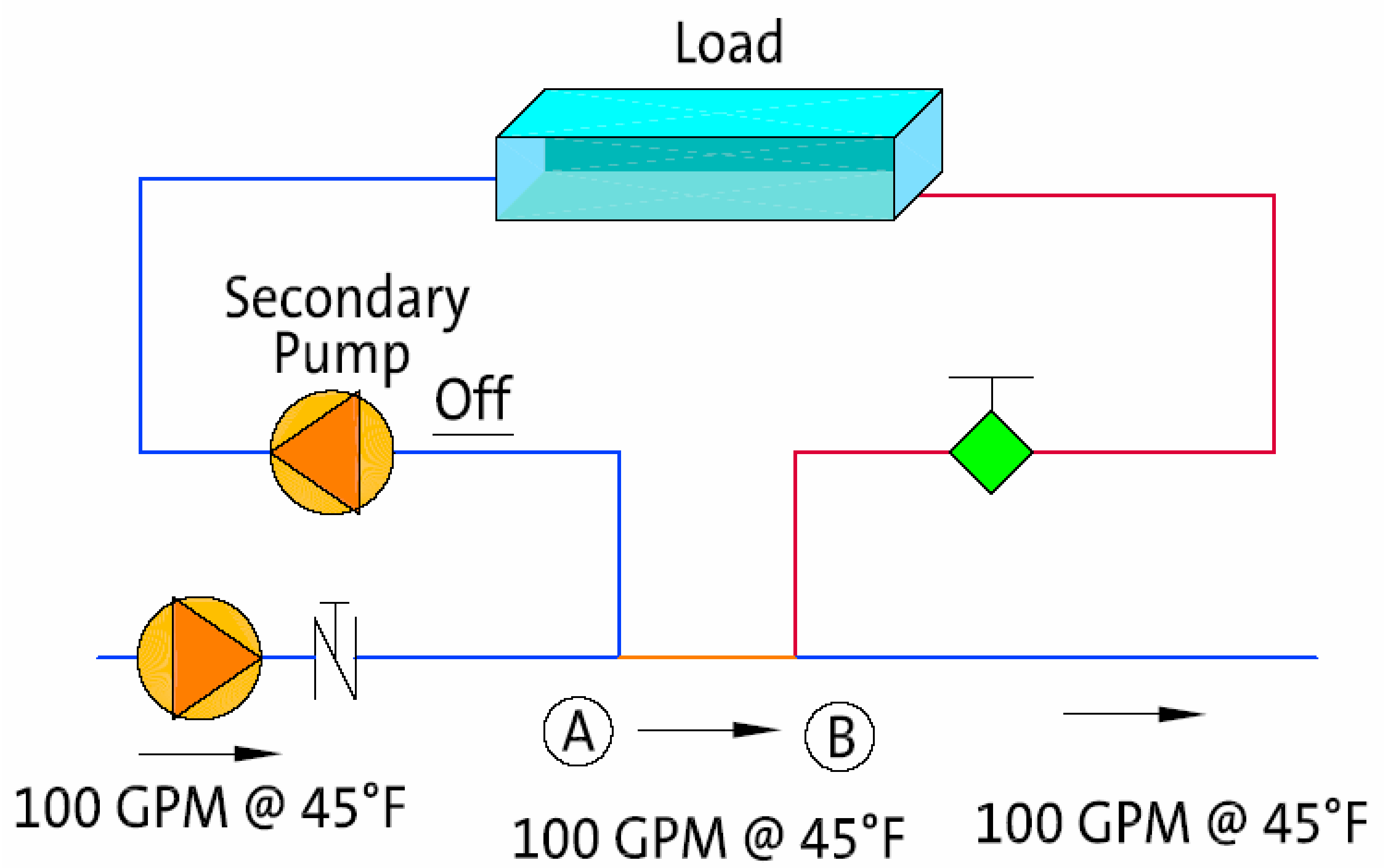
Primary – Production Loop

Secondary – Distribution Loop

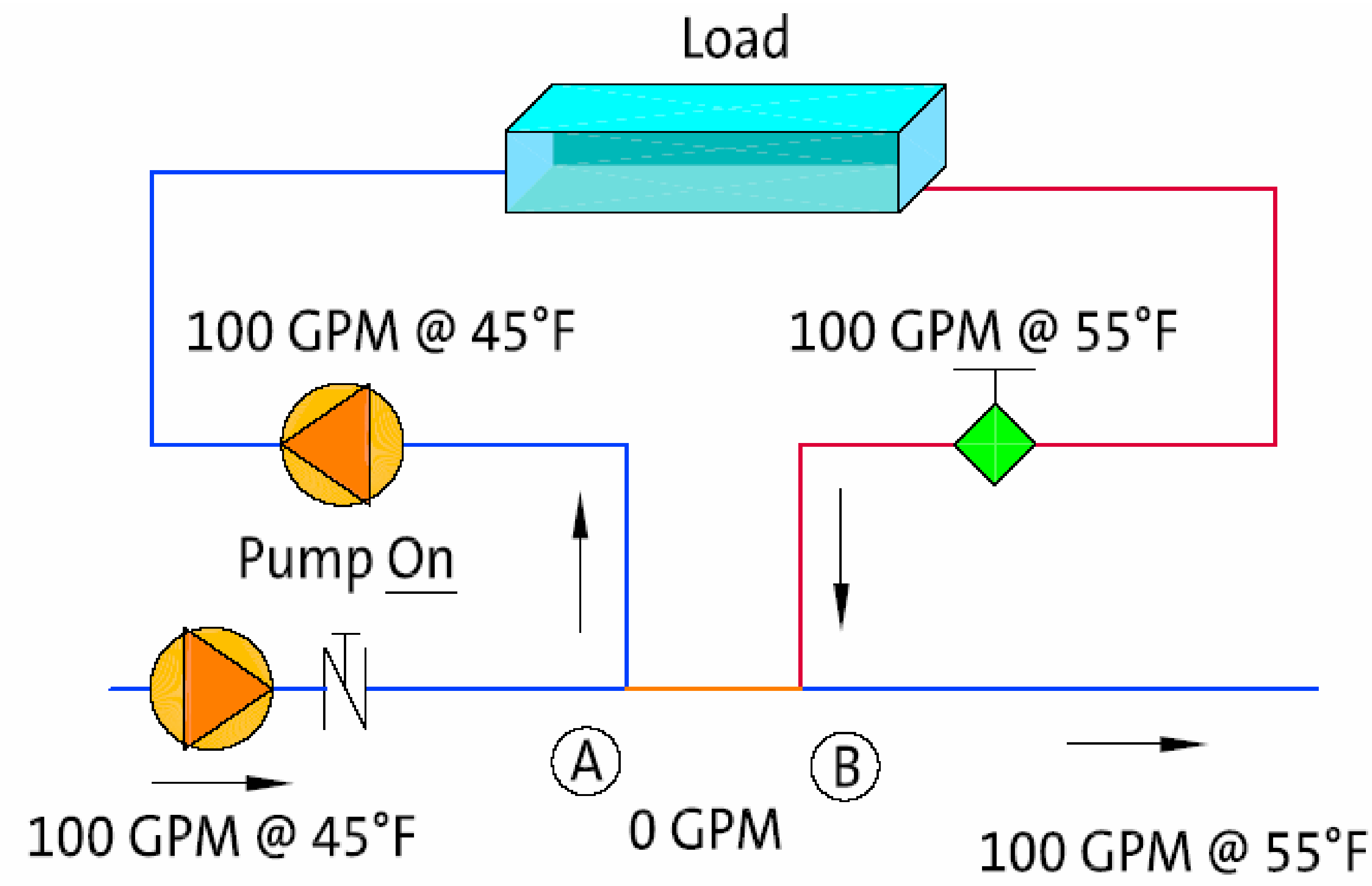
Fundamental Idea



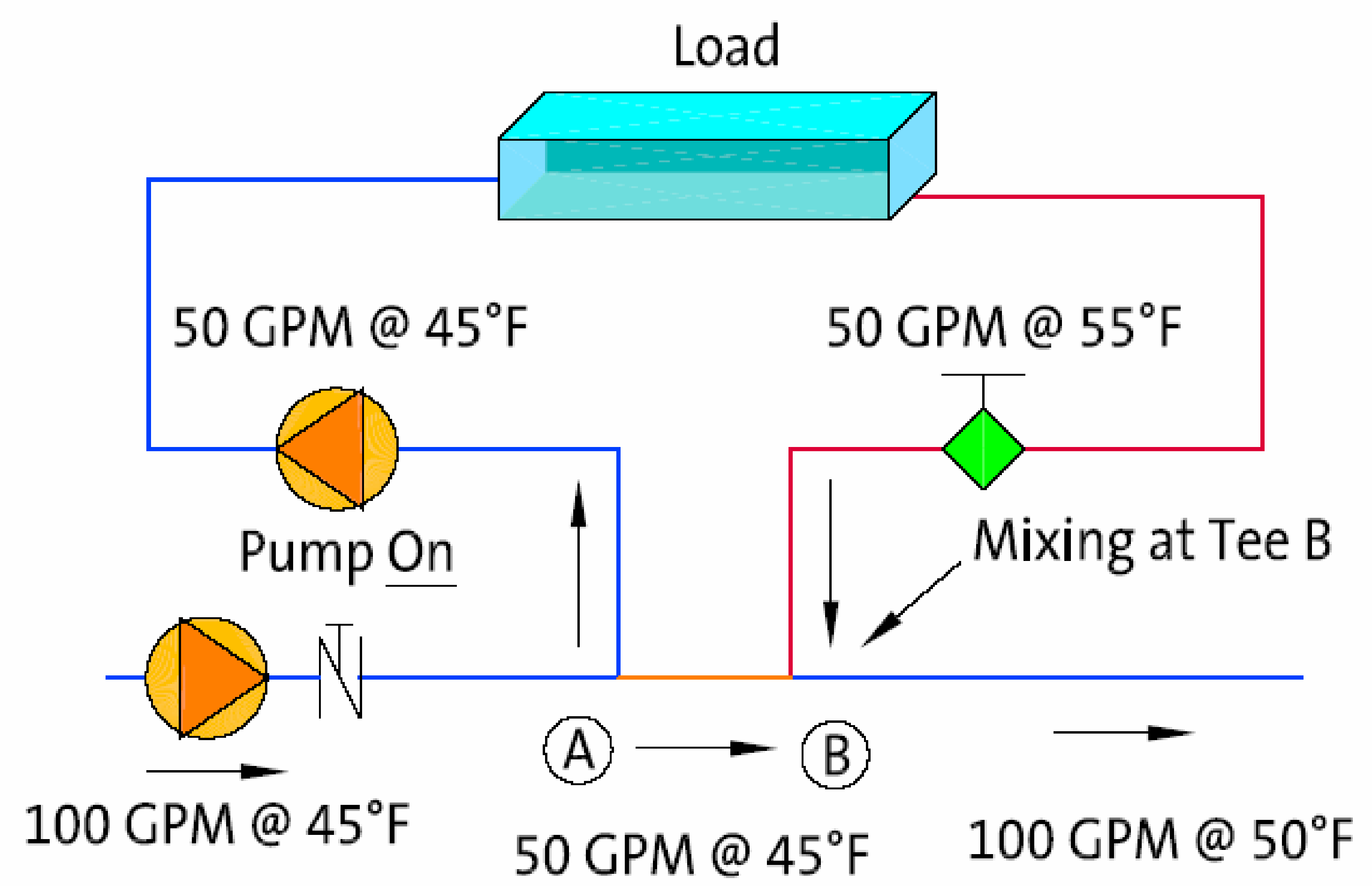
No Secondary Flow



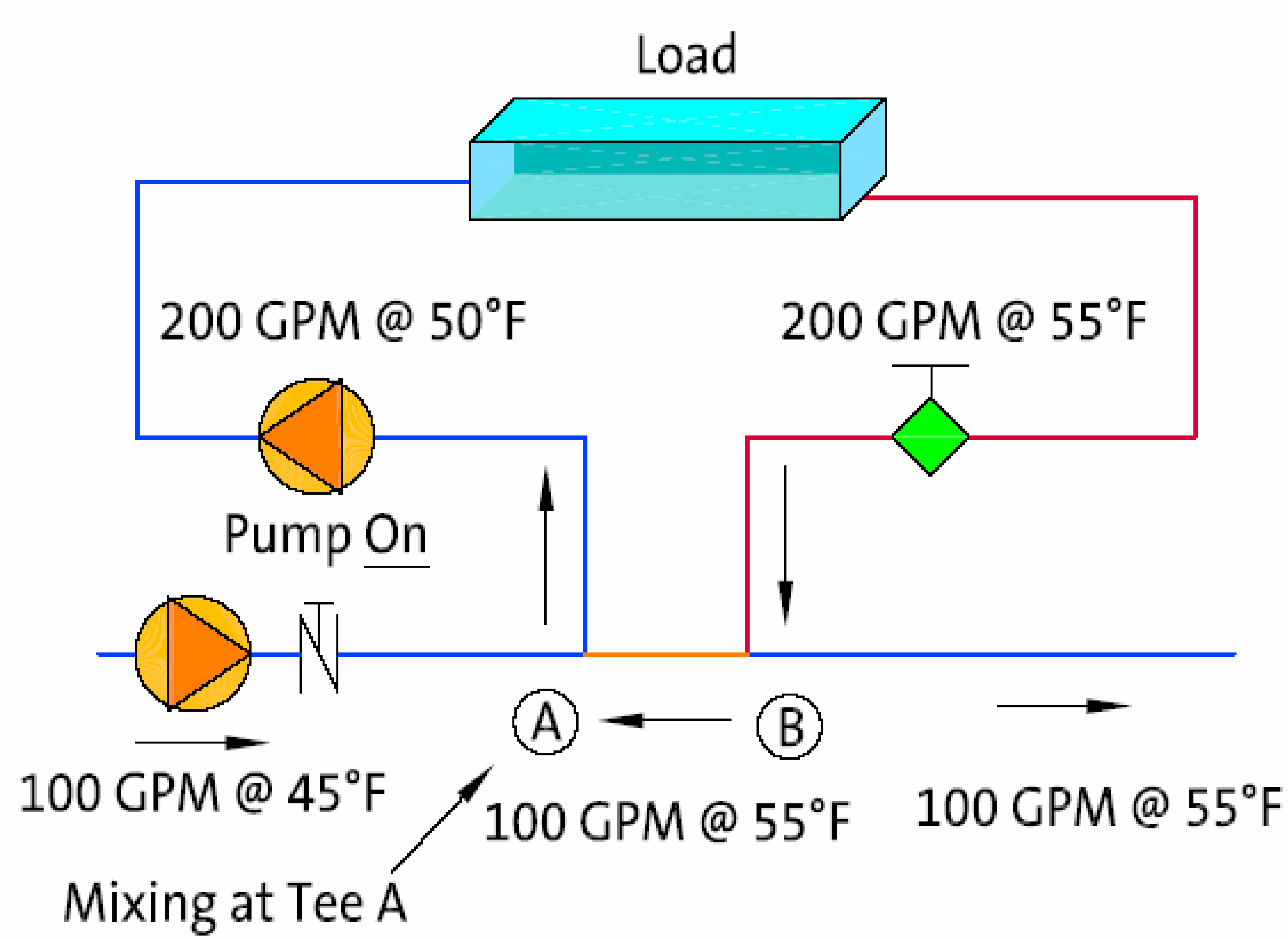
Primary = Secondary



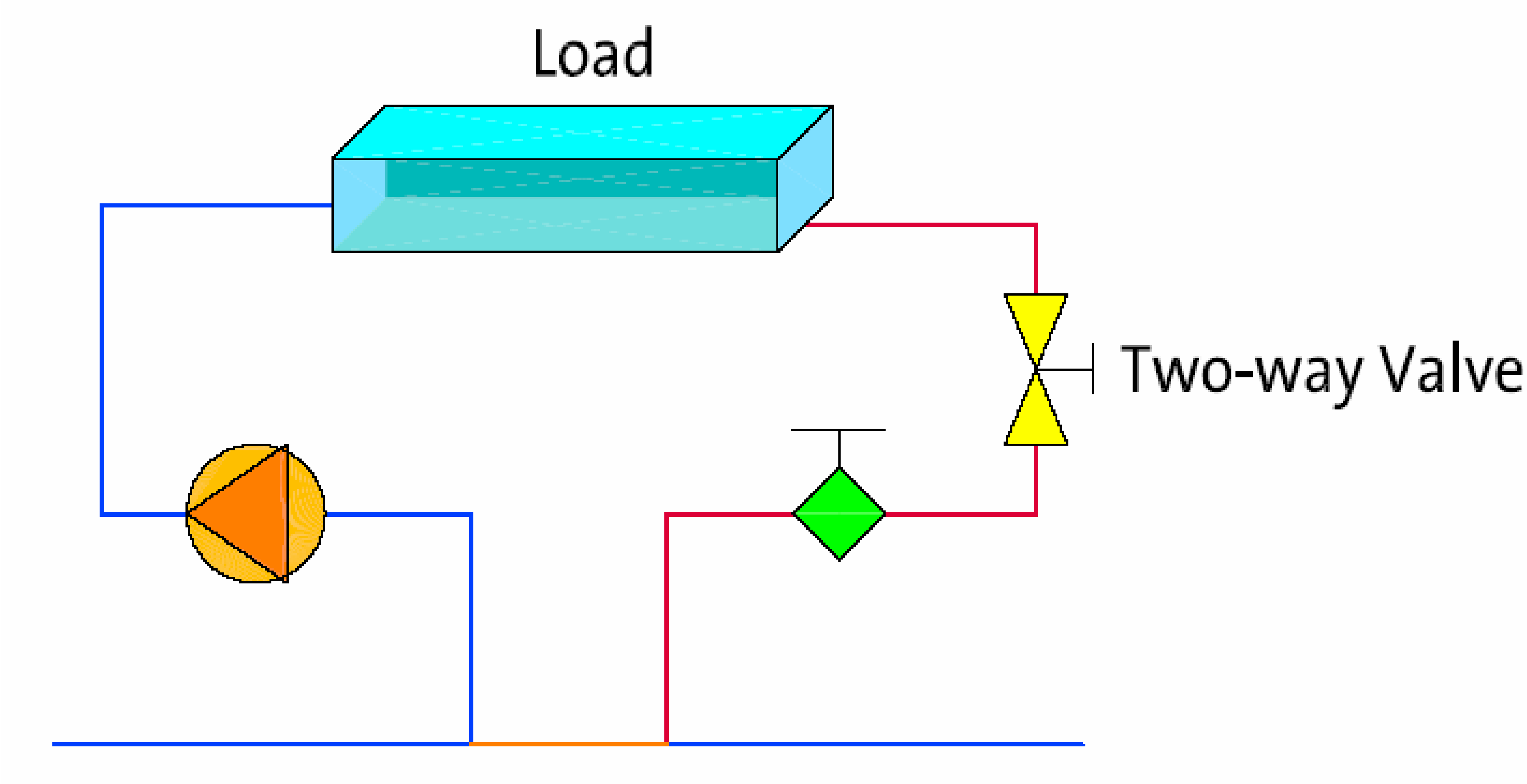
Primary > Secondary



Primary < Secondary



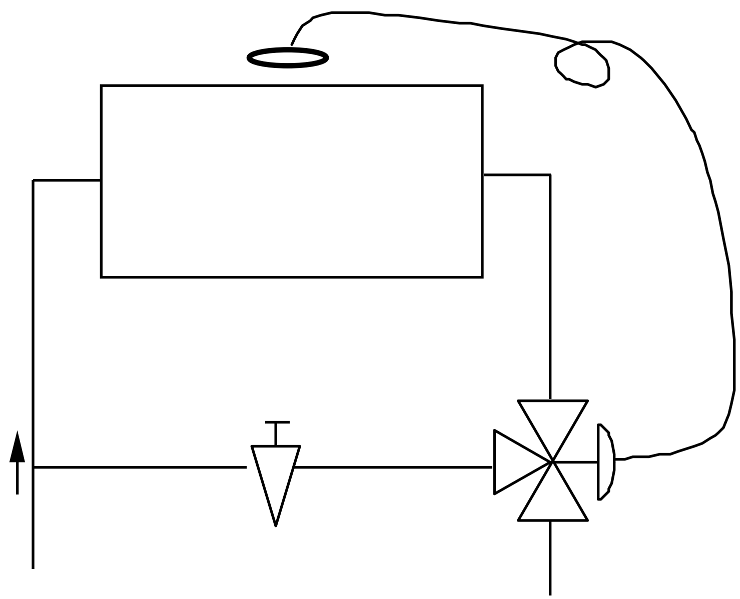
Control Valve in Secondary



Common Pipe Design Criteria

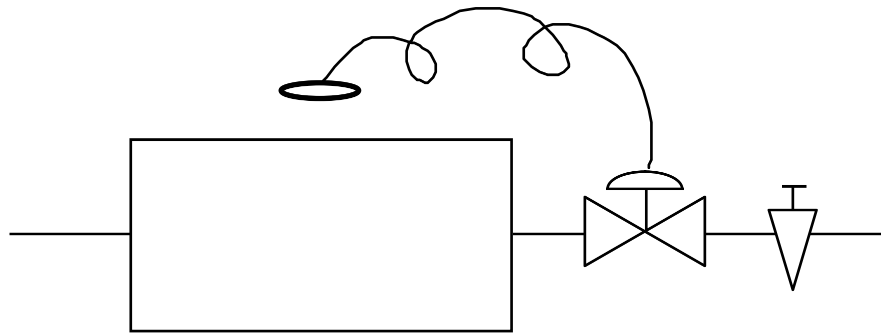
- Use the flow of the largest chiller
  - Chiller staging at half of this flow is common
- Head loss in common <1 1/2 ft
  - Distribution pipe size is often used where reductions would be inconvenient
- Three pipe diameters between tees
  - Excessive length increases total head loss
- Low velocities in system piping

Control Valve in Secondary



Variable flow through coil
Constant flow through system

Three Way Valve

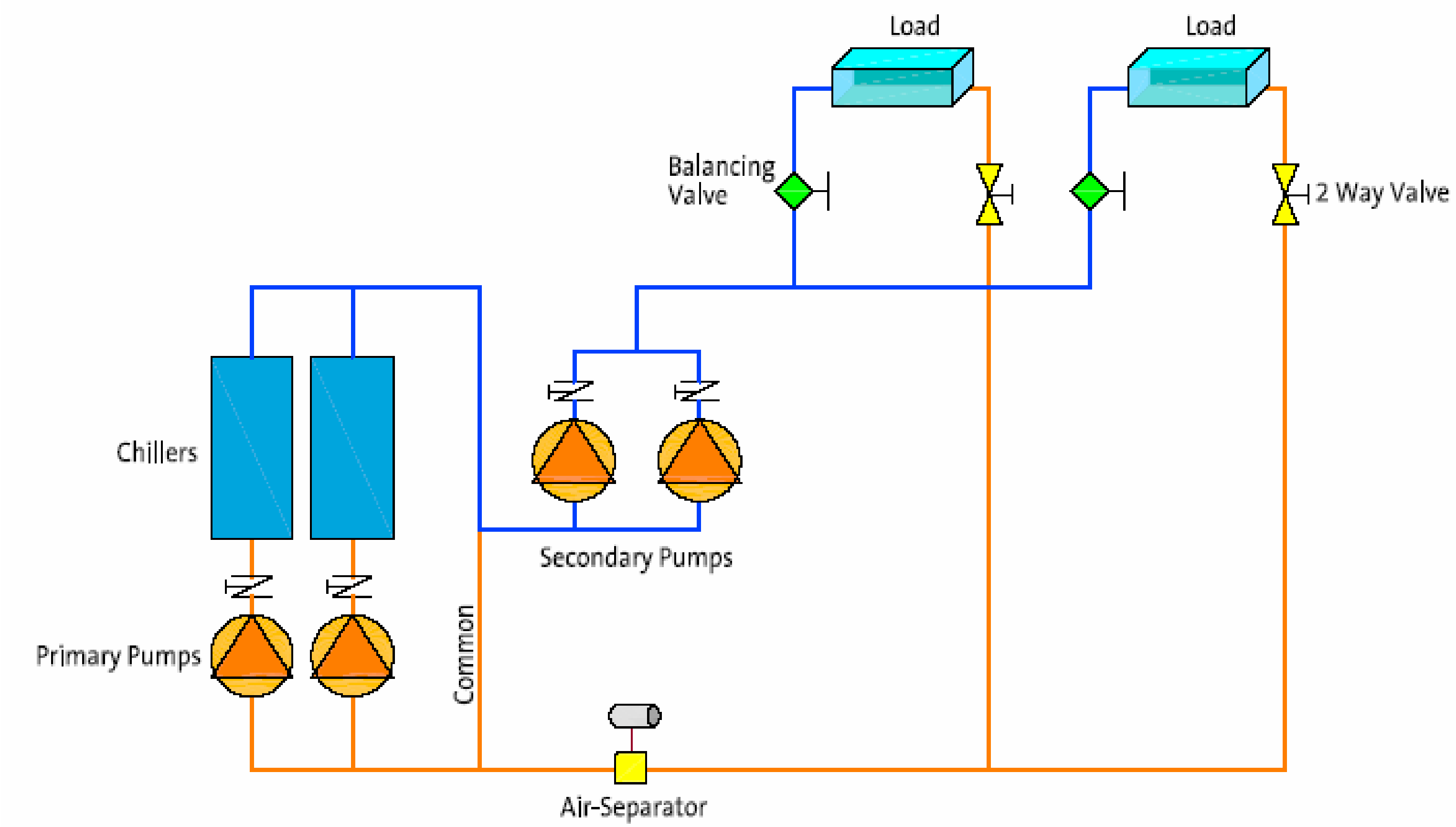


Variable flow through coil
Variable flow through system

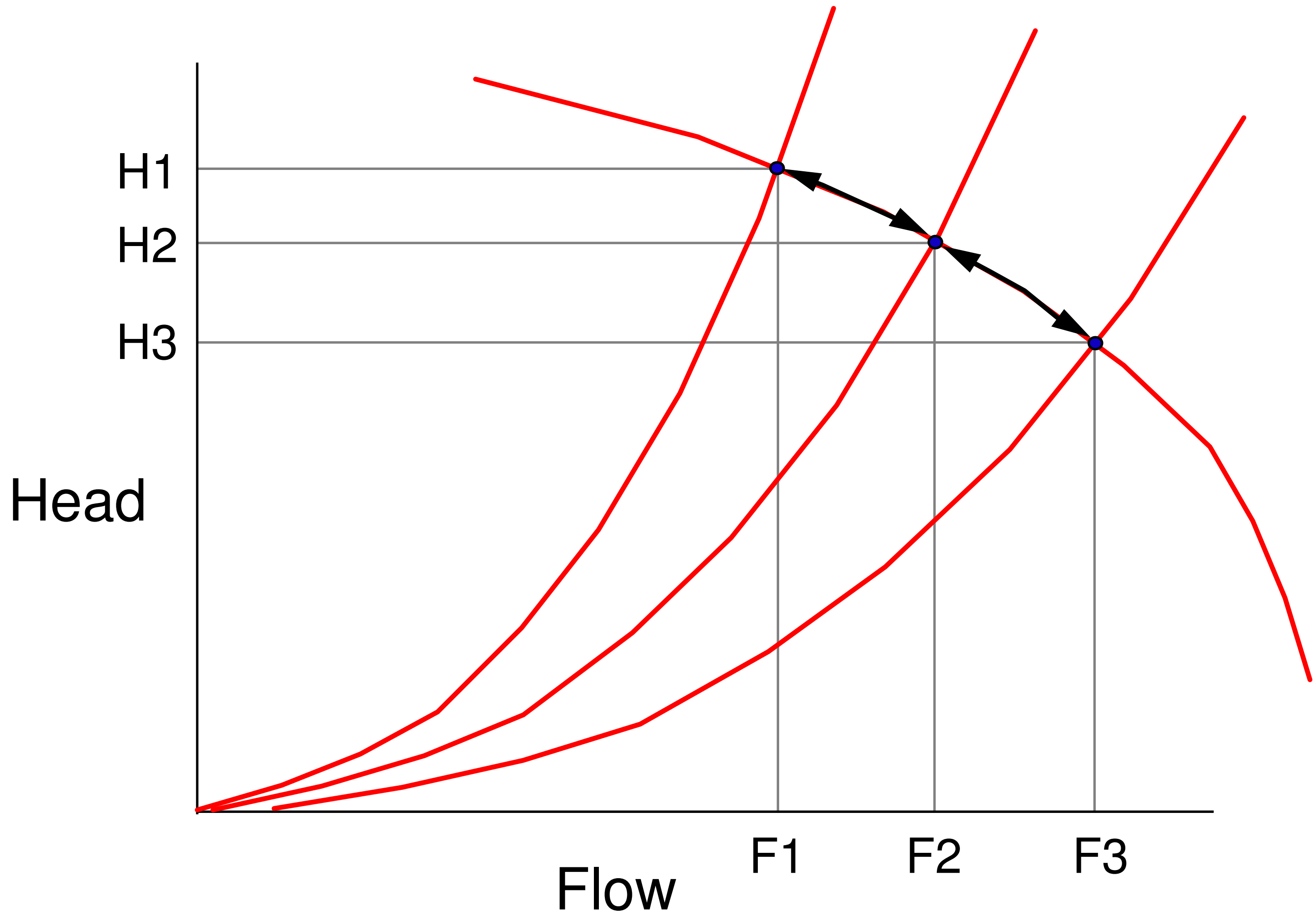
Two Way Valve

Variable Volume Constant Speed

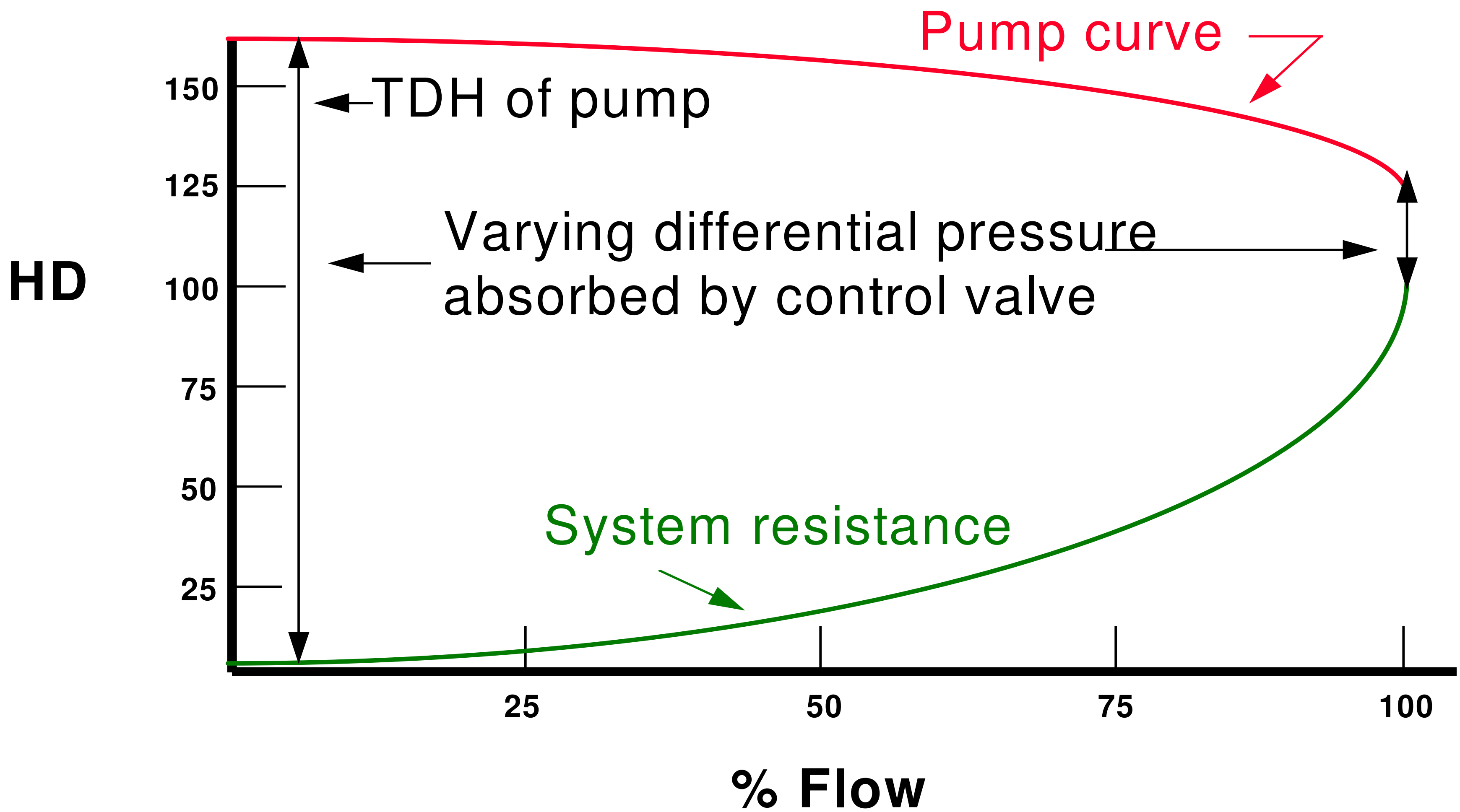
PRIMARY – SECONDARY CIRCUIT



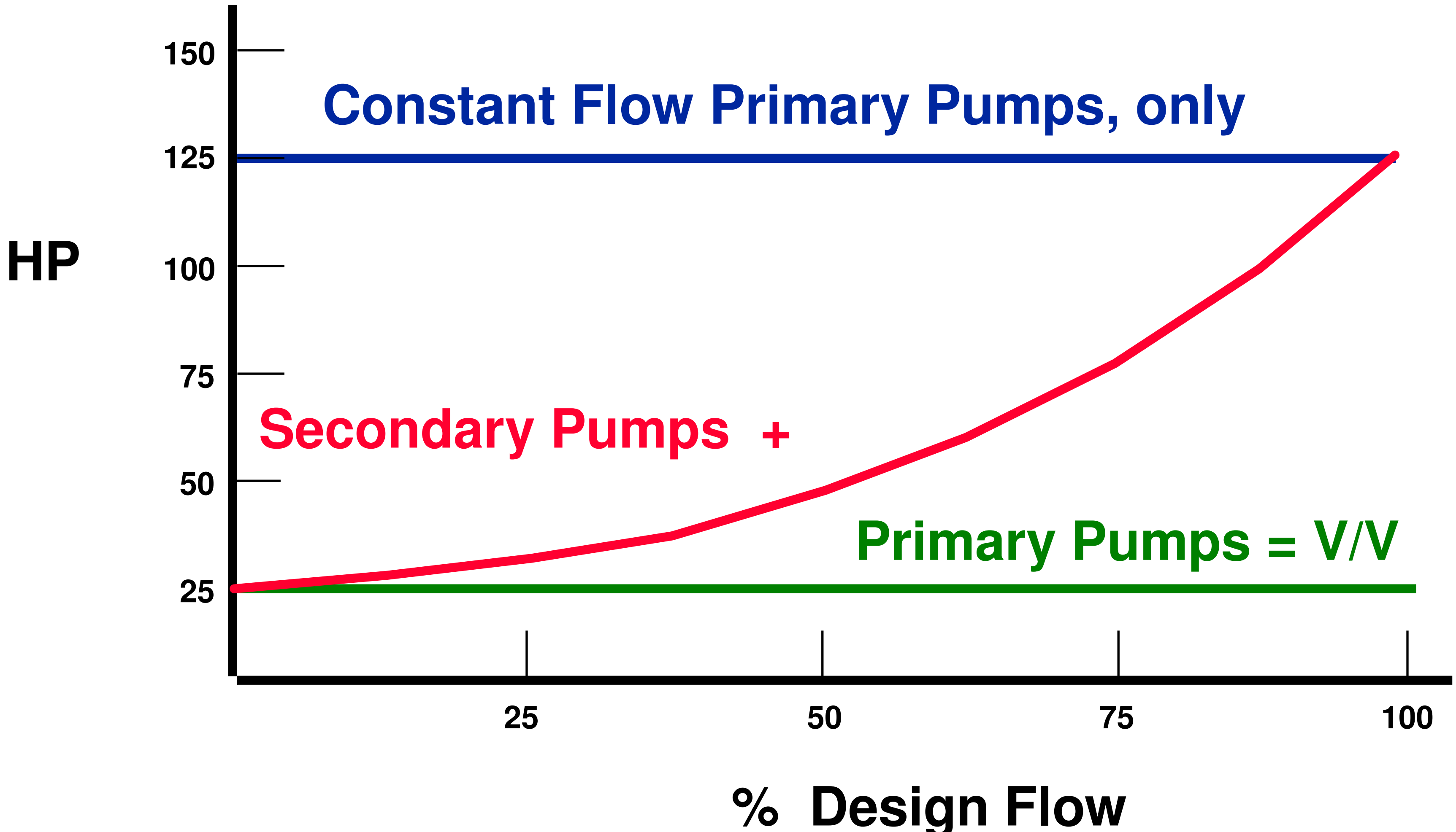
Control Valves Change the Secondary System Curve



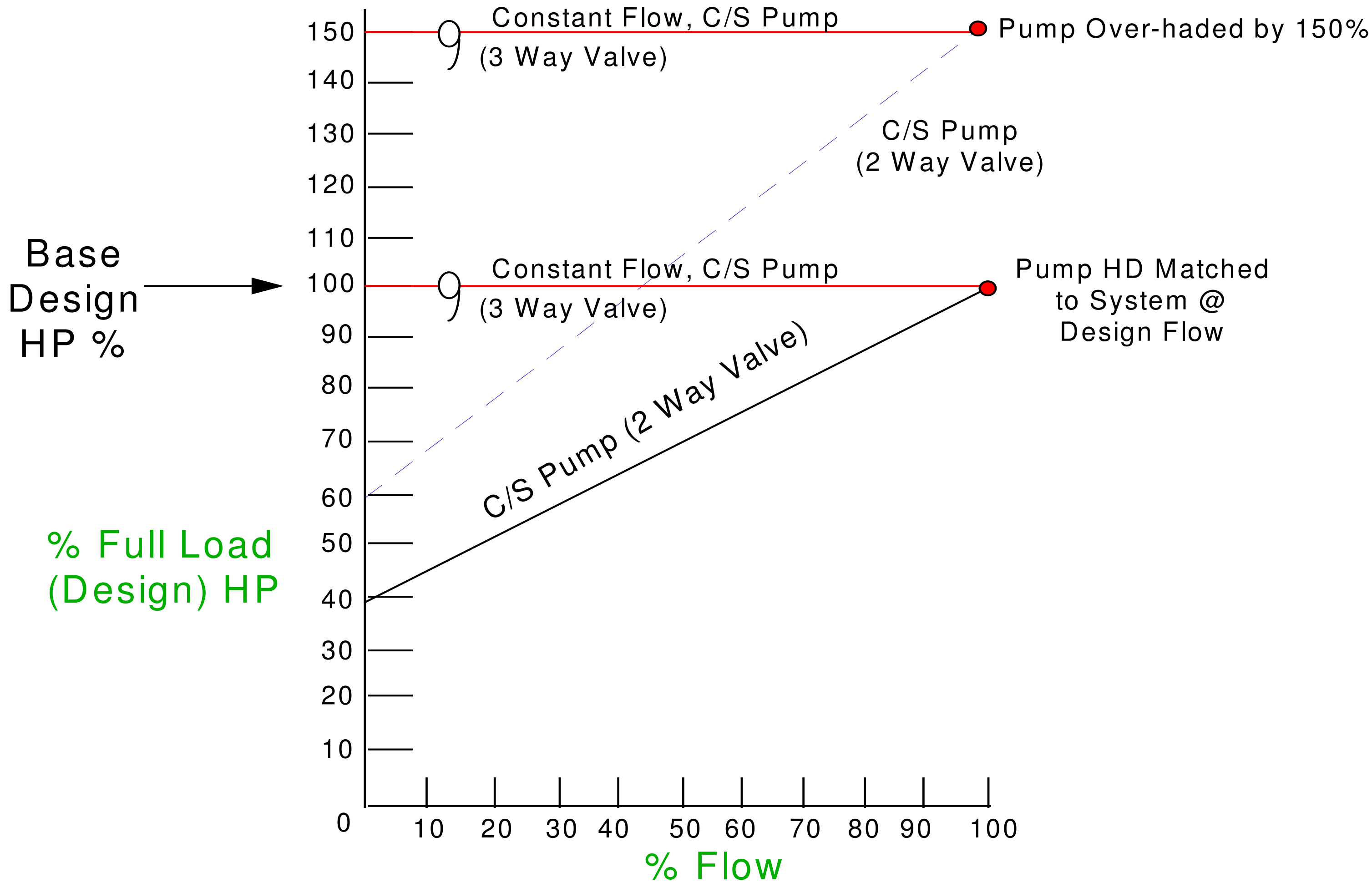
Head Absorbed by 2-way Valves



Pump Horsepower Comparison



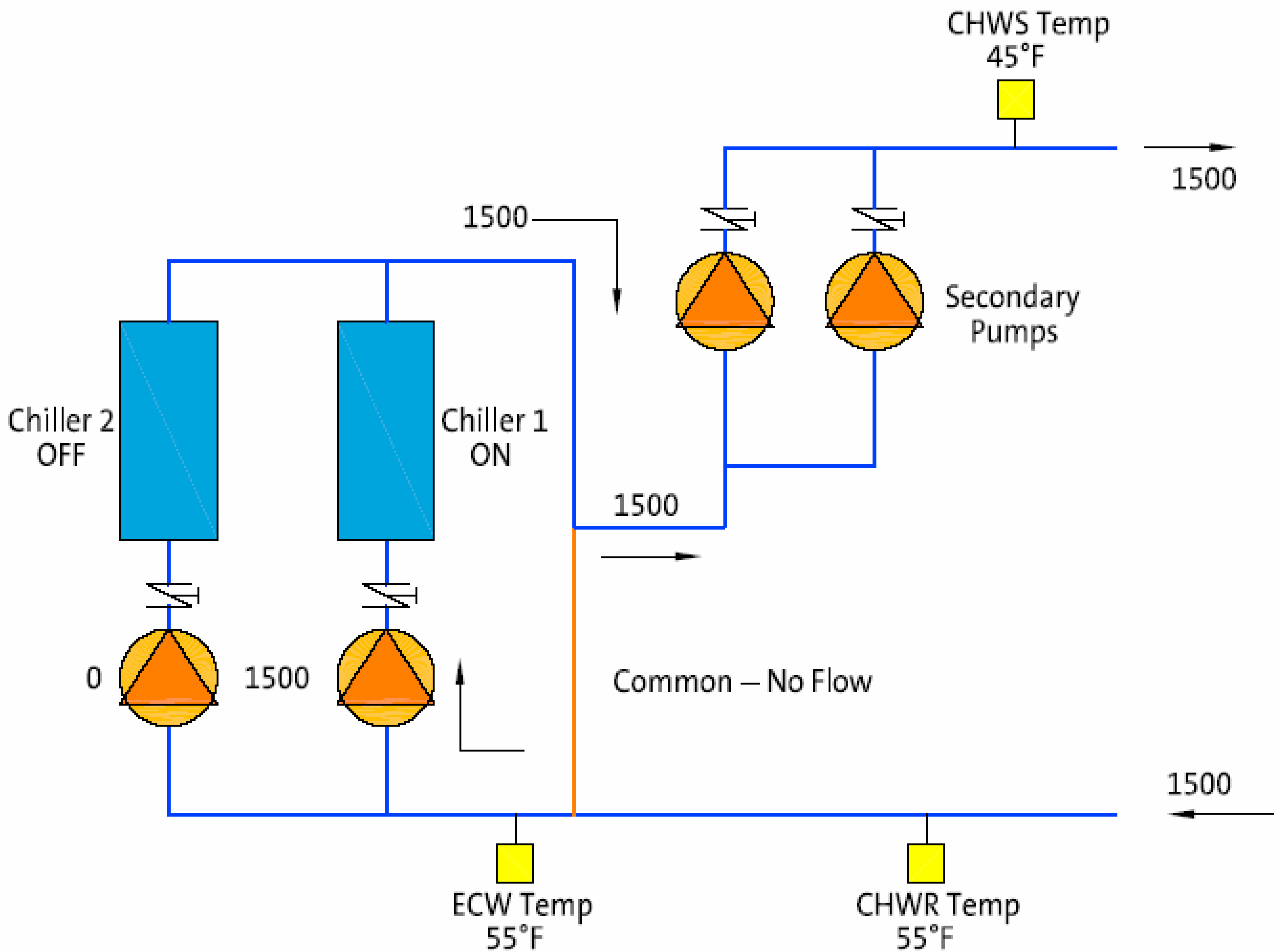
Constant vs Variable Volume



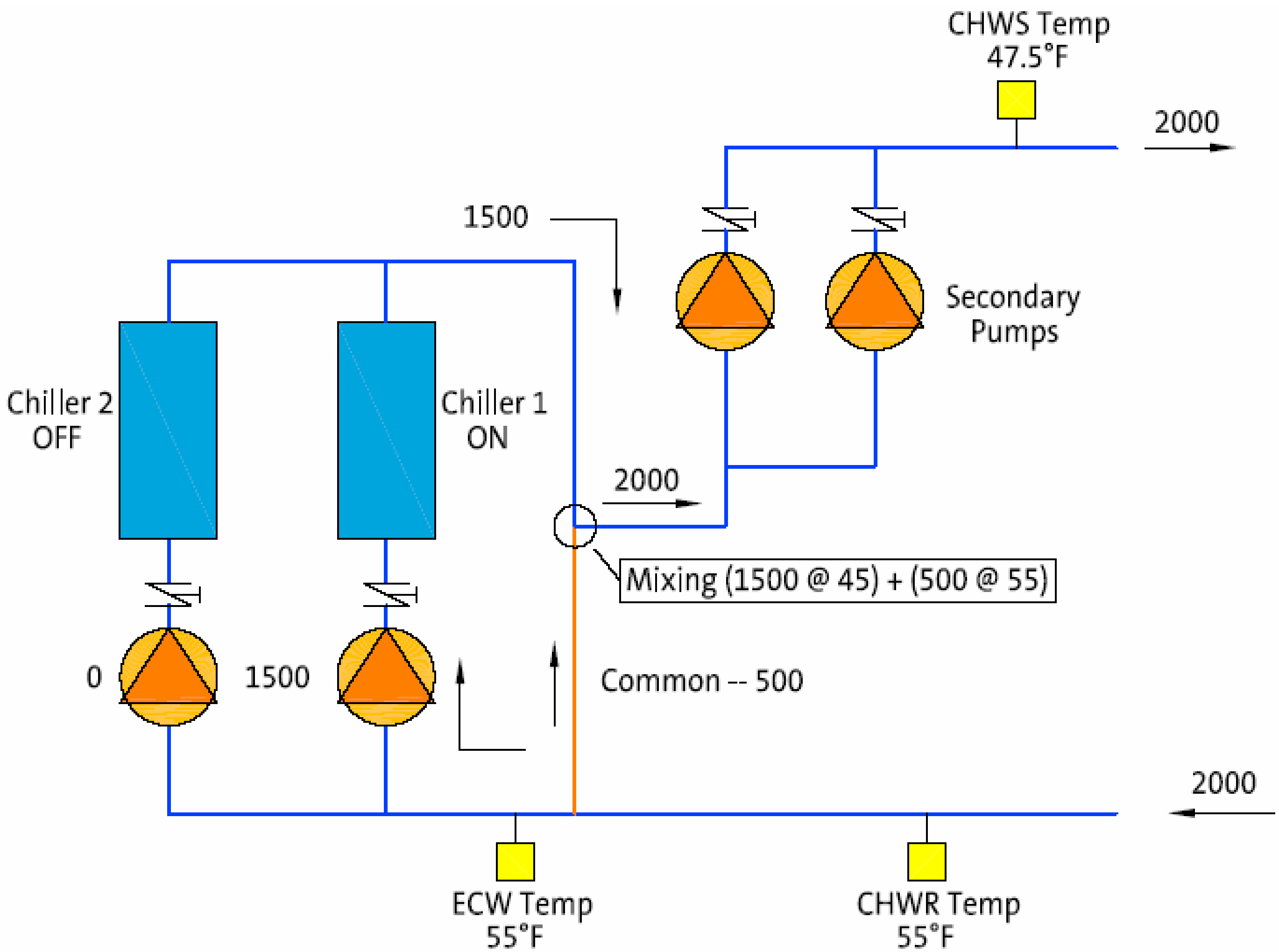
Any Questions?

Step Function of Chillers

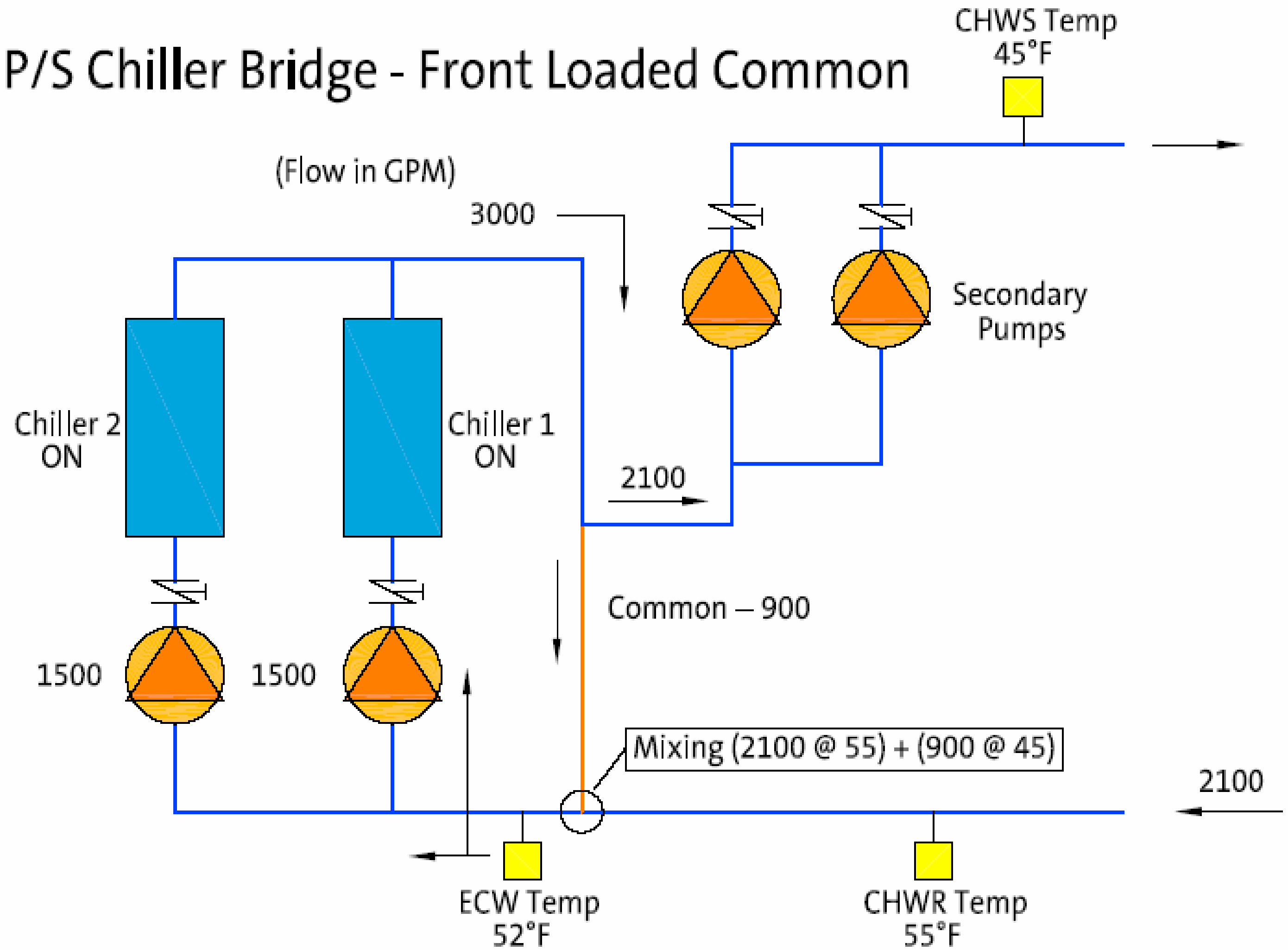
Production = Distribution



Distribution > Production



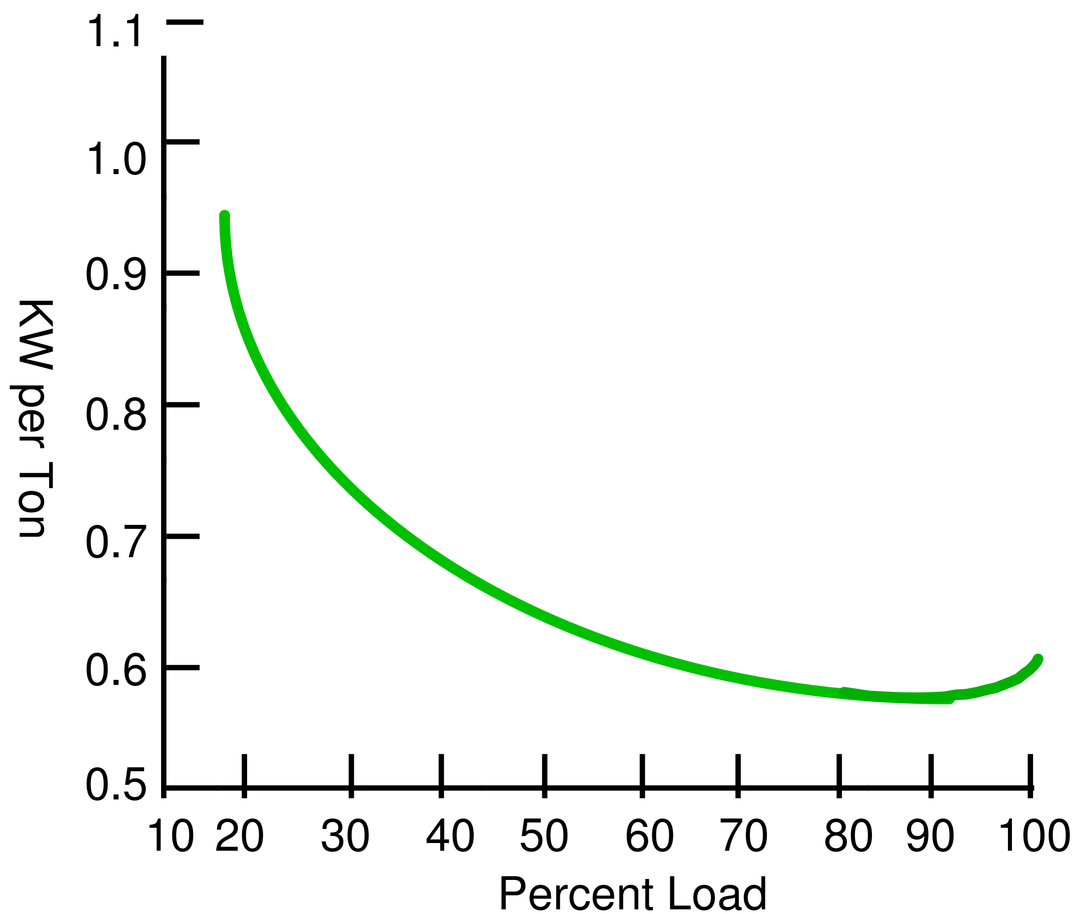
› Production > Distribution



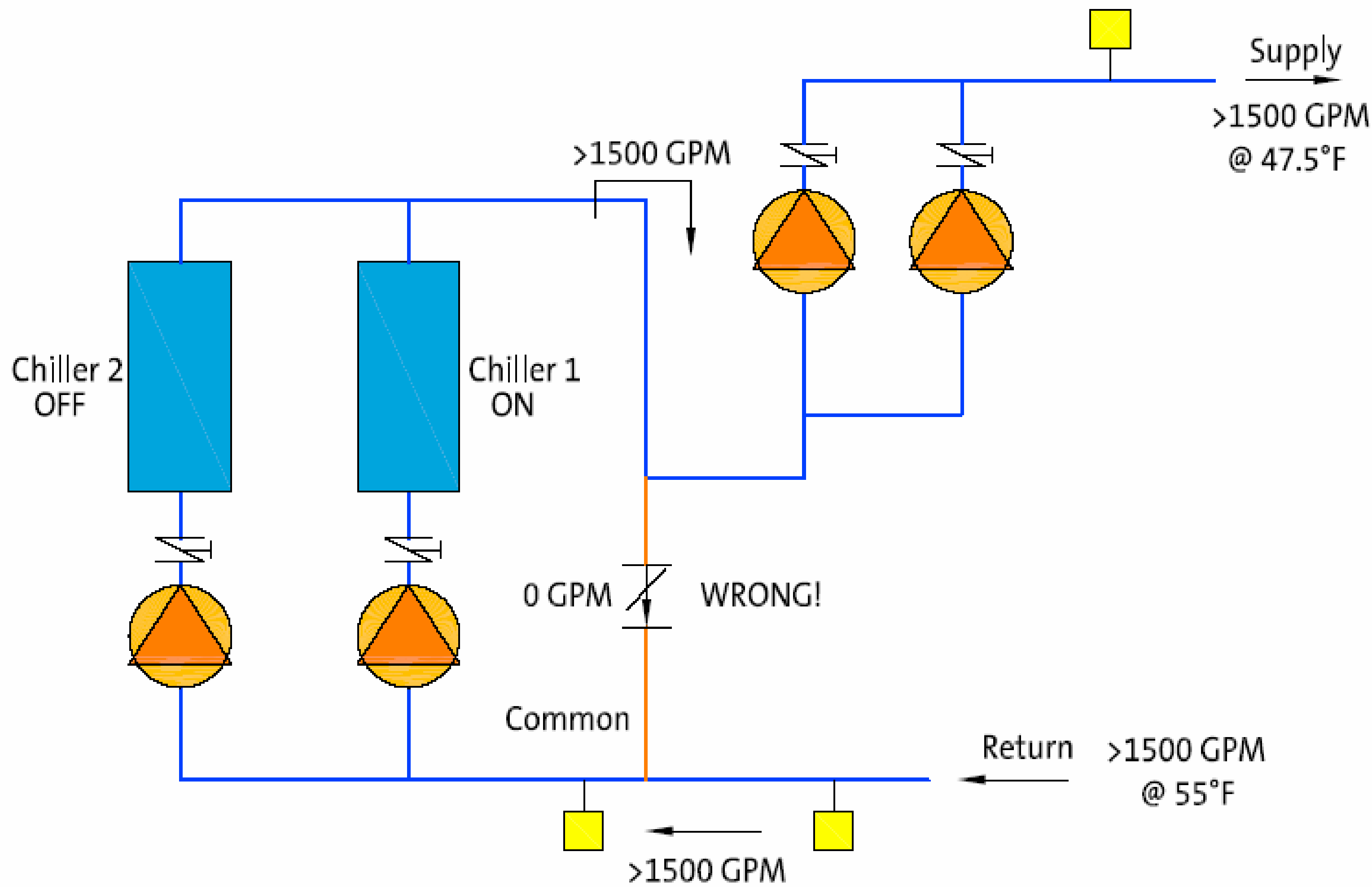
"Loading" a Chiller

- A chiller is a heat transfer device. Like most equipment, it is most efficient at full load.
- To "load" a chiller means:
  - Supply it with its rated flow of water
  - Insure that water is warm enough to permit removal of rated Btu without freezing the water

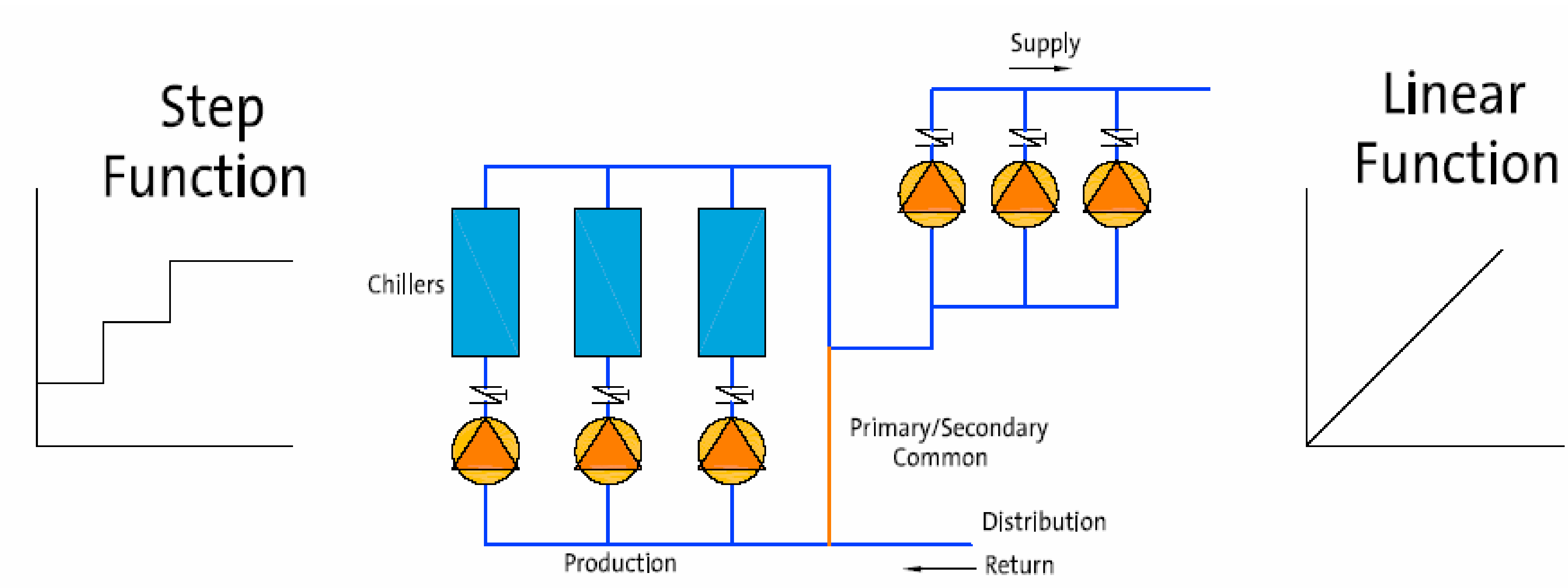
Chiller Performance Curve



Check Valve in Common?



What can we do?



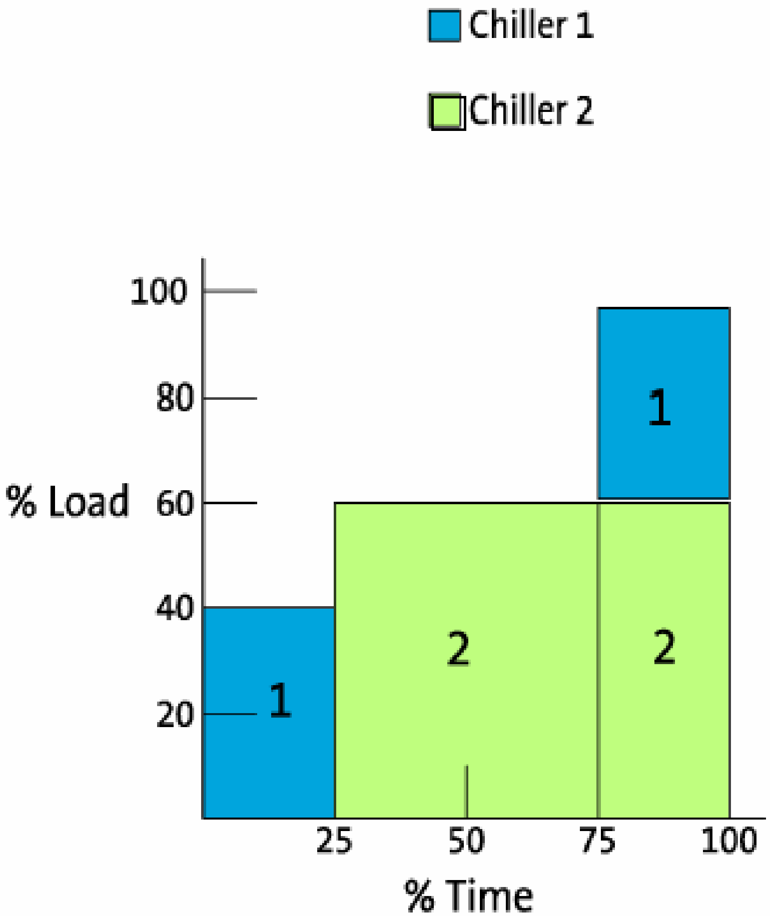
What else can we do?
Reset Supply Temperature

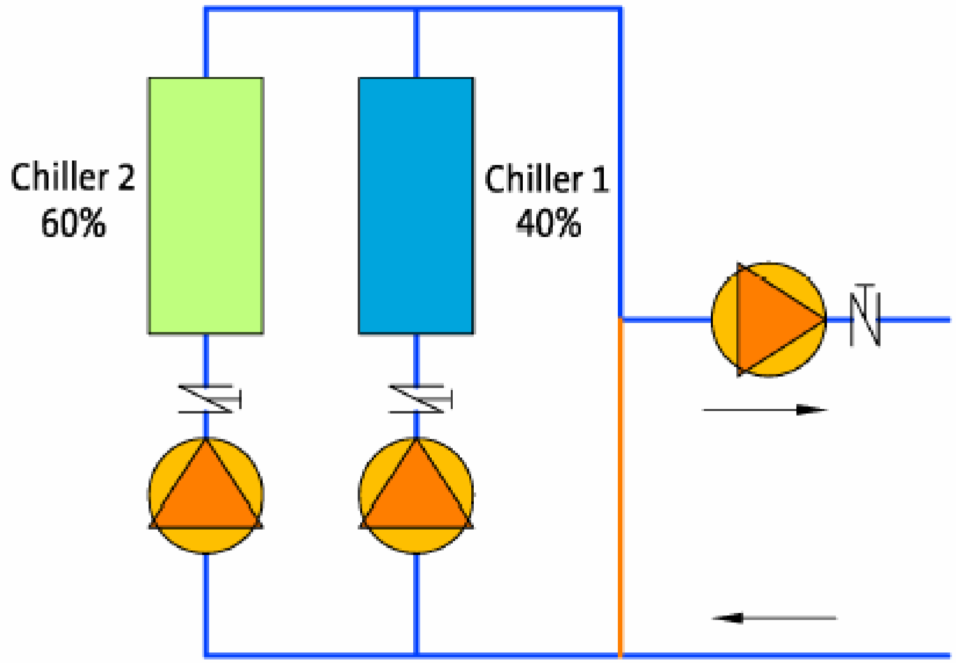
- Lower chiller set point when mixing occurs to maintain a constant temperature to the system.
- Expect increases in cost of chiller operation at lower set point: 1-3% per degree of reset.
- Delays start of the next chiller.

What else can we do?

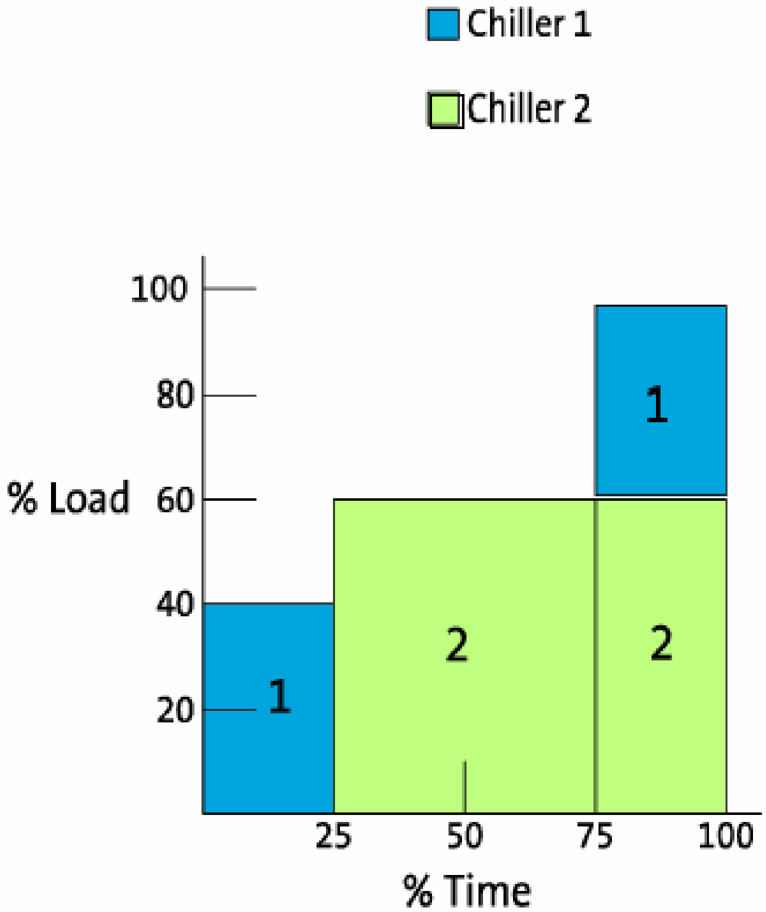
- Coils that are selected at higher supply temperatures will not be impaired by small changes.
- Loads that require fixed temperatures may use a small chiller to reverse the effects of mixing.

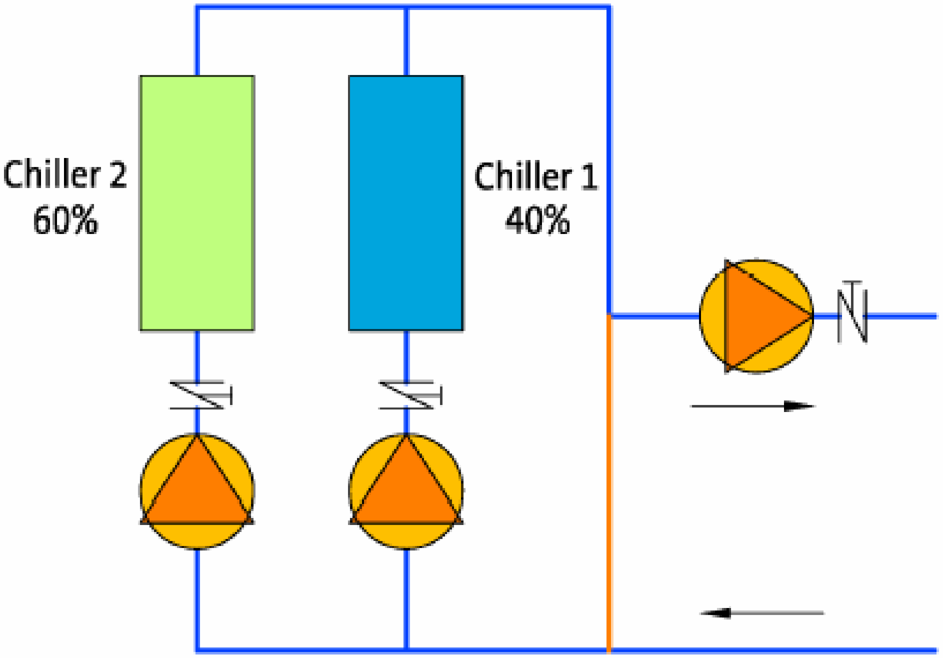
Multiple Chillers



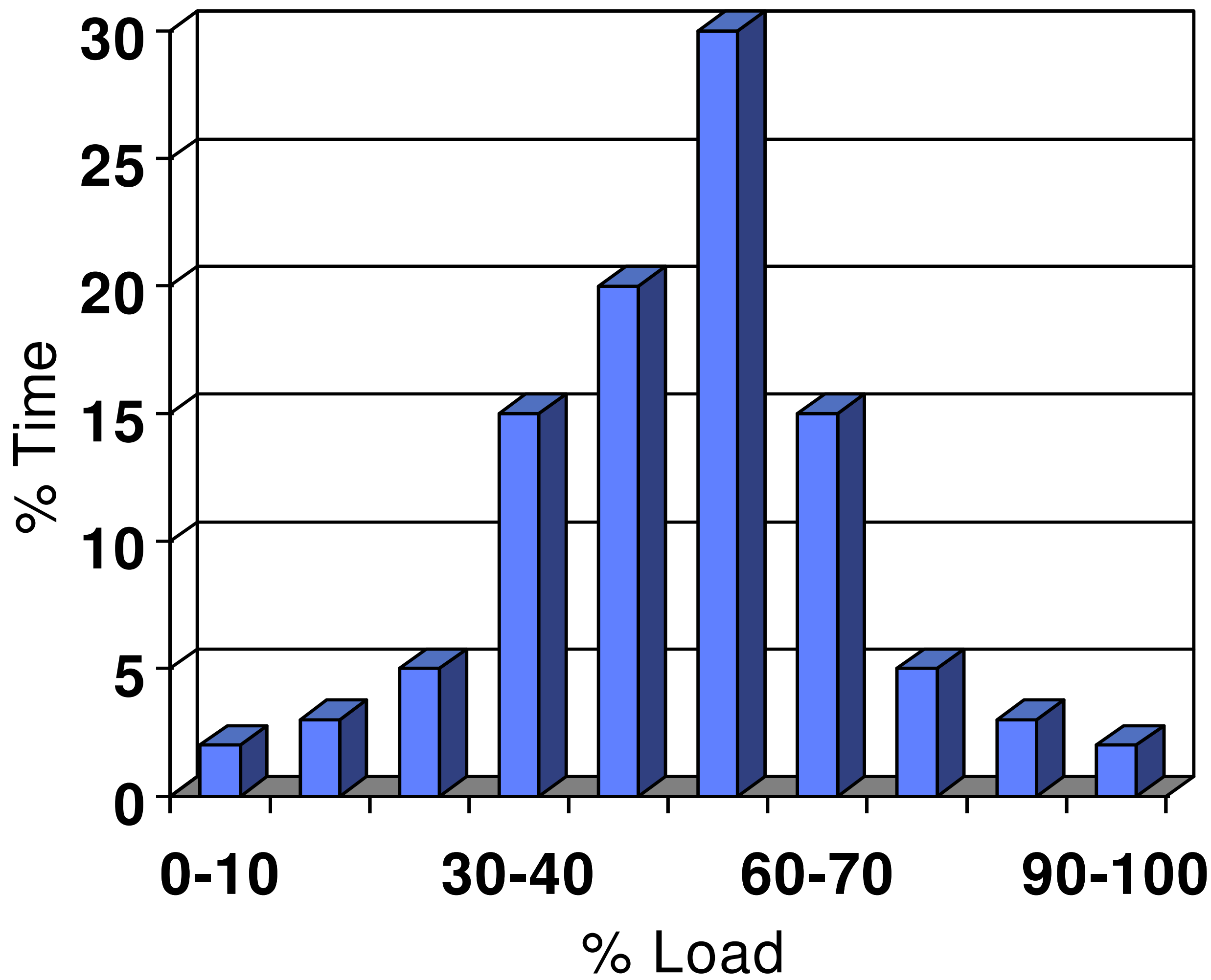


60/40 Chiller Split to Help Minimize Low Part Load Operation

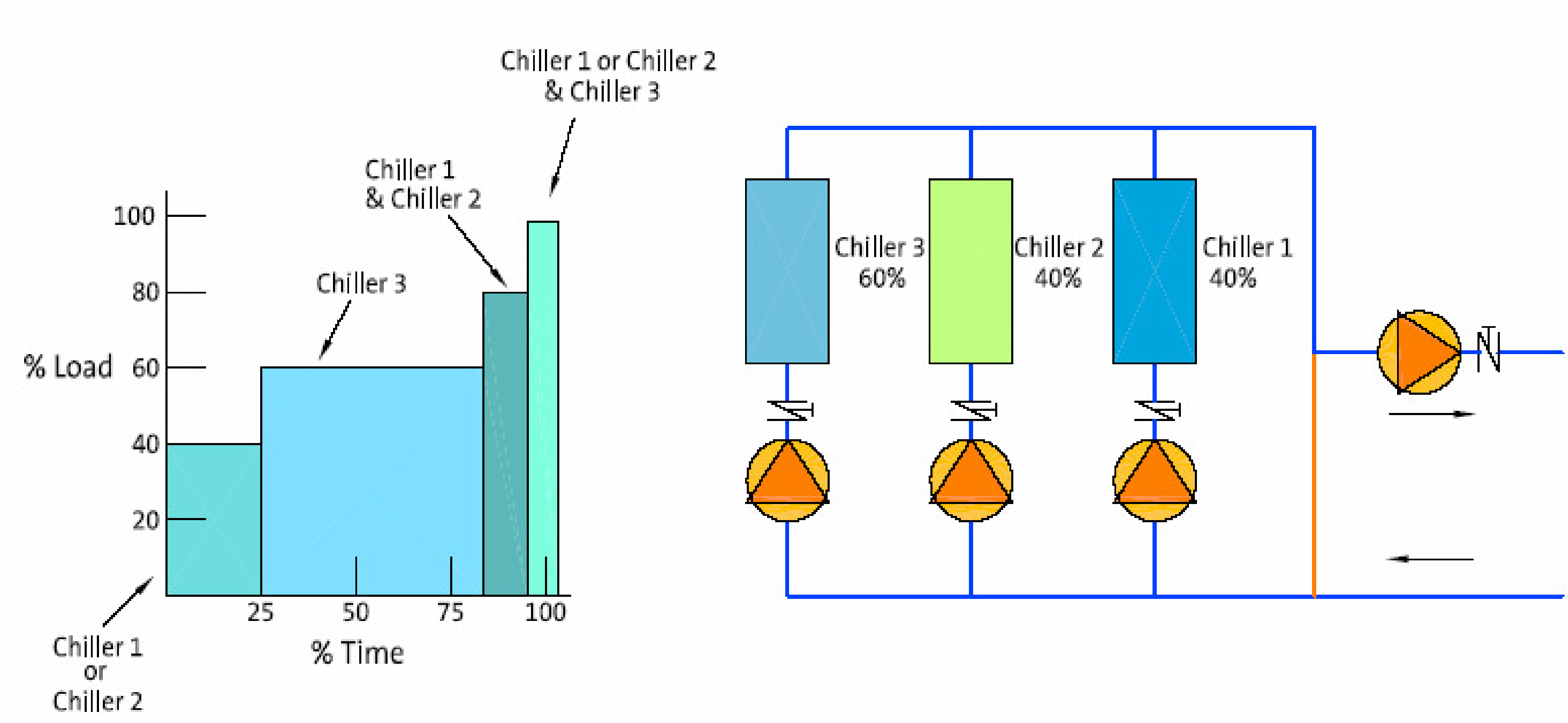




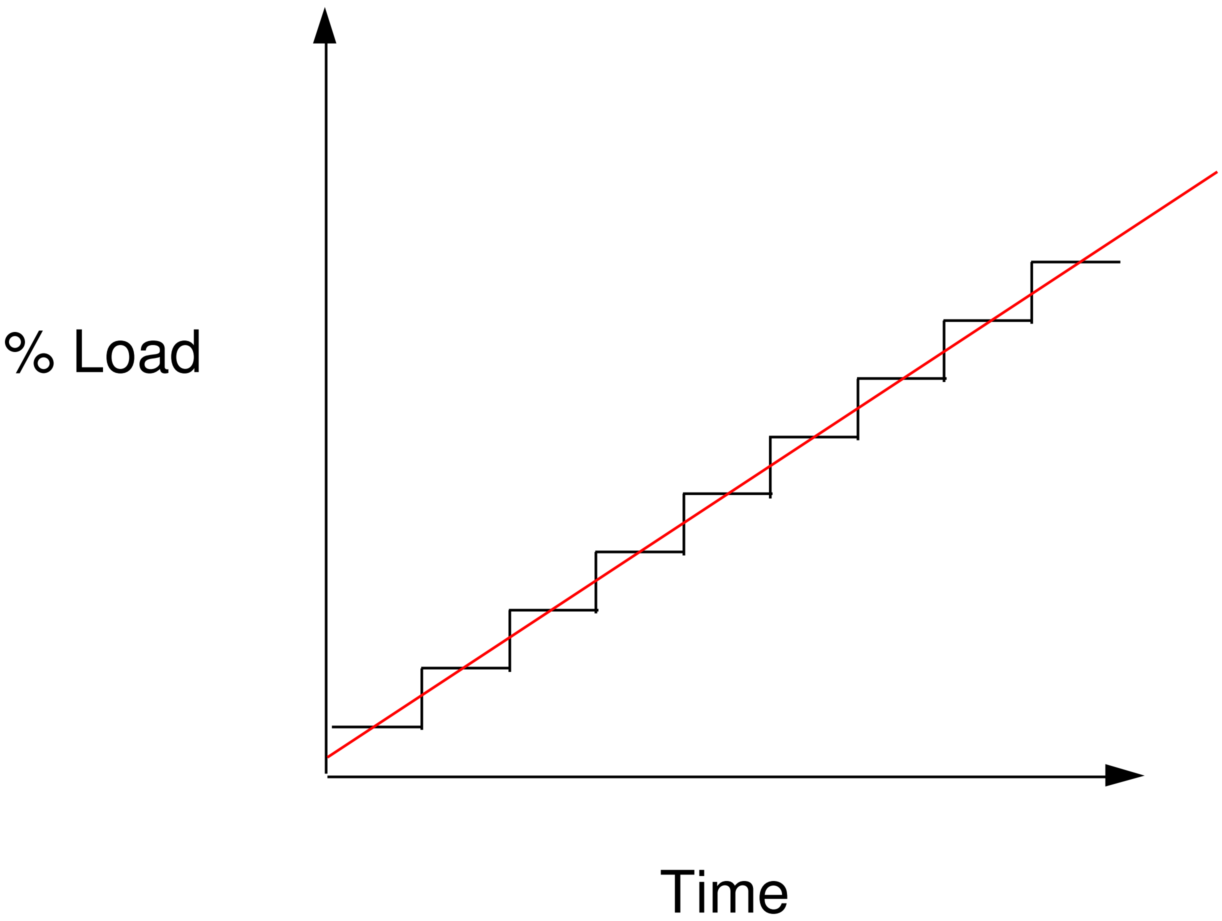
Typical Load Profile



Three Unequally Sized Chillers

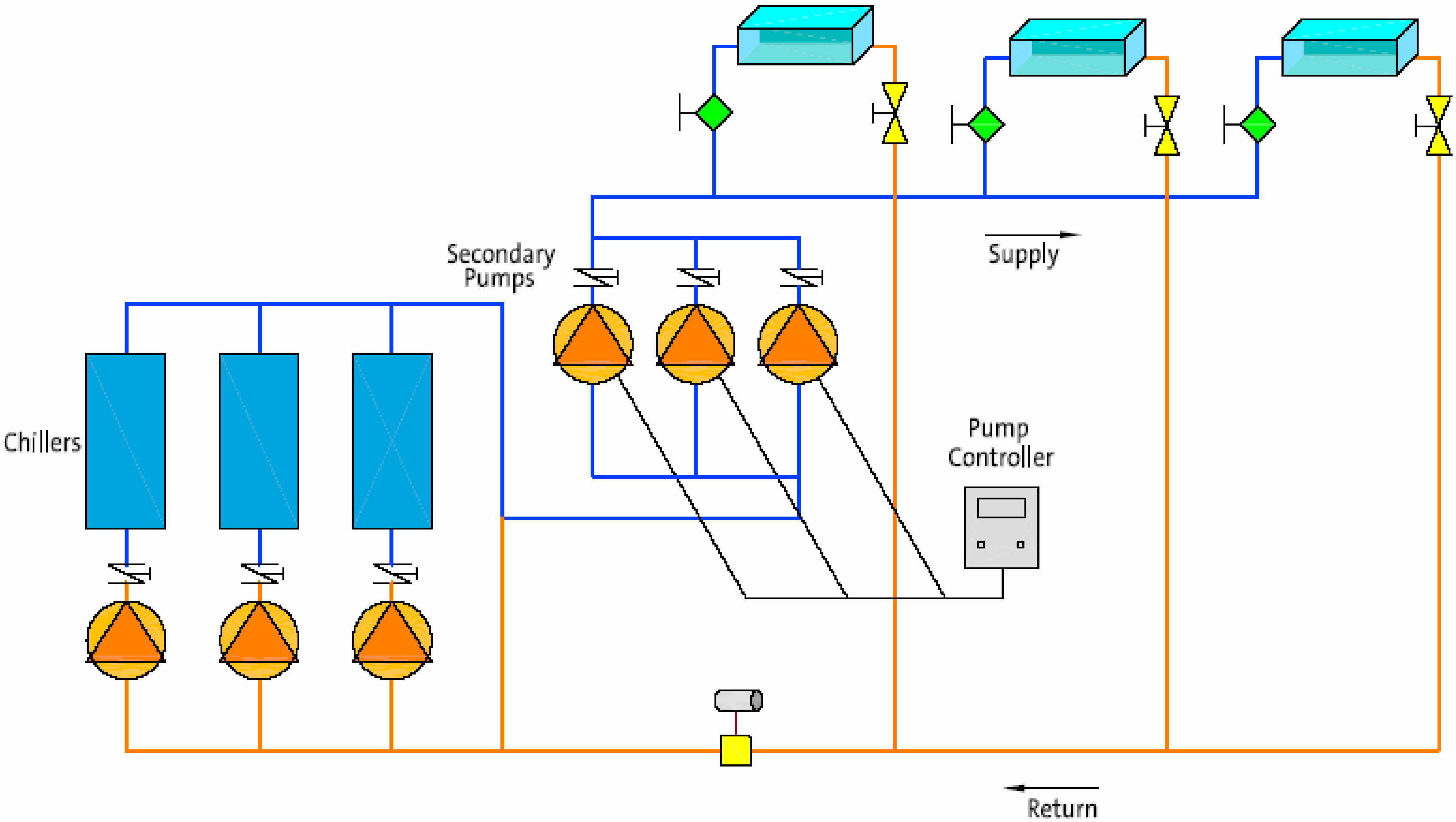


Approaching Flow = Load

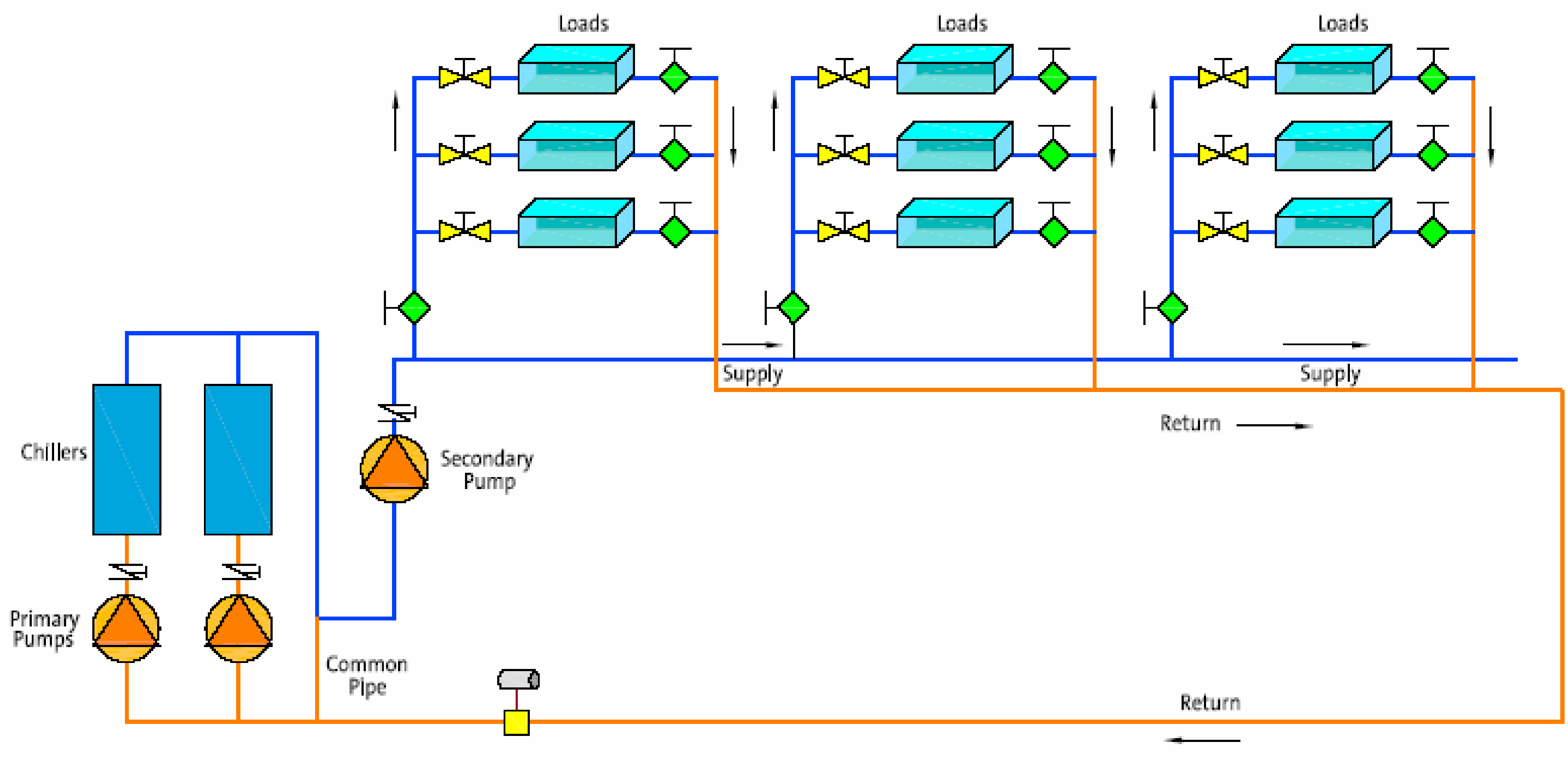


Any Questions?

Two Pipe Direct Return



Two Pipe Reverse Return

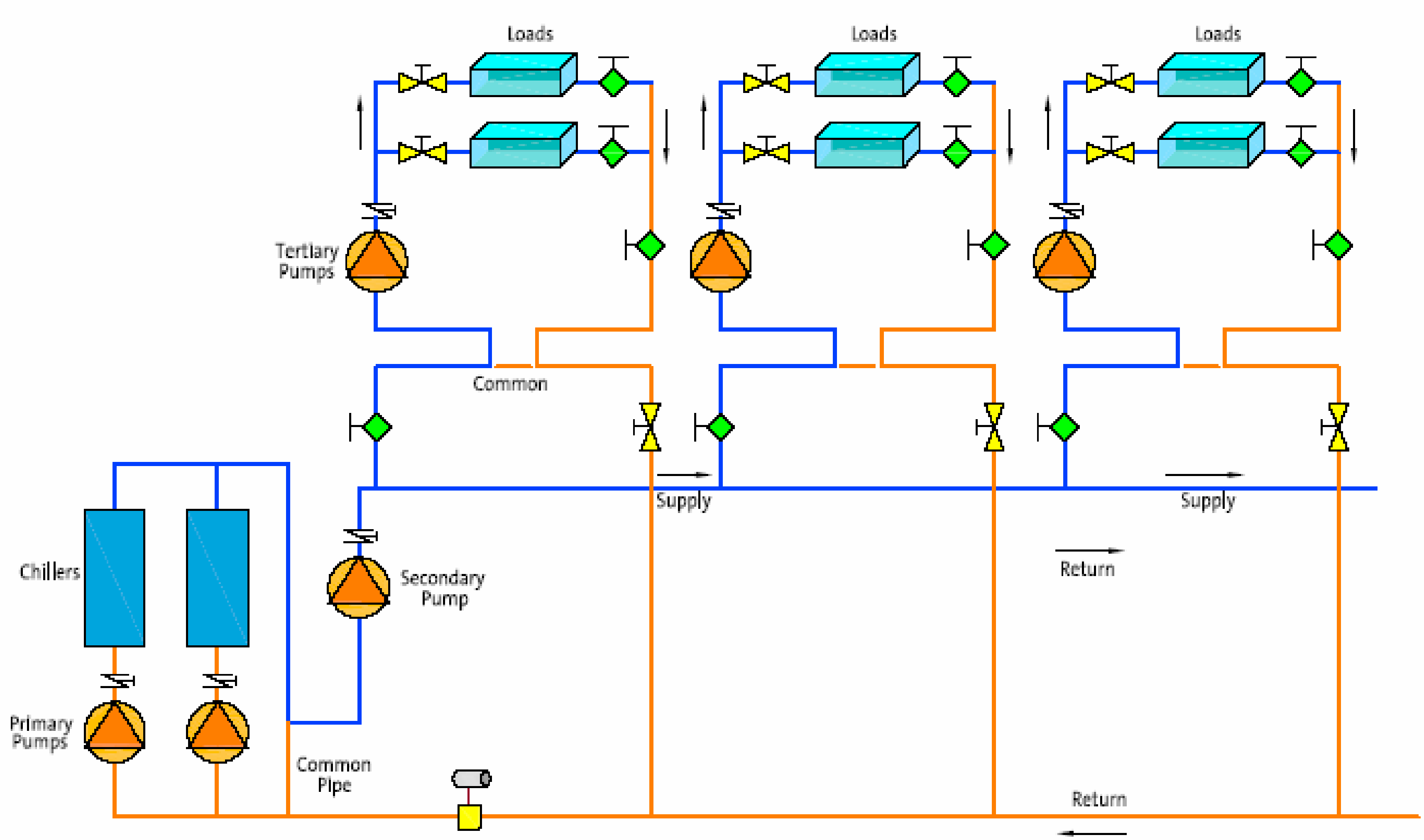


Primary-Secondary Pumping.

- Simplest to install.
- Simplest to operate.
- Flexible in design for present and future.
- Efficient to operate.

- May over-pressurize near zones.

Primary-Secondary-Tertiary

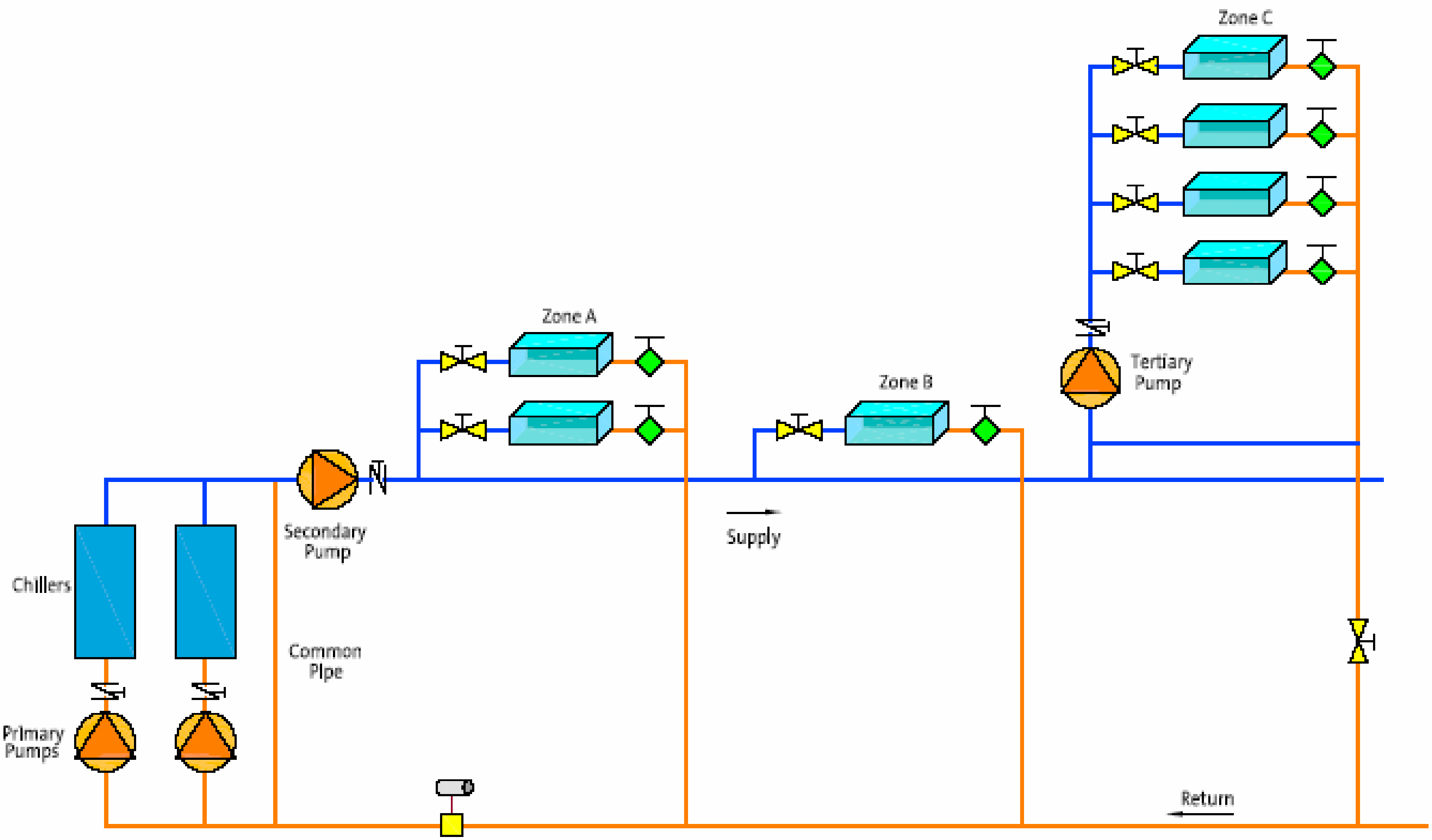


Primary-Secondary-Tertiary Pumping.

- Best piping flexibility.
- Best expansion flexibility.
- Provides hydraulic decoupling.
- Efficient to operate.

- May require added horsepower.
- Requires additional pumps and piping.
- Increased controls complexity.

Primary-Secondary-Tertiary Hybrid

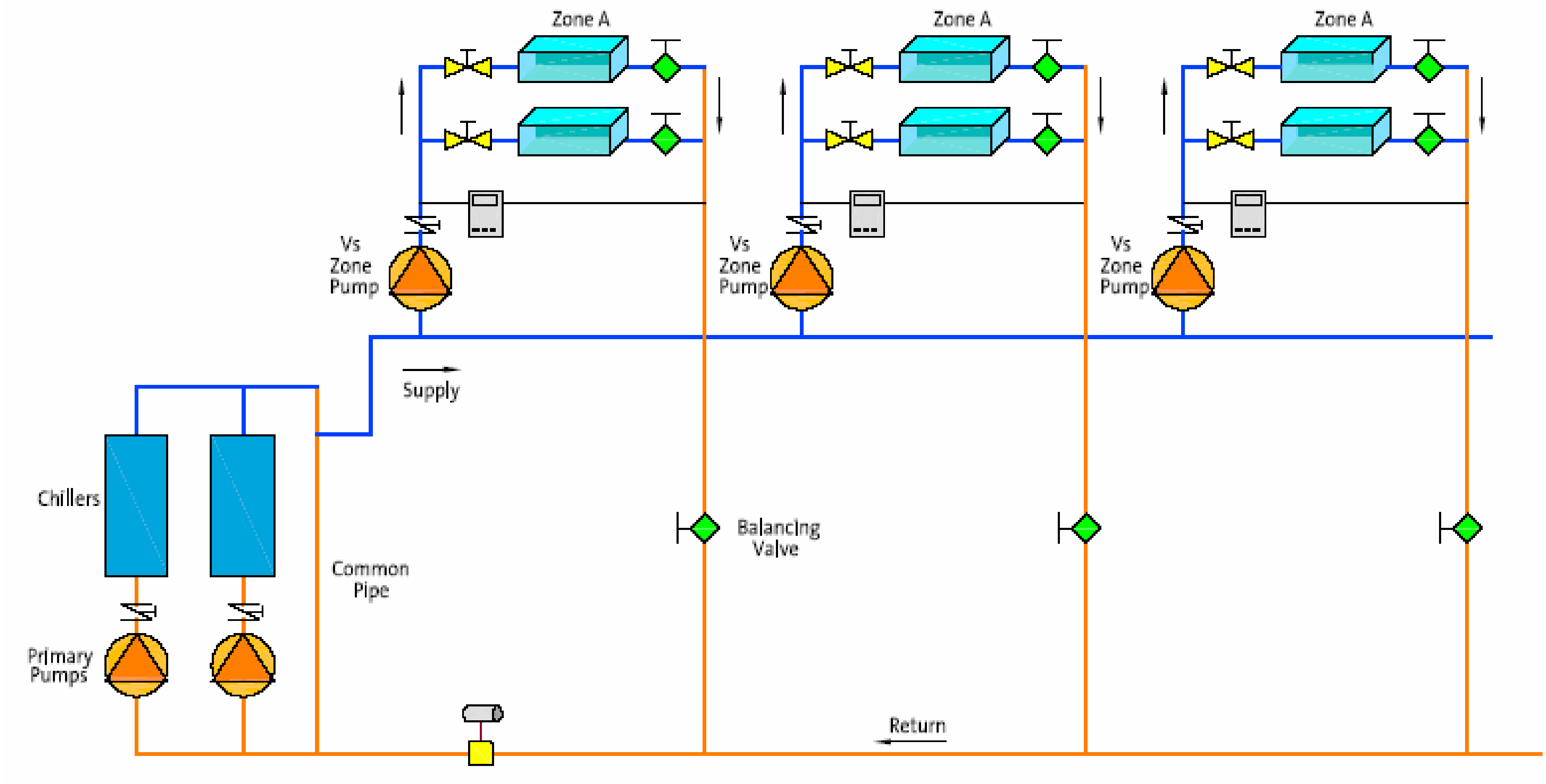


Primary-Secondary-Tertiary Hybrid Pumping.

- Low present horsepower.
- Low future horsepower.
- Good piping flexibility.
- Good expansion flexibility.
- Provides hydraulic decoupling.

- May require added horsepower
- Requires additional pumps and piping.
- Increased controls complexity.

Primary-Secondary Zone Pumping



Primary-Secondary Zone Pumping.

- Low ‘built out’ horsepower.
- Low system head.

- Increased control complexity.
- Present horsepower total higher due to future needs.
- Present pumps sized for future requirements.
- Difficult to apply in retrofits projects.

Any Questions?

Variable Volume Variable Speed

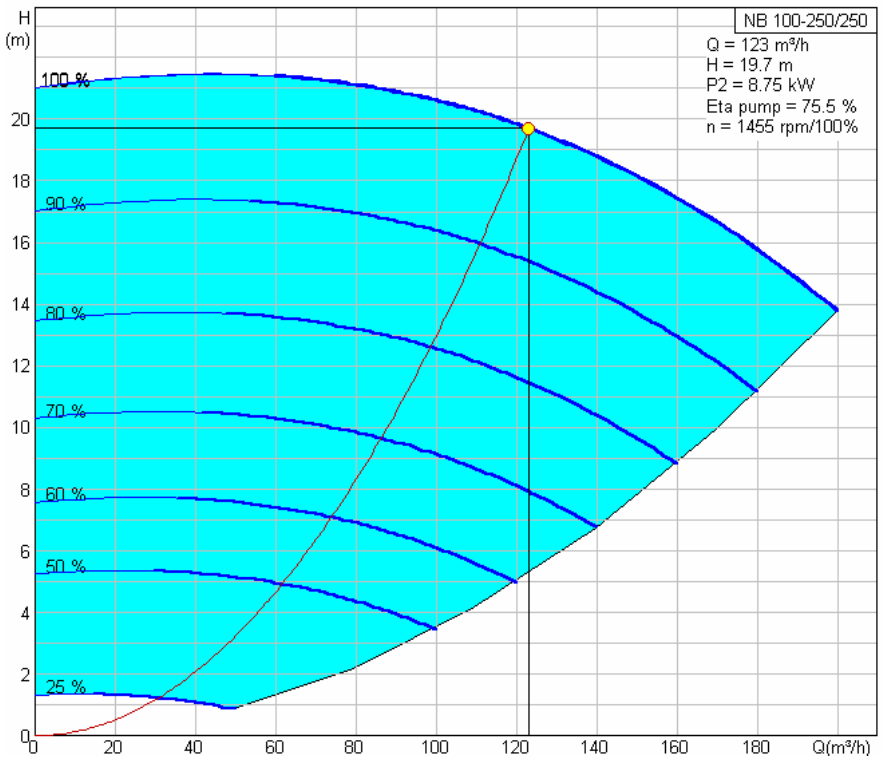
Why Do We Need Variable Speed Secondary Pumps ???

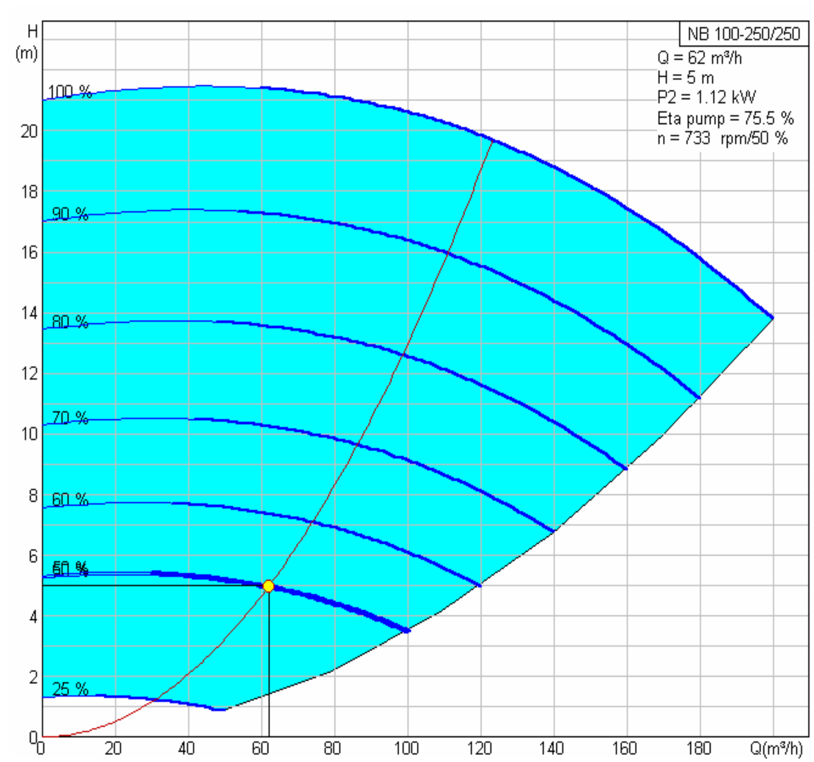
- For Energy Saving….
- For better & optimise operation….

How Do We Achieve This Reduction In Power Consumption ??

By Using Variable Frequency Drive and Logic controller with the Secondary Pumps….

Power Comparison at Reduced Speed



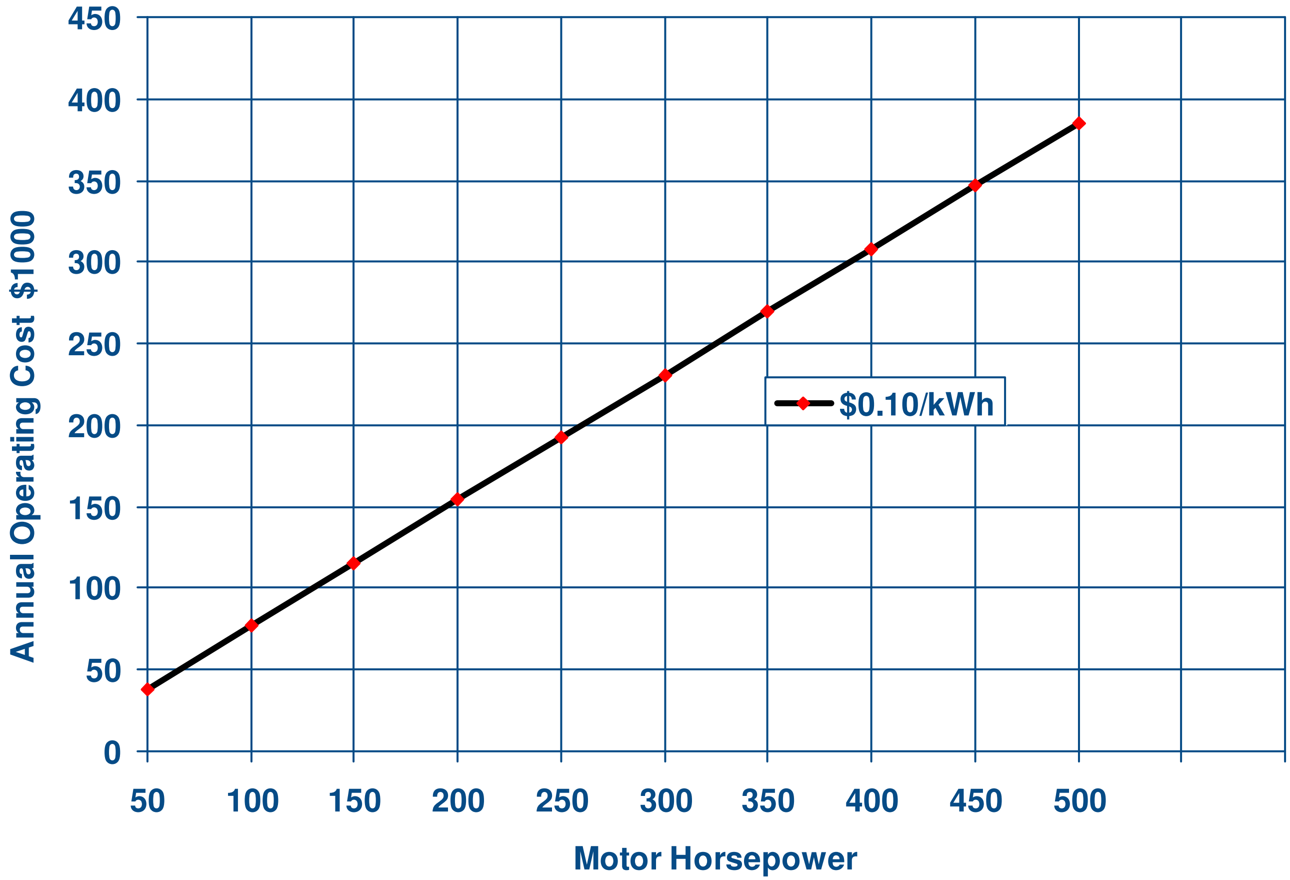


Basic Law which helps in achieving this – Affinity law

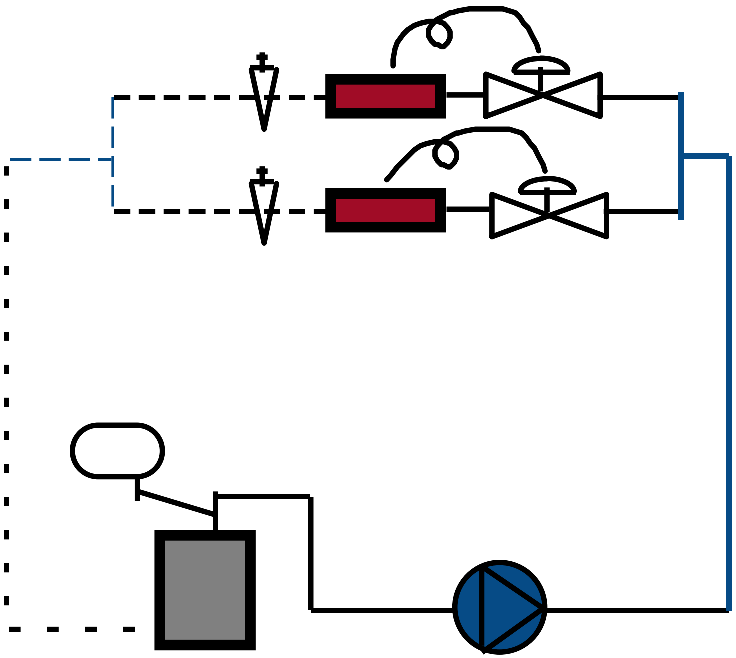
1. $Flow_2 = Flow_1(Speed_2/ Speed_1)$
2. $Head_2 = Head_1(Speed_2/ Speed_1)^2$
3. $BKW_2 = BKW_1(Speed_2/ Speed_1)^3$

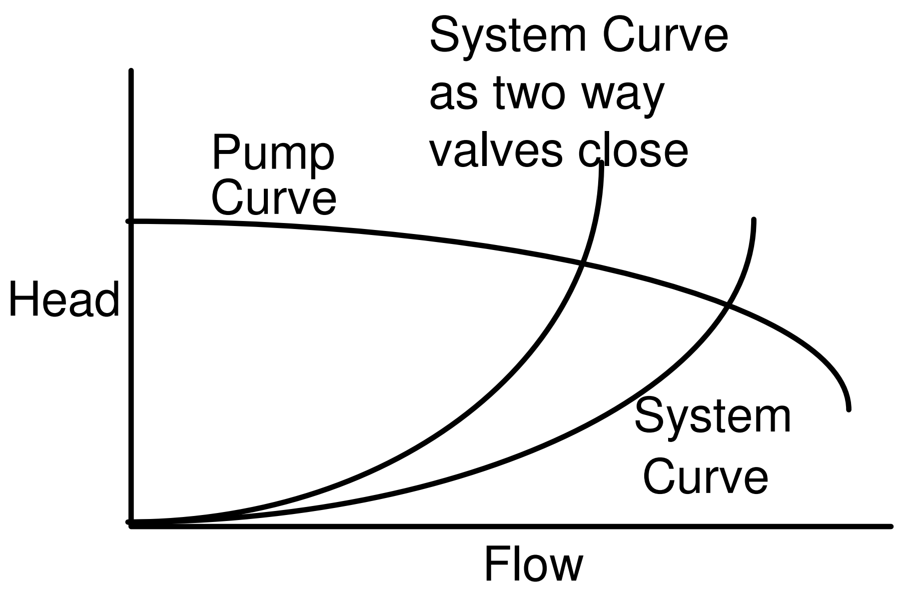
If Diameter of Impeller is to be trimmed then instead of speed the same can be used in above formulas.

Operating Cost

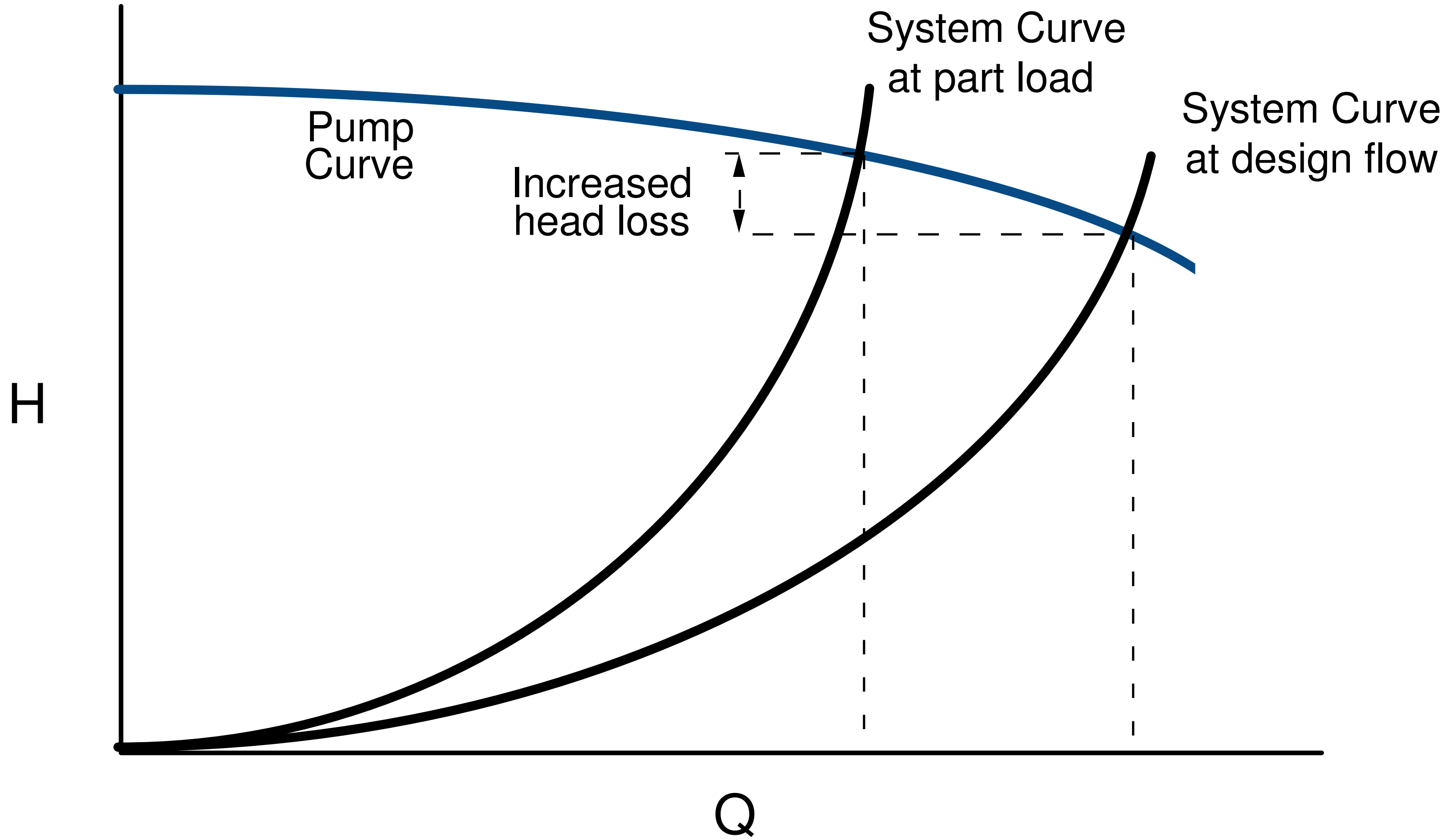


Variable flow system

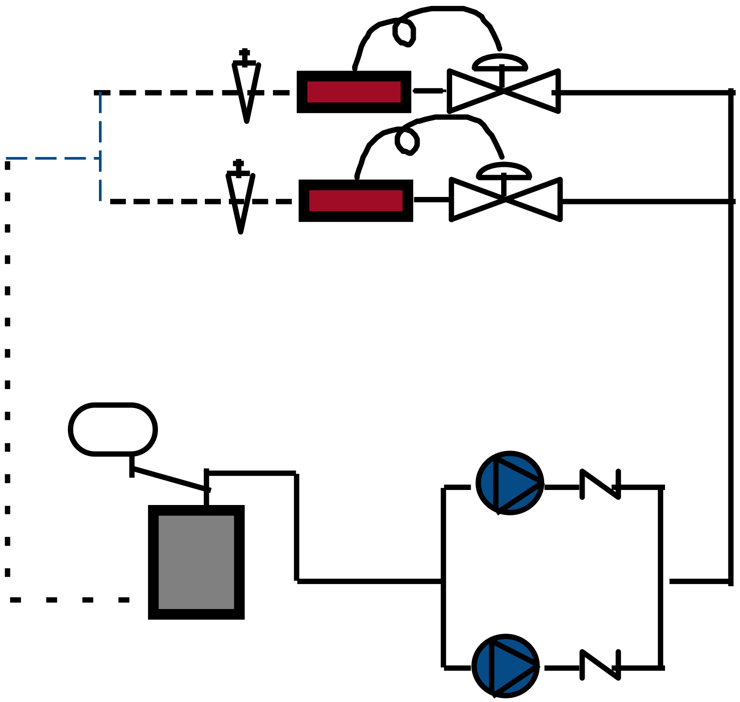


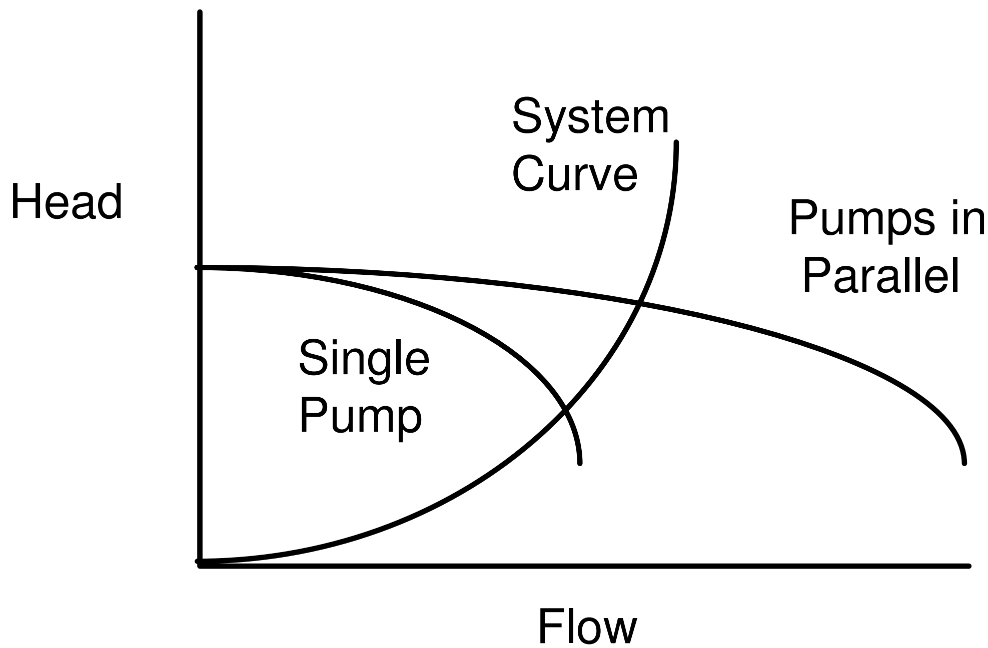


Energy savings offset

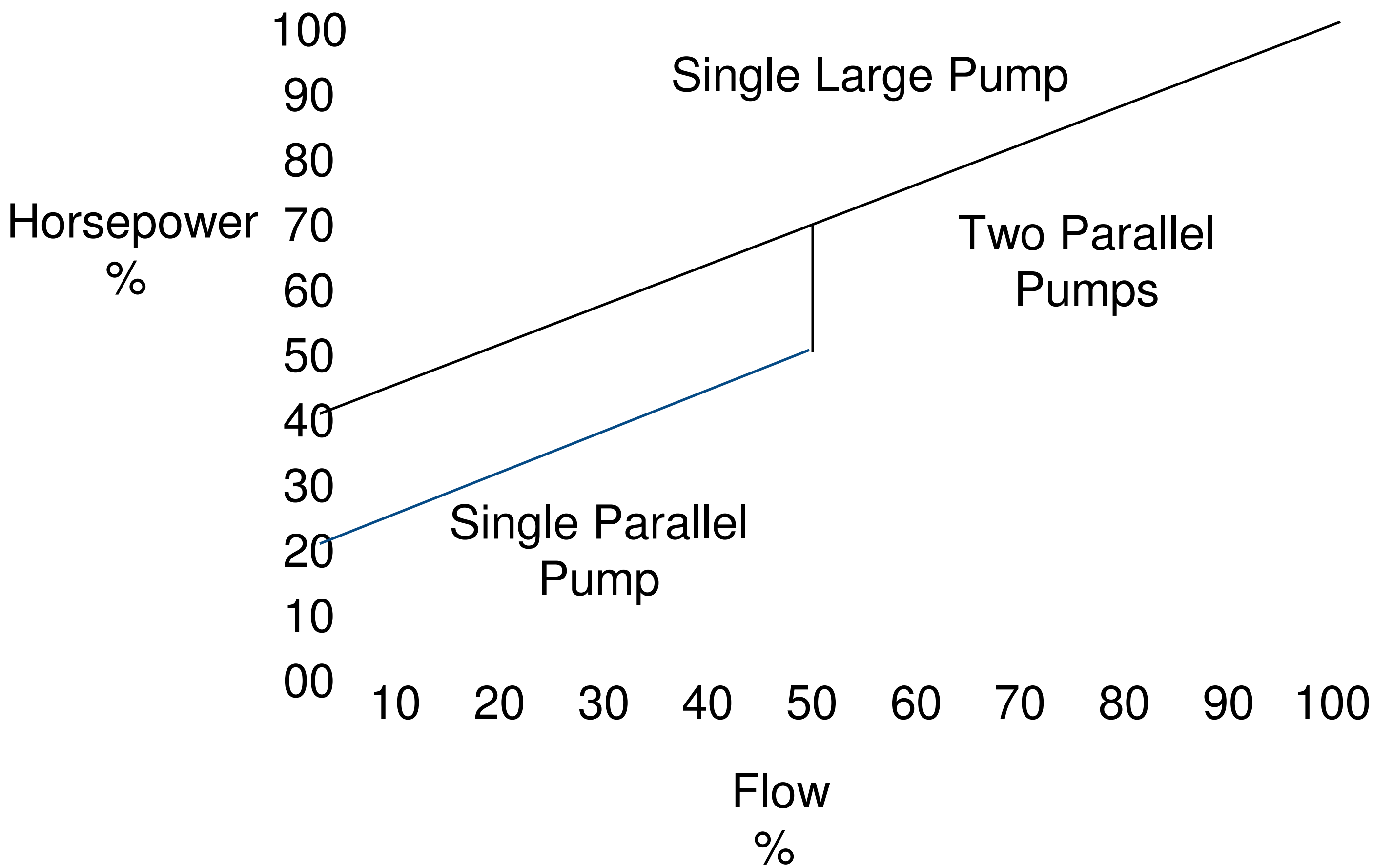


Pumps in parallel

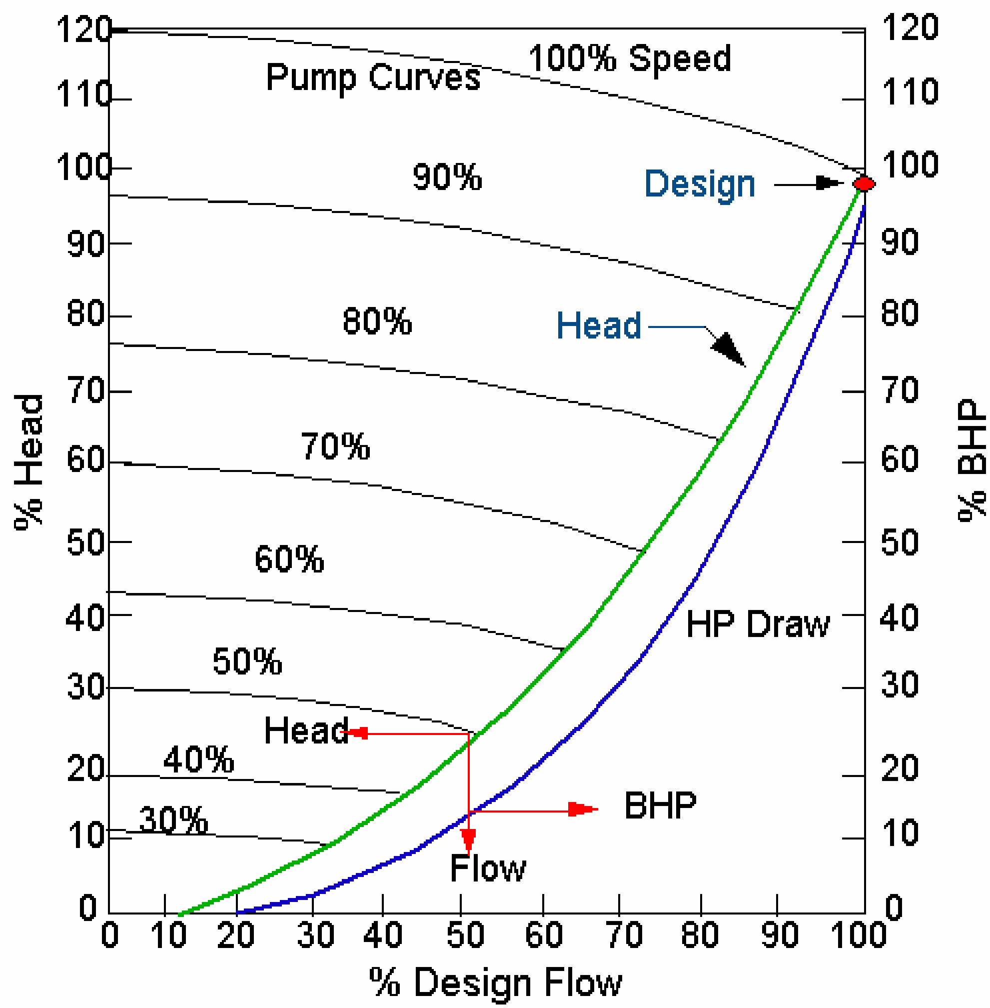




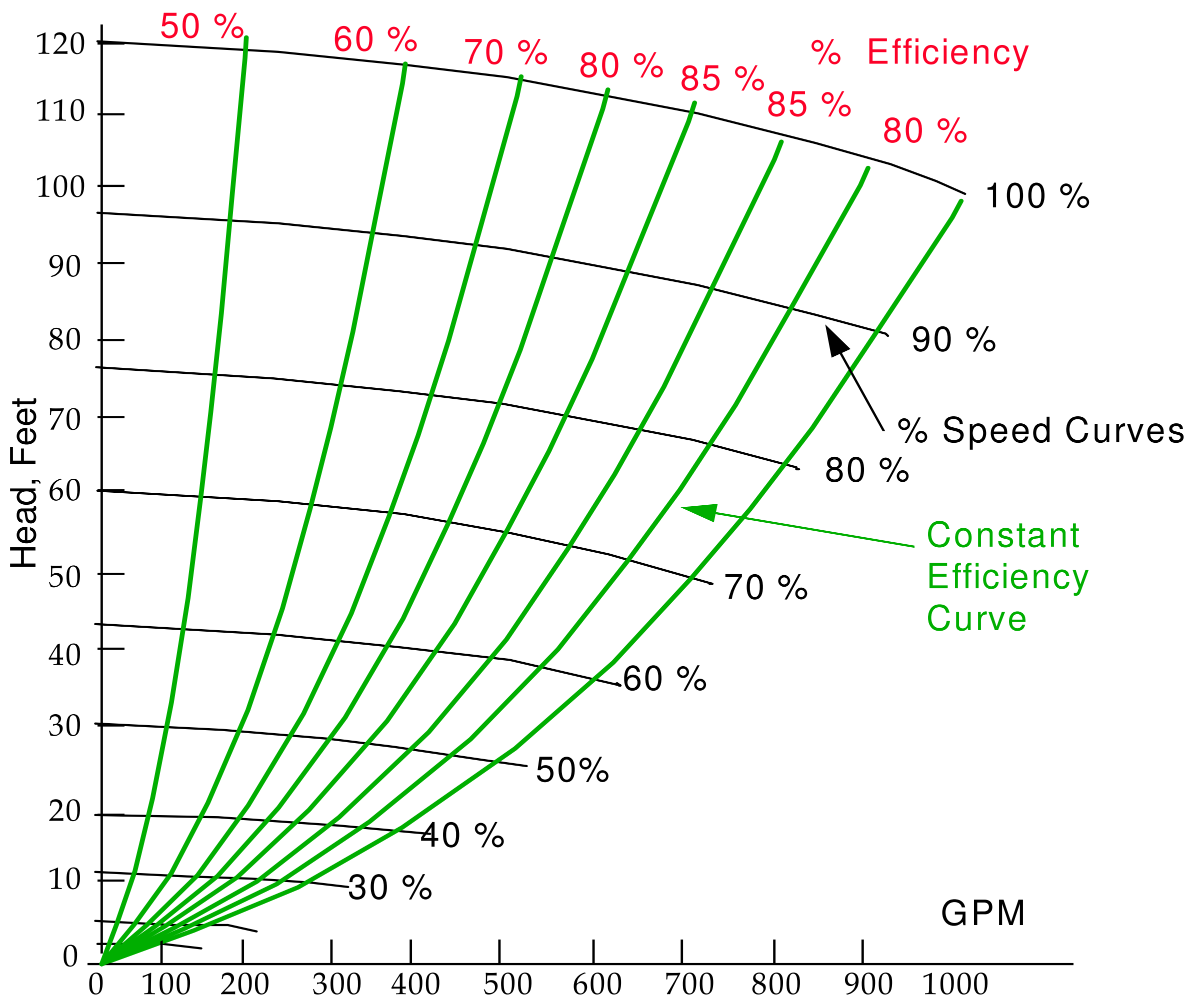
Parallel pumping power savings



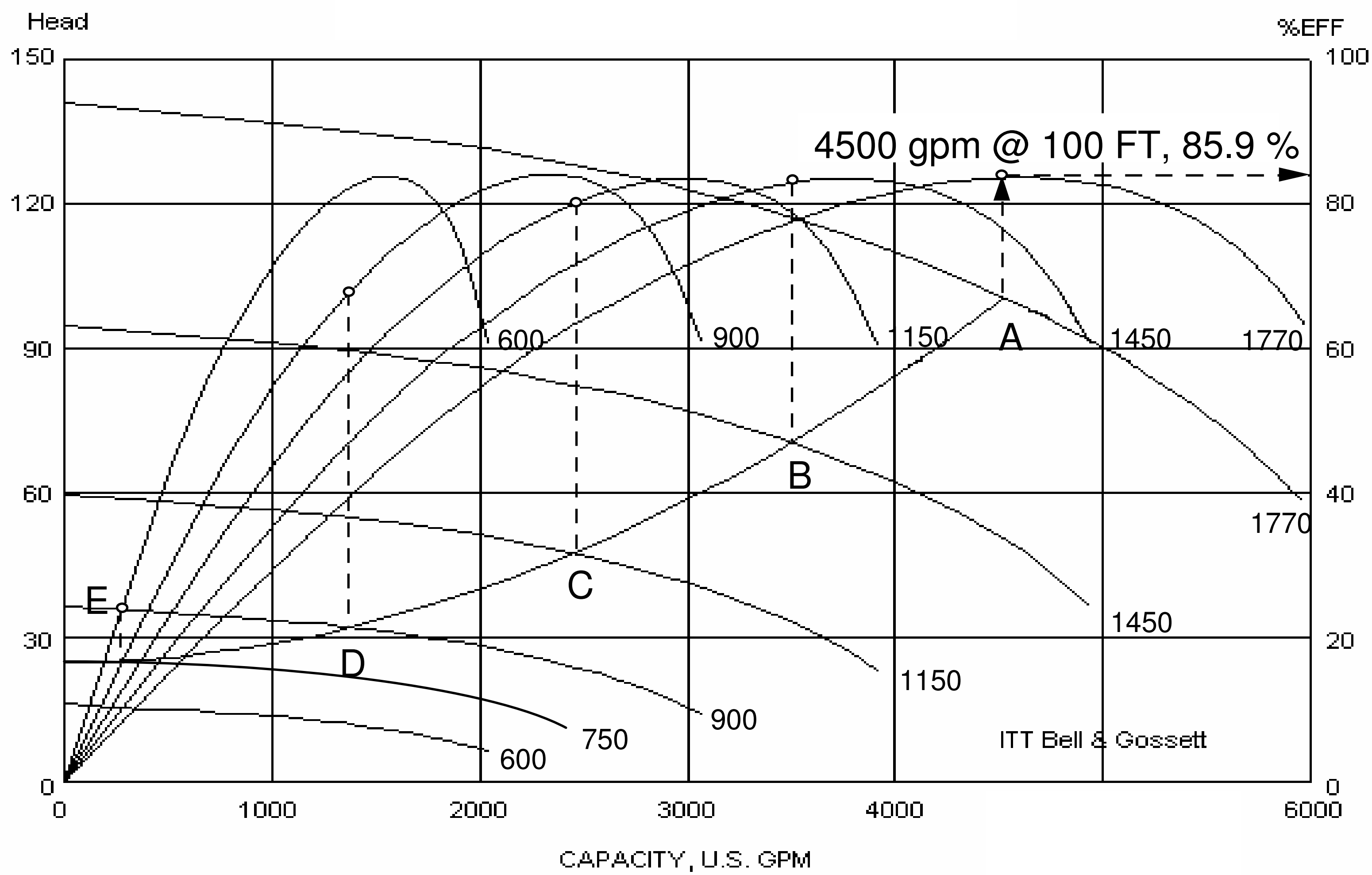
Theoretical Savings



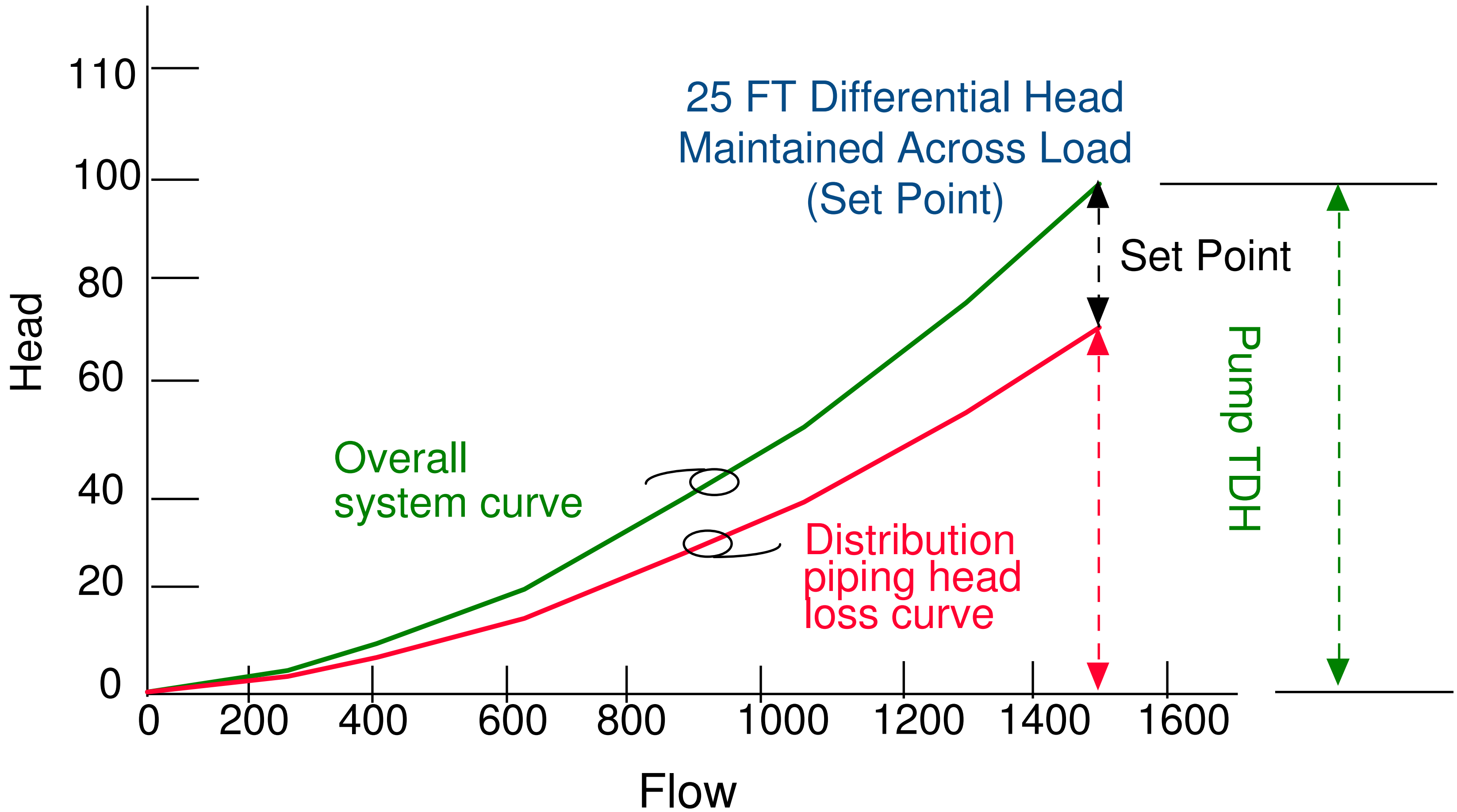
Establishing Efficiency Curves



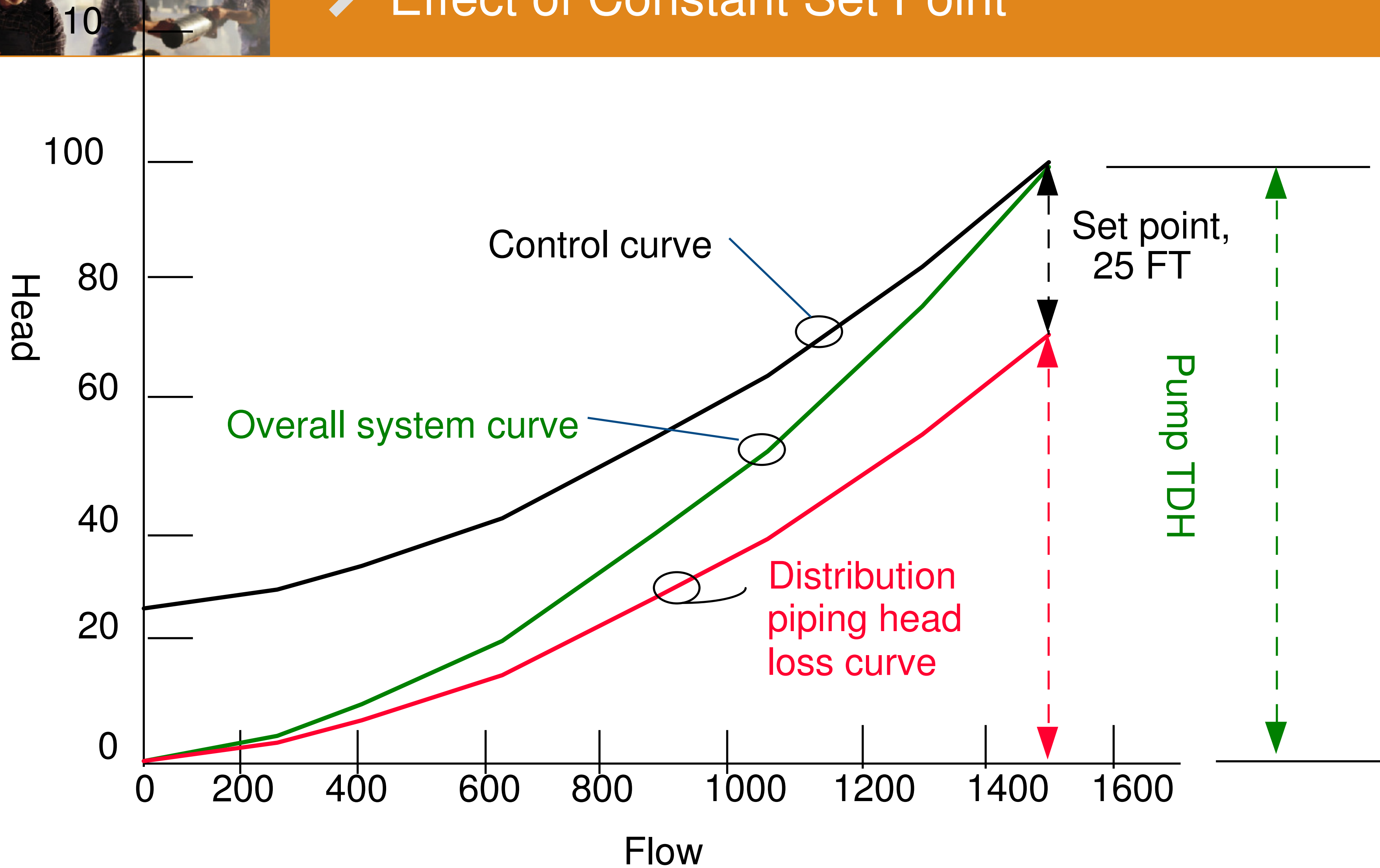
Variable Speed Efficiencies



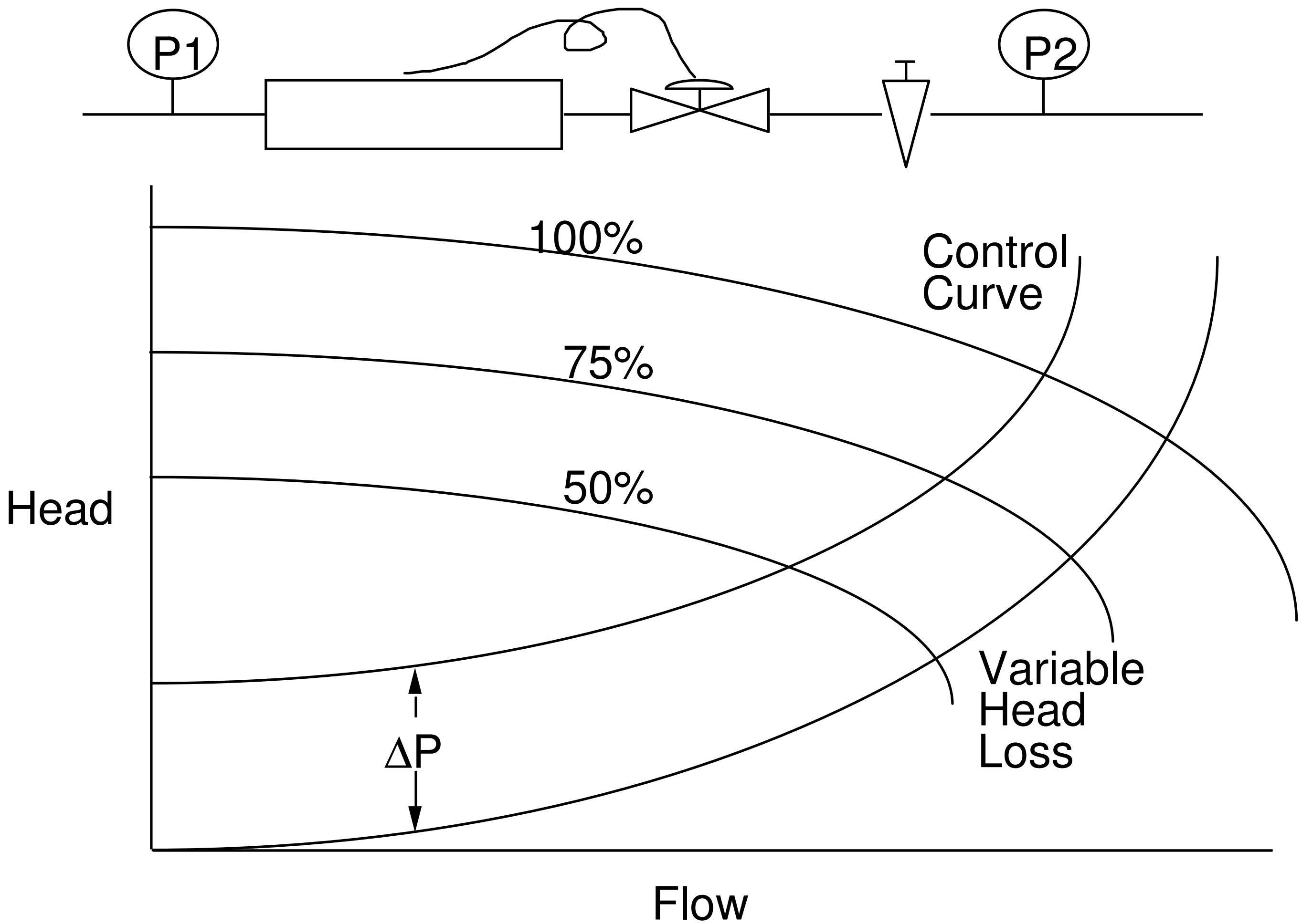
"No Valve" System Curve



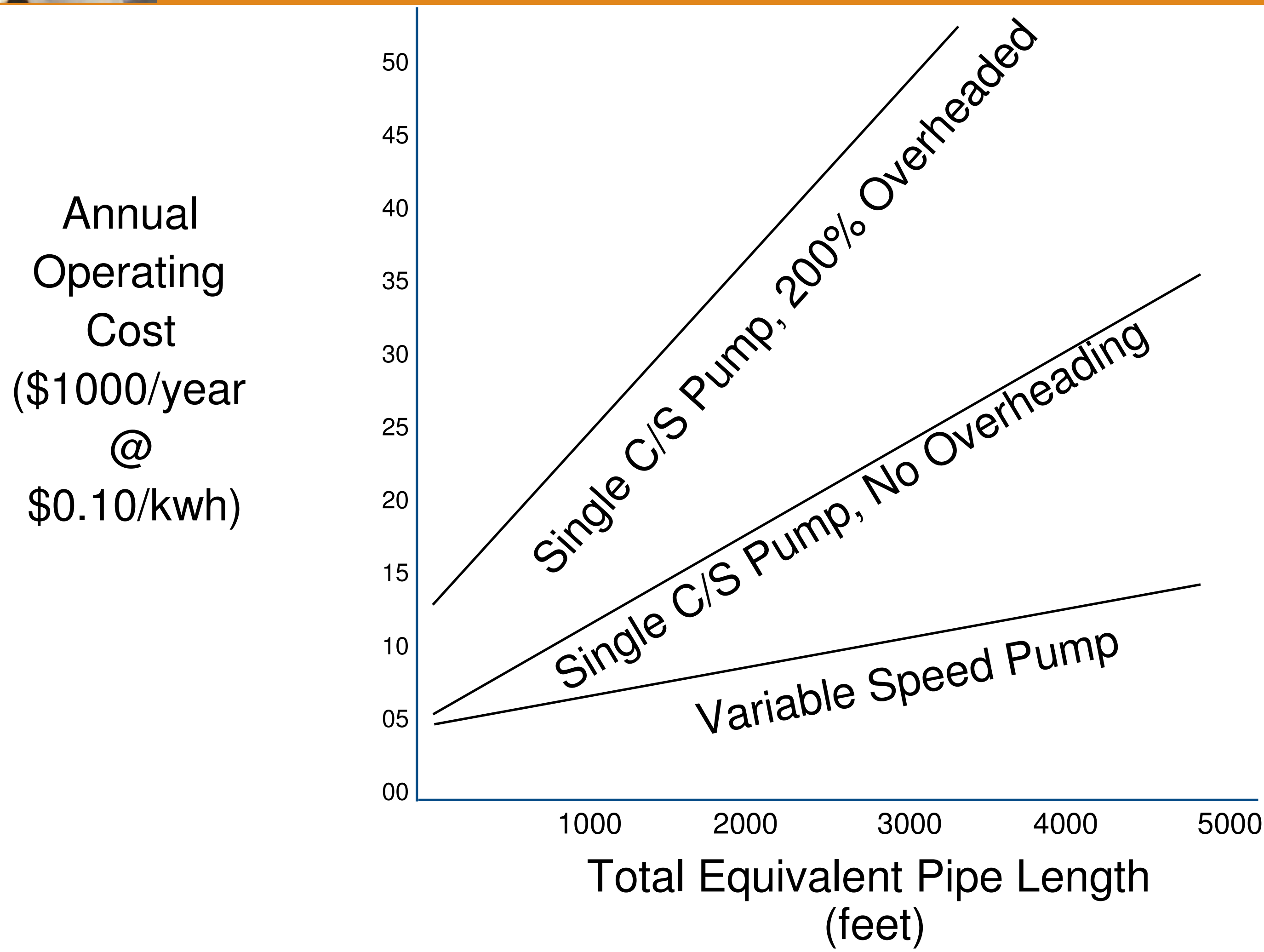
Effect of Constant Set Point



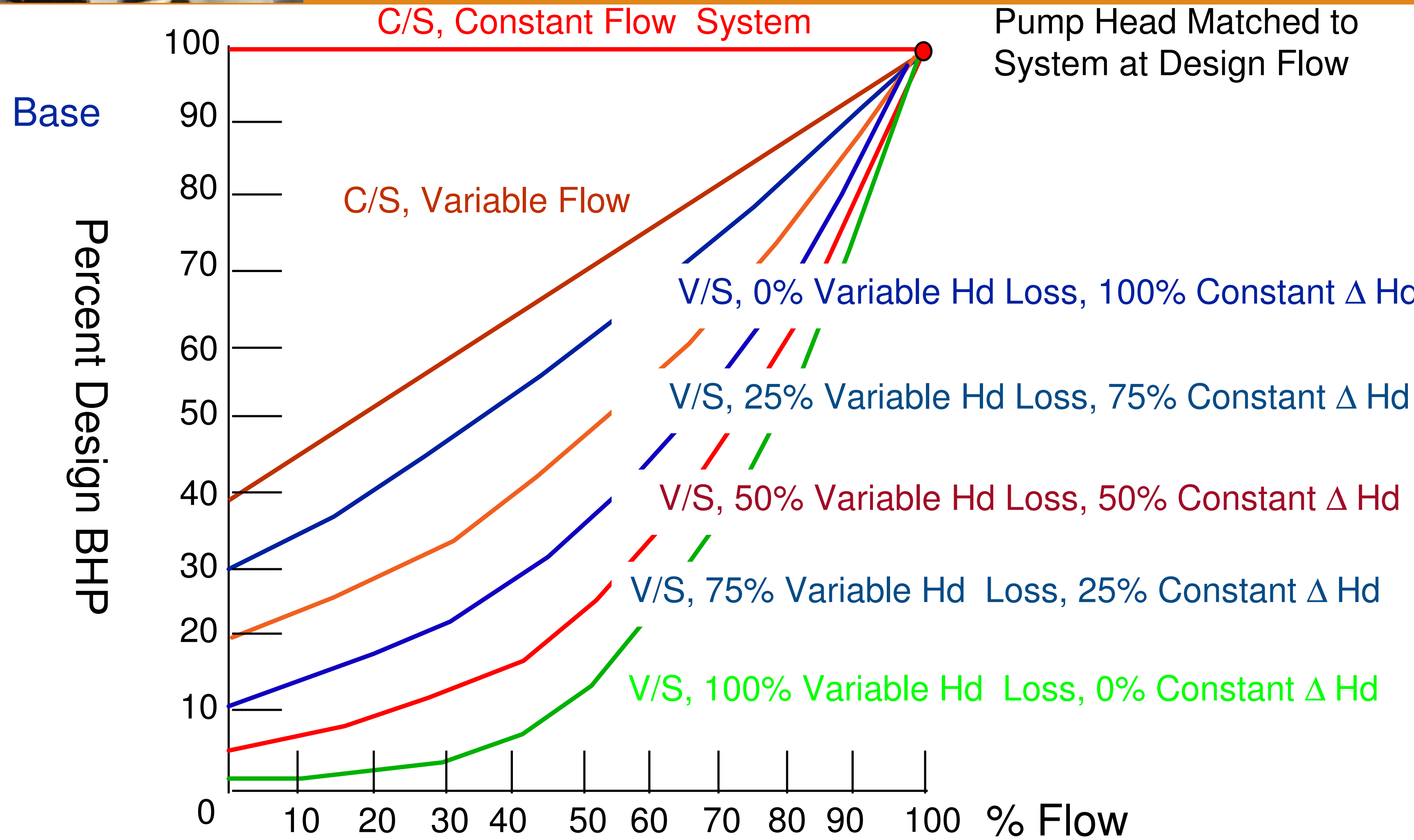
Control curve



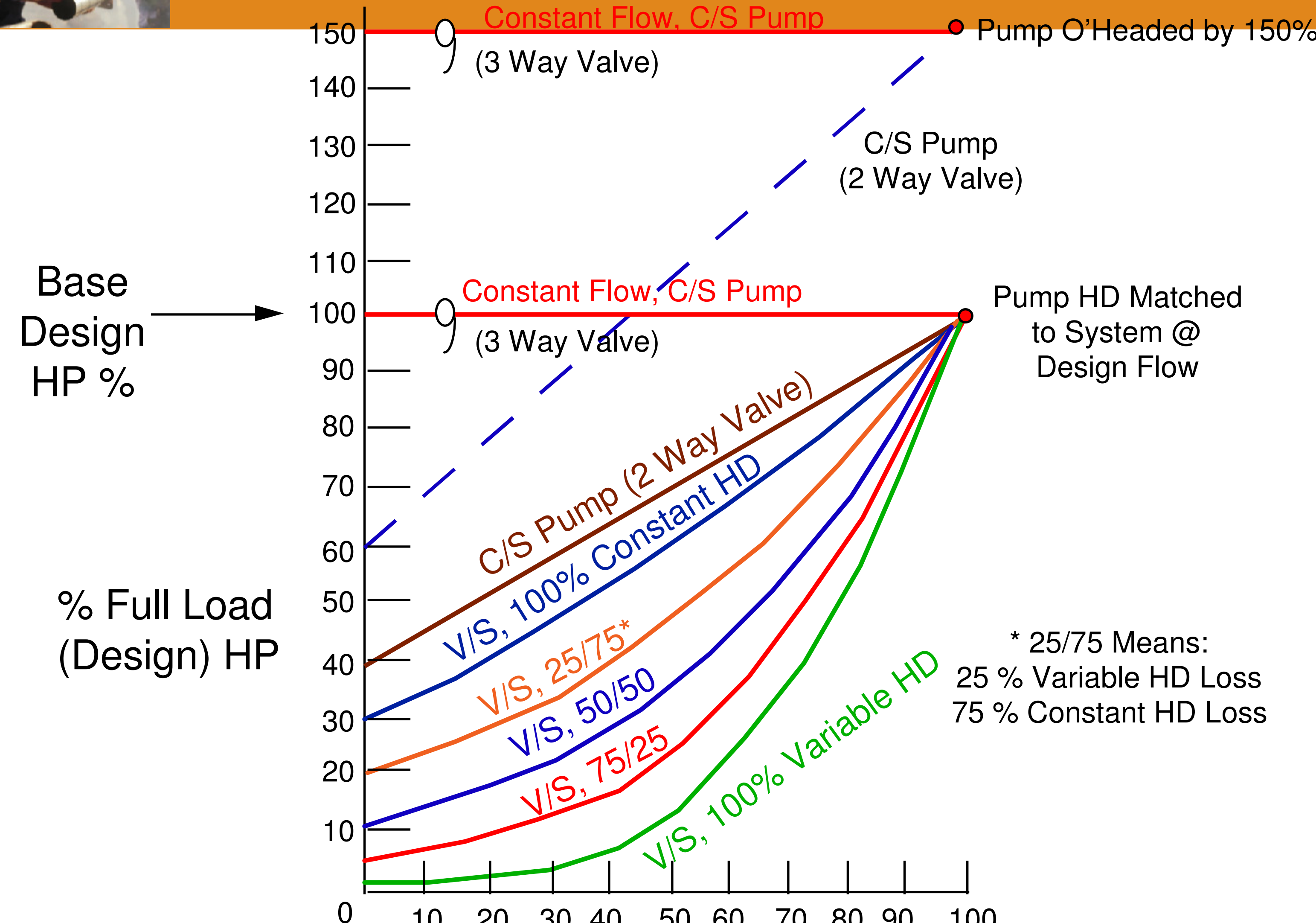
Large systems, long pipe runs



Variable Head Loss Ratio



Variable Head Ratio w/ Overheading

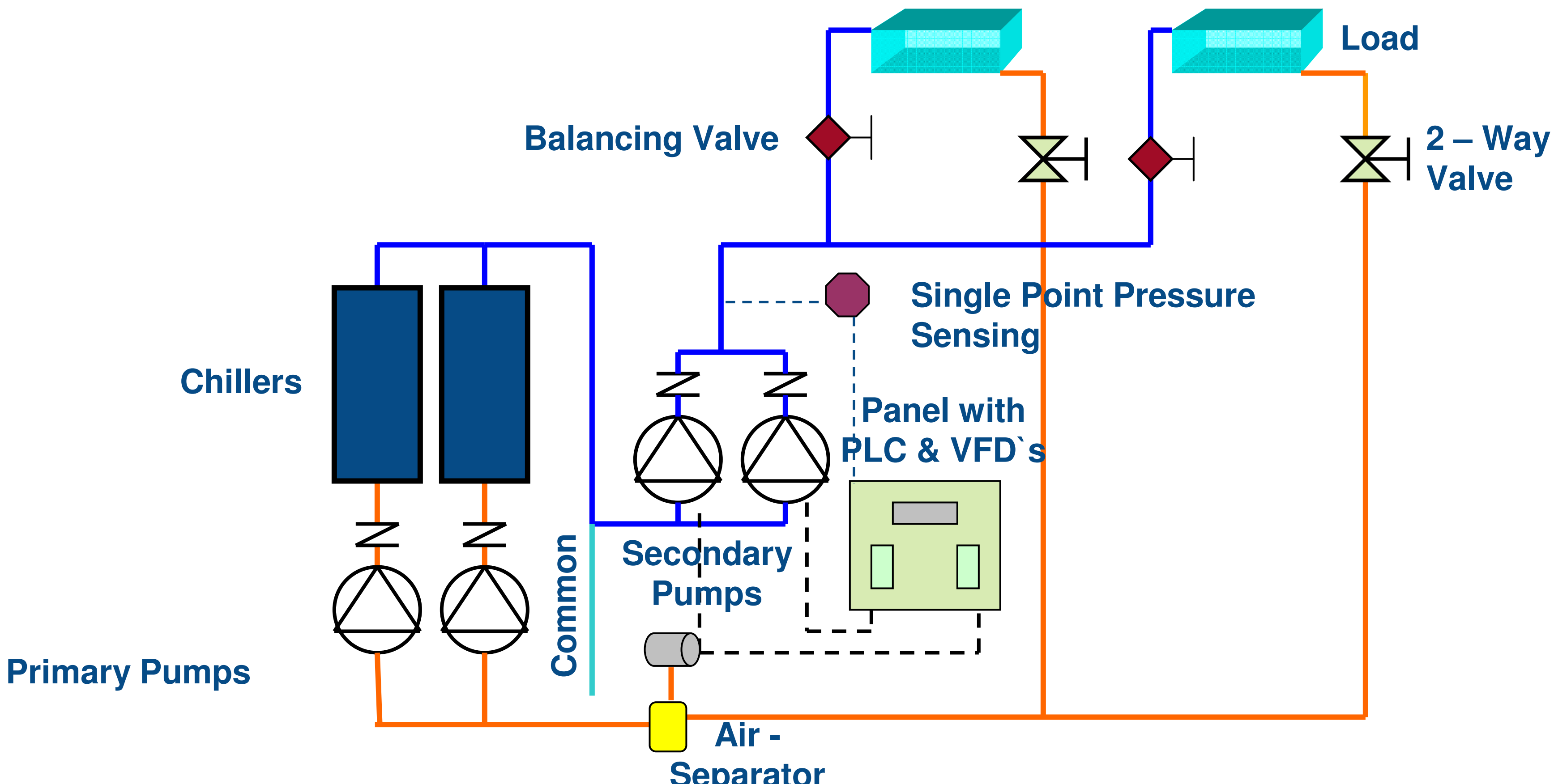


Locations of Sensor

Where to install the Sensor?

What type of Sensor?

Single Point Pressure Sensor



Single Point Pressure Sensor

Is Single Point Pressure Sensor Correct?

Wrong !!

Why?

-Pump is a differential pressure device.

-A single point is only influence by pressure. This is good for booster only.

-In a closed loop system, system pressure rises due to thermal expansion, pumps will slow down.

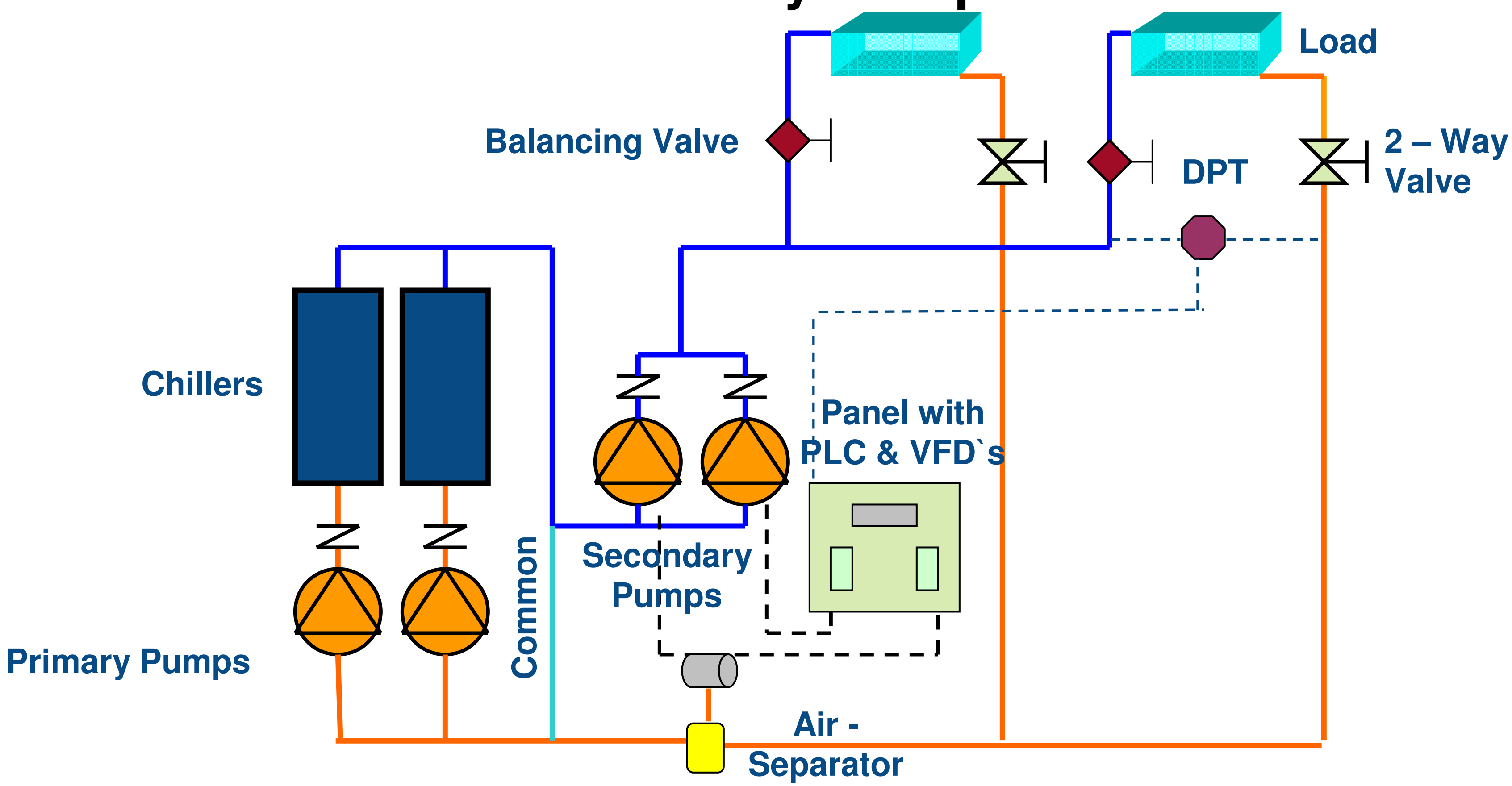
-When static pressure decrease, pumps will speed up.

-This is self-defeating since now the pump speed is not influence by the system load changes, but rather by system water pressure.

-Therefore, single pressure sensor are a misapplication in a closed loop HVAC system.

Single Point Differential Pressure Sensor

Primary - Secondary Circuit With Variable Speed Secondary Pumps

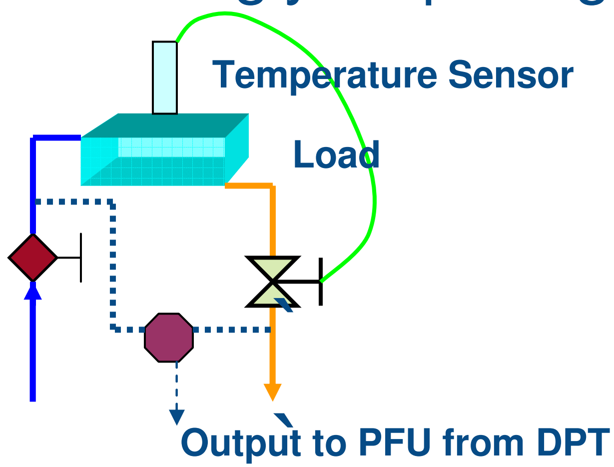


2 Way Valve Control

Opening/Closing of 2- Way Valve

-Signal from the sensor, installed at load regulates the valve opening & closing.

-This way differential across 2-way valve also changes & accordingly output signal is given to PLC.



Question:

Can we put the DPT across coil alone?

Question:

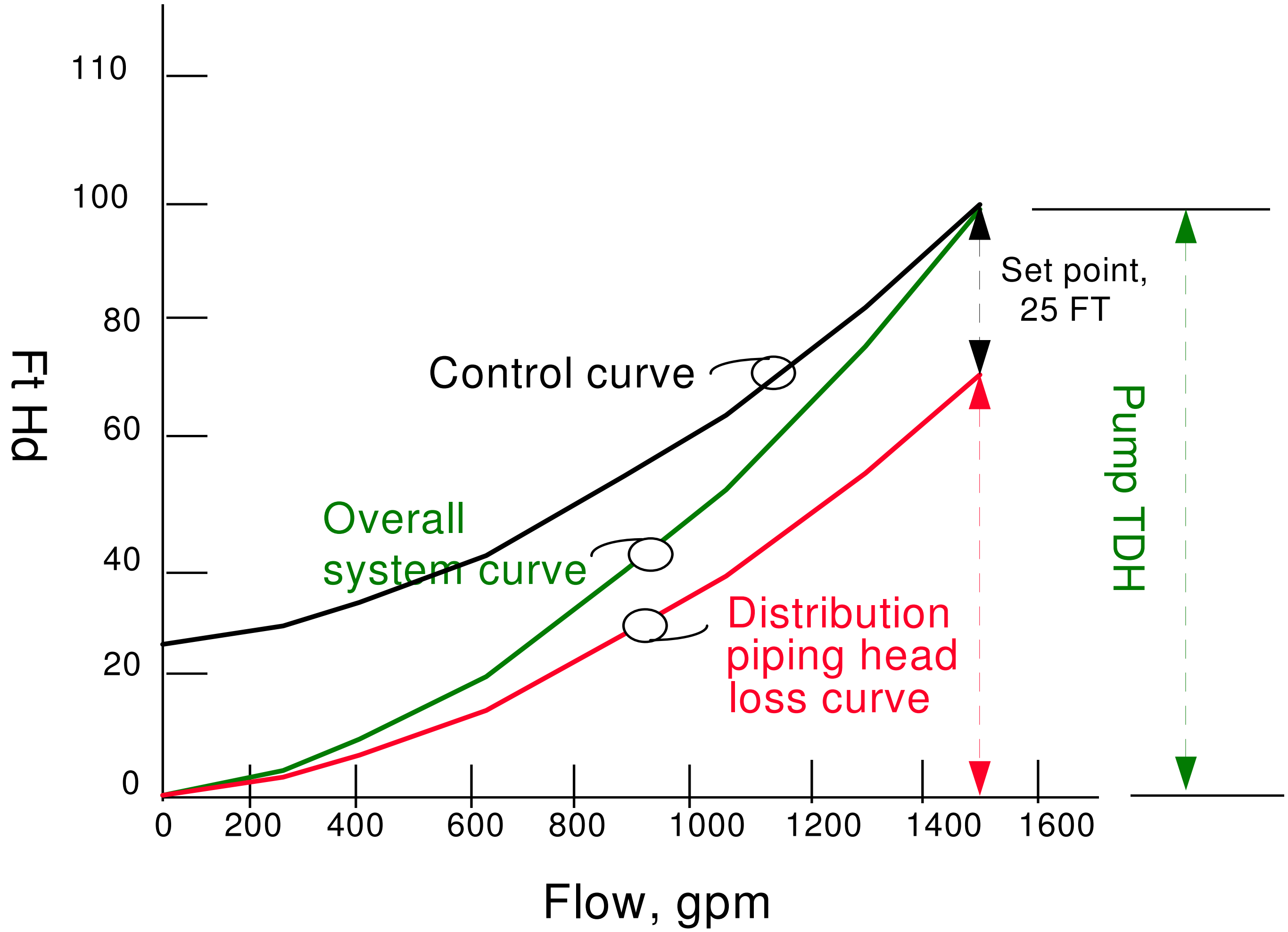
Across the pumps?

Single Point Differential Pressure Sensor

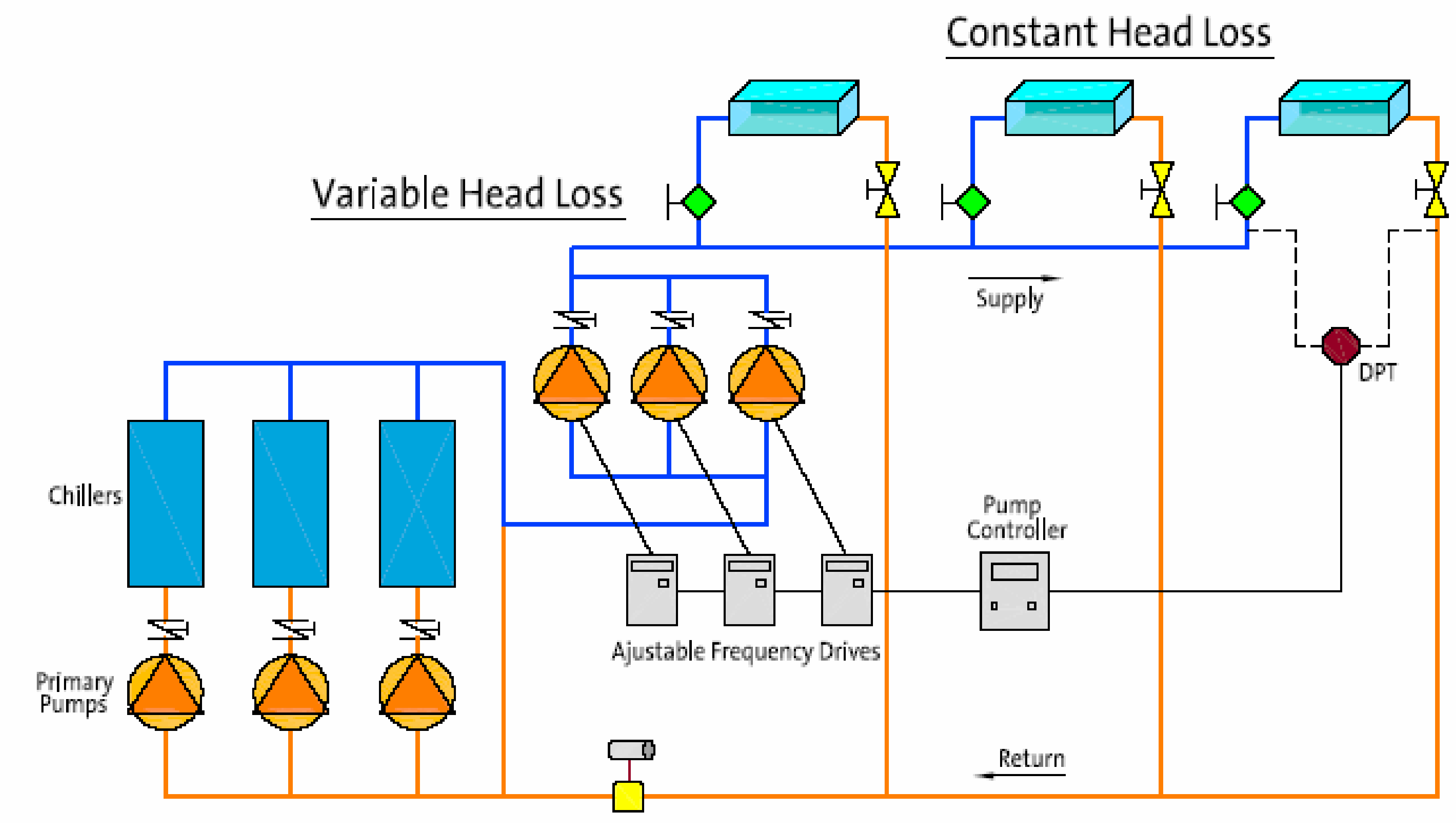
Primary - Secondary Circuit With Variable Speed Secondary Pumps

To Maximize energy system, we must maximize the variable head loss in the system. This is done by locating the sensor at the most remote zone (hydraulically) in the system.

System Control Curve



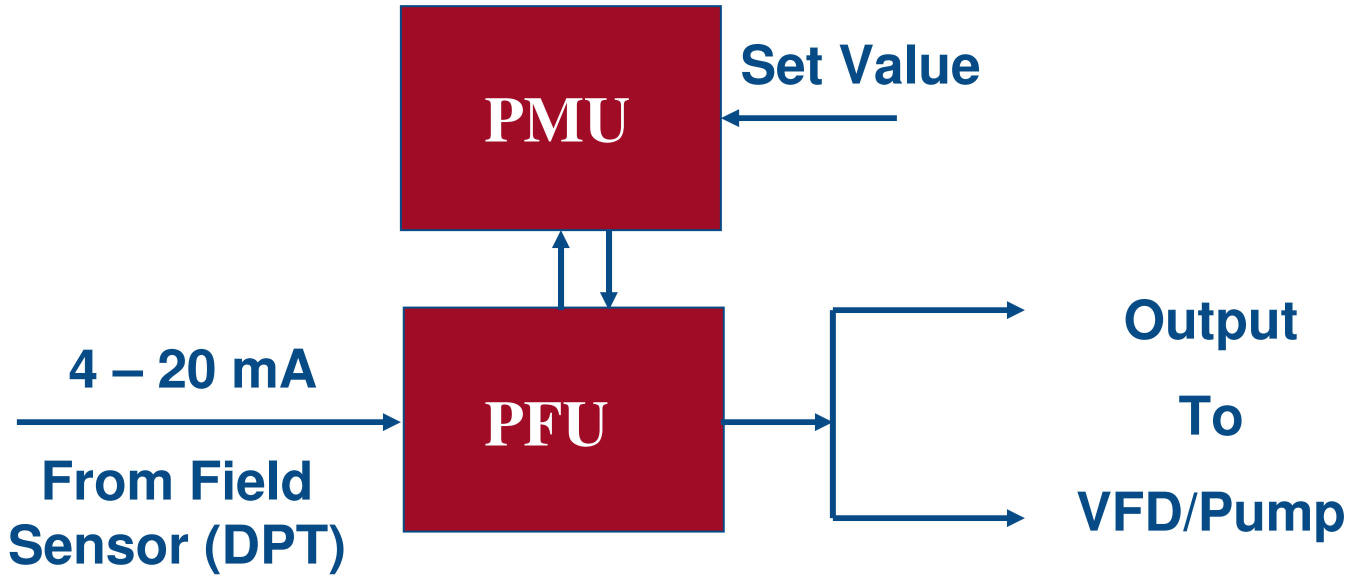
Variable vs Constant Head Loss



The “Active Zone”

- Zone set points do not have to be the same.
- Pump controller scans all zones often, comparing process variable to set point in each case.
- Pumps are controlled to satisfy the worst case.
- What happens to the rest of the zones?

Basic Concept

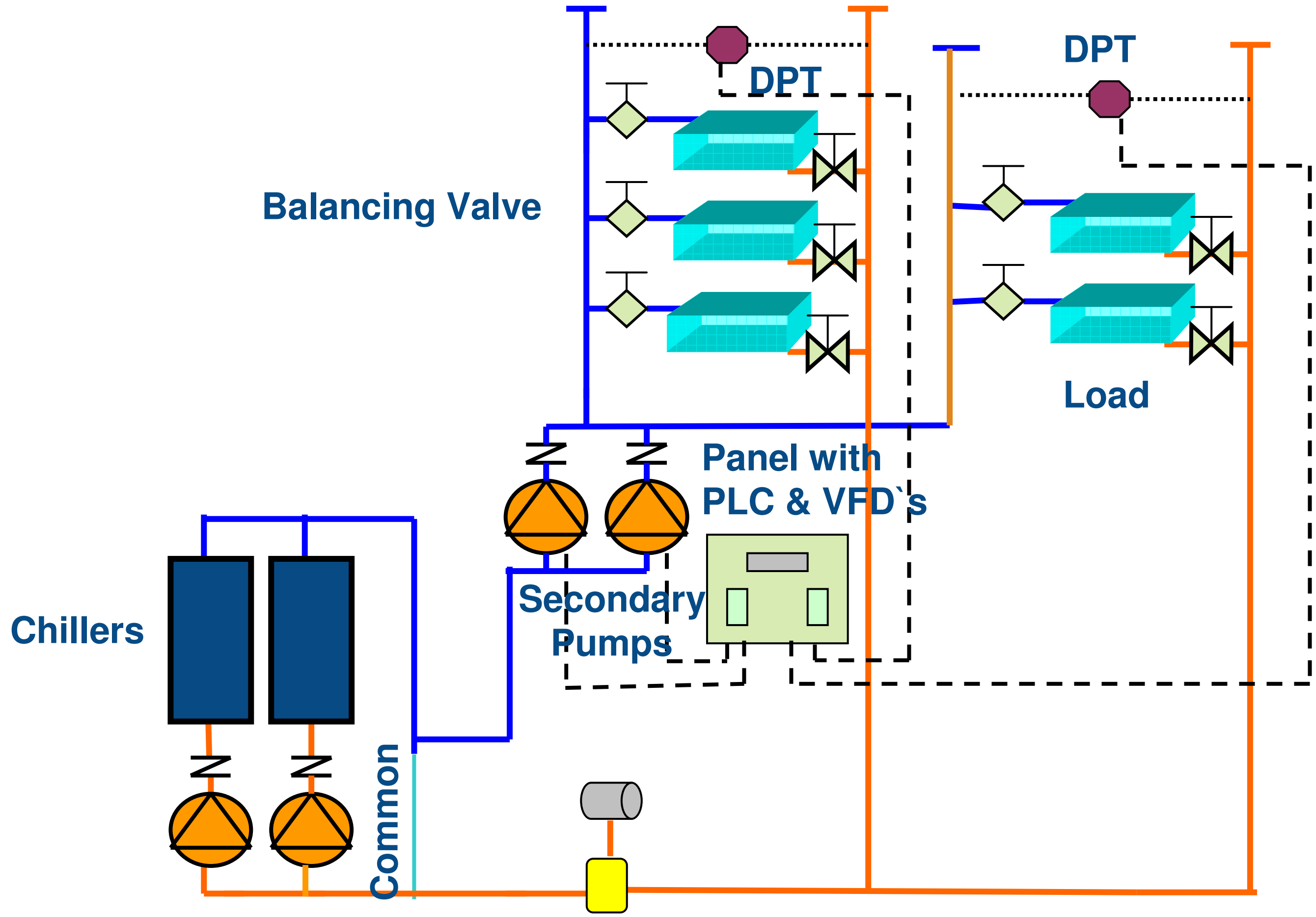


PFU – Pump Functional Unit

PMU – Pump Management Unit

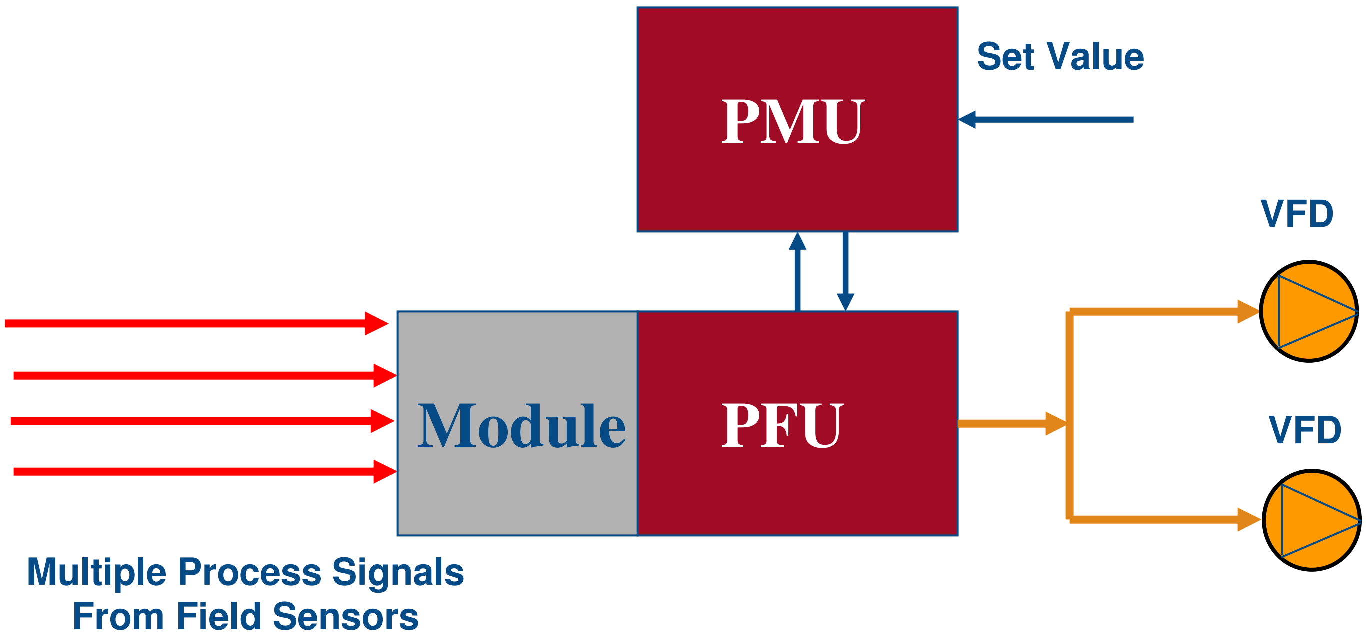
Multi Point Differential Pressure Sensor

Different Sensor Signal To Common PFU Panel



Multi Point Differential Pressure Sensor

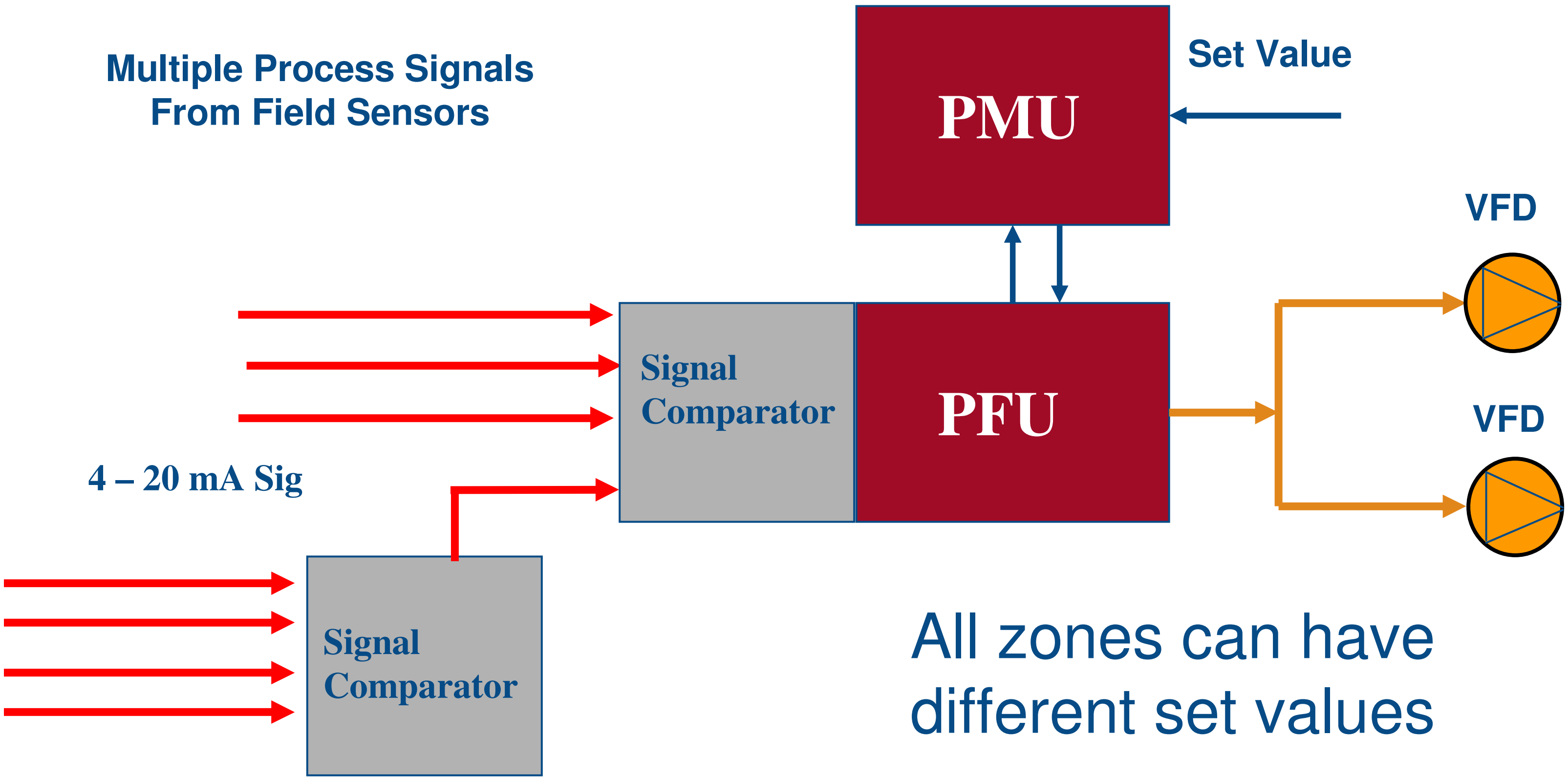
POSSIBILITY OF MULTIPLE PROCESS SIGNALS FROM DIFFERENT ZONES



All zones can have different set values

Multi Point Differential Pressure Sensor

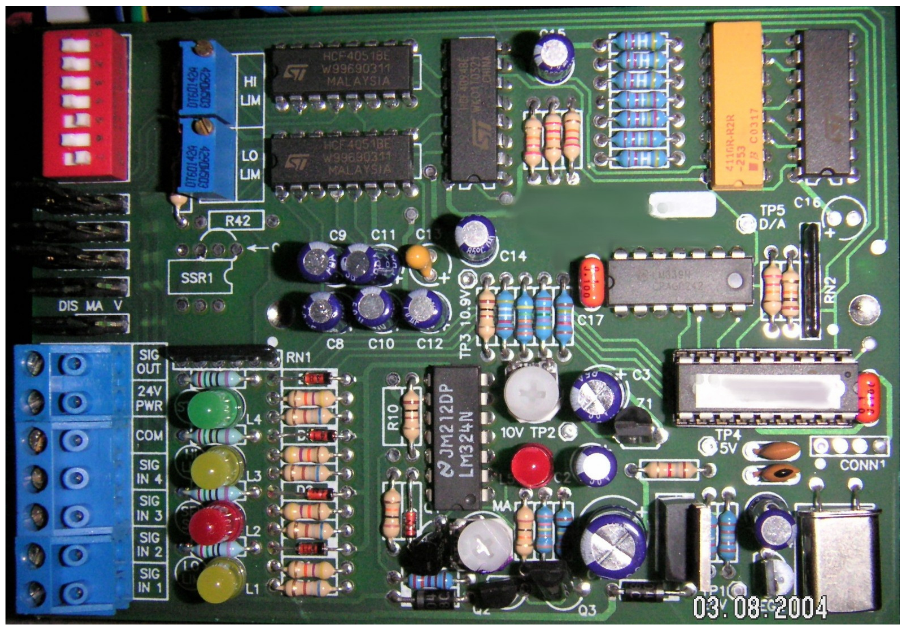
POSSIBILITY OF MULTIPLE PROCESS SIGNALS FROM DIFFERENT ZONES



All zones can have different set values

HVAC Control System

DPT Signal Comparator



DPT Signal Comparator

- High and Low Signal Selections
- Signal Averaging
- High/Low Limit Control

The module has the addition following features :

1) LED status indications
2) Accepts voltage or milliamp input signal
3) DIP switch-selectable operating modes
4) Accepts 24 VAC/DC power

HVAC Control System

DPT Signal Comparator

Benefits

1) We are able to supply VFD systems with multiple inputs signals ranges to compete with our competitors.

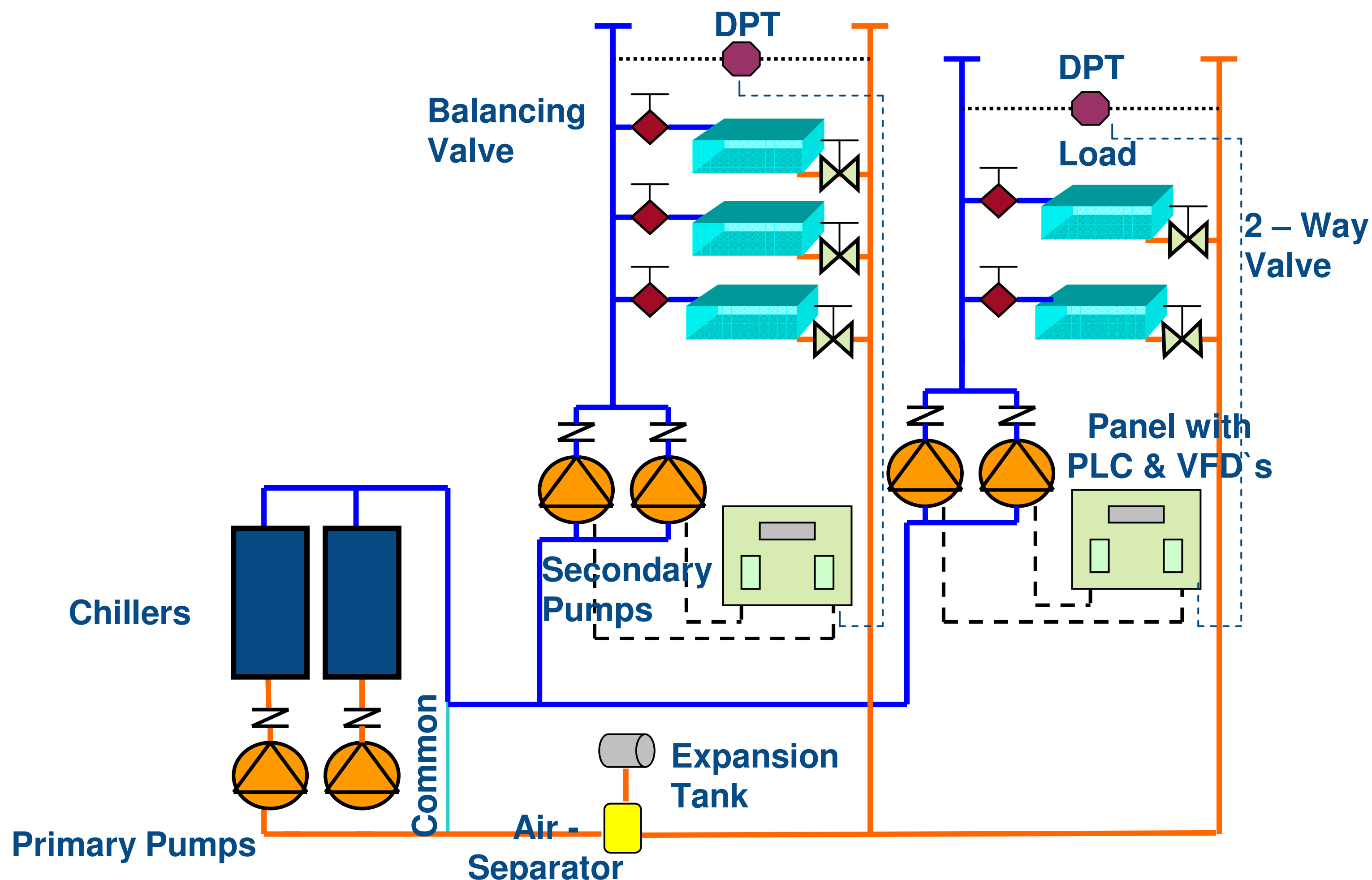
2) We are able to use Grundfos PFU 2000 as the main processor to control the full system operations.

3) We will be minimising outsourcing or external controller in order to serve the HVAC market.

4) The MM allows us to integrate into the system multiple sensor control at a more cost effective price.

Other Types of Systems

Separate System for Each Zone



Separate System for Each Zone

Systems In Multi - Zones

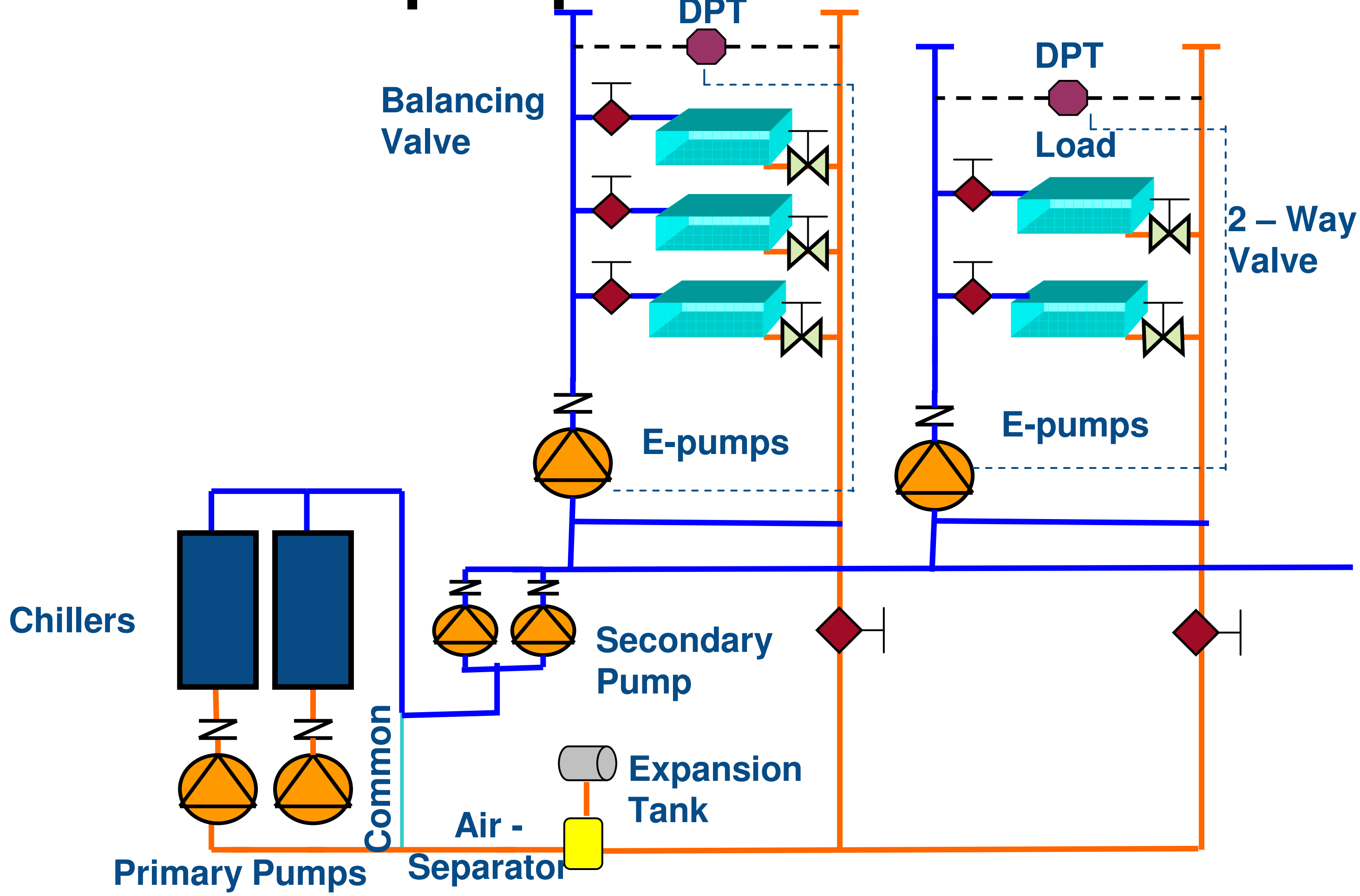
Two options:

1. Separate Systems can be used for different zones. So each zone will have its own sensor.

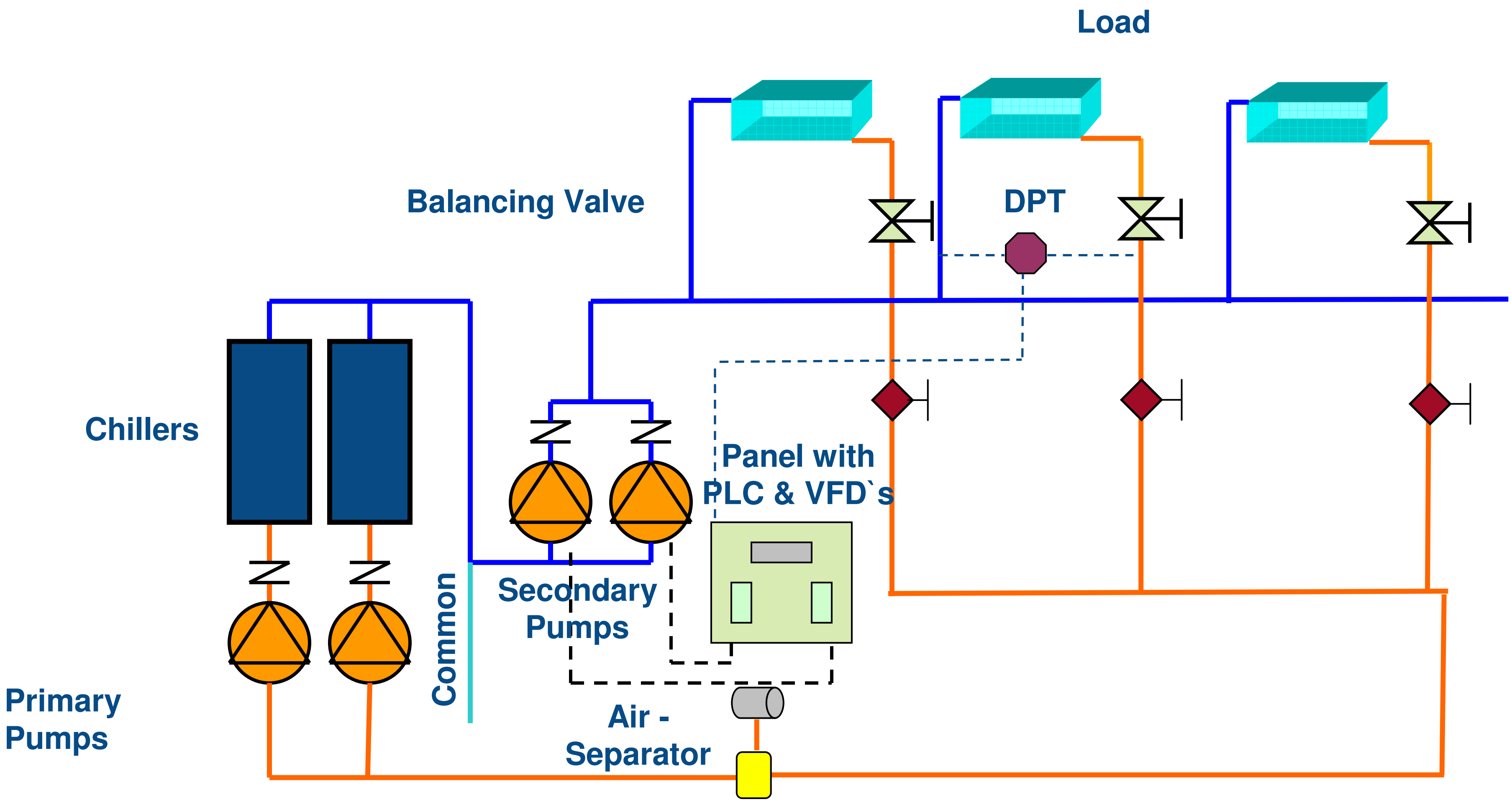
2. Signal from different zone sensors is given to the common PFU and most deviated signal, from the set point, is given as output.

Tertiary Pumping System

VFD pumps For Each Zone



Reverse Return Pumping



Reverse Return Pumping

Benefits :

1) Equalize the pressure drops of each zone.
2) Selections of the sensor becomes easier.
3) If load are similar or symmetrical, 1 centrally located sensor is adequate.
4) As in direct return system, multiple sensor can still provide a benefit to the end user.

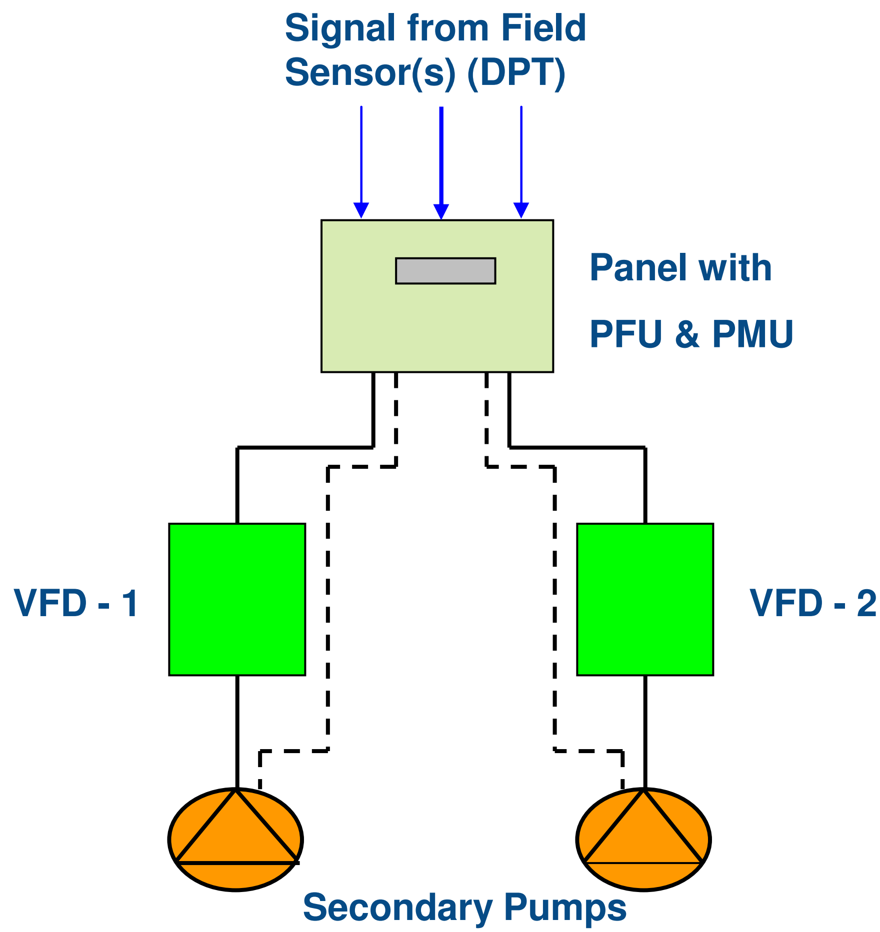
Type of VFD Systems

Possible Options of Variable Speed panels

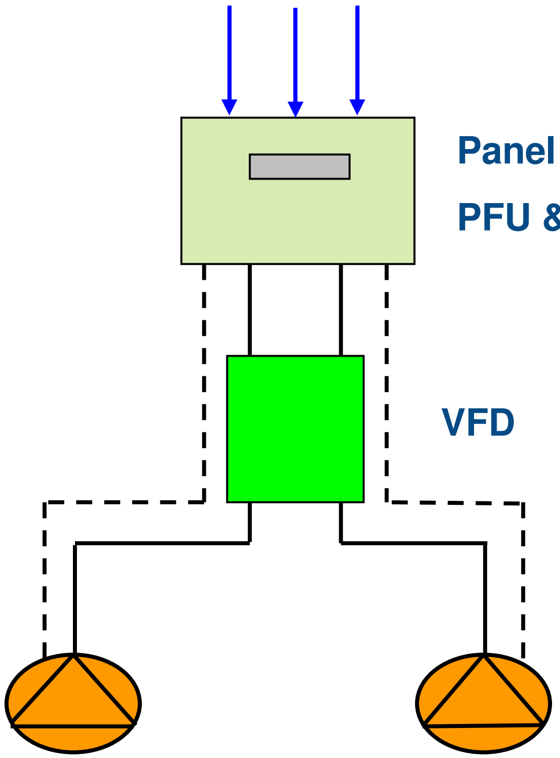
Type ME - Multiple Pumps & Multiple VFDs.

Type MF - Common VFD for Multiple Pumps.

System with Multi Pumps & Multi VFDs



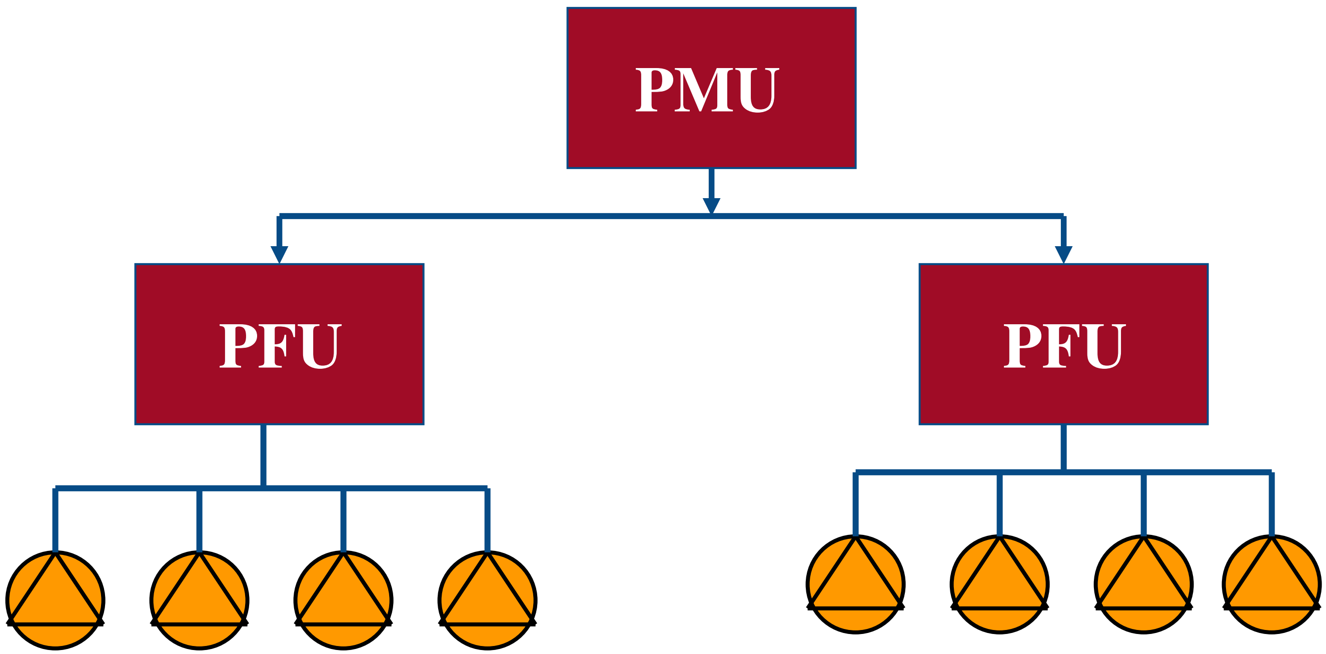
System with Common VFD for All Pumps



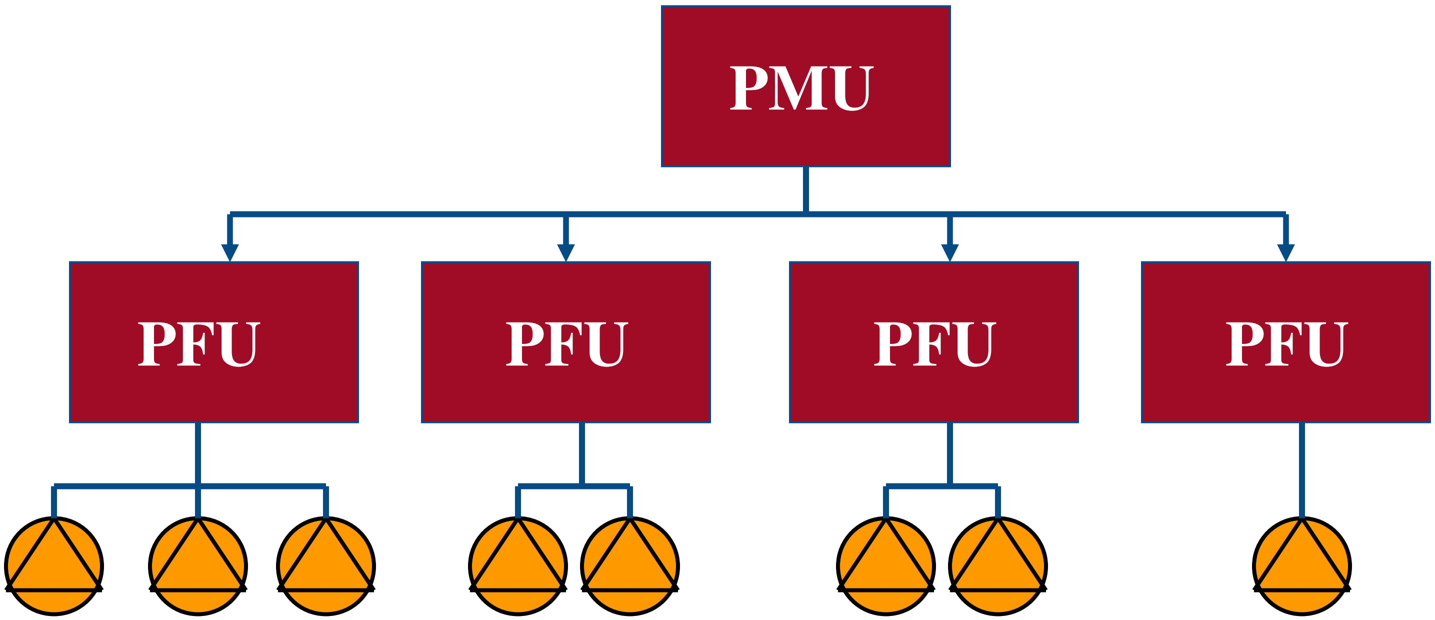
APPROVAL FROM INTERNATIONAL AGENCIES

Approval from – CE, U/L
Conforms to - Electromagnetic compatibility (89/336/EEC) to standard EN 50 081 – 1 and EN 50 082 – 2 and Electrical equipment design 73/23/EEC standard to EN 60 204-1.

Single PMU For Control of 8 Zones/Pumps



Single PMU For Control of 8 Zones/Pumps



The End